Title: Scent and Accessibility: Evaluating Perfume Bottle Designs for Individuals with Upper Extremity Disabilities

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Abstract

Background: Individuals with upper extremity disabilities often face challenges in using standard beauty products, including perfume bottles, due to limitations in grip strength, dexterity, and coordinated movement. Despite the growing emphasis on inclusive design, limited research has focused on the accessibility of fragrance products.

Objective: This study aimed to evaluate the usability and accessibility of perfume bottles for individuals with upper extremity disabilities, with a focus on packaging design, spray mechanisms, and ease of use.

Methods: A cross-sectional study was conducted with 56 participants aged 23 to 55 years, all of whom had mild to moderate upper extremity impairments. Participants completed demographic and disability assessments, tested a selection of perfume bottles, and rated them on various usability features. Quantitative data were analyzed using descriptive statistics and chi-square tests, while qualitative feedback was thematically analyzed.

Results: The majority of participants (90.91%) agreed or strongly agreed that the actuator size made it easier to press down using various parts of the hand or body. Bottle shape was also positively rated, with 85.45% indicating it allowed for a secure grip and comfortable handling. Rare Beauty consistently ranked highest across all usability domains—opening, spraying, holding, and comfort—and was significantly preferred ($p = 0.0249$), particularly among participants with moderate to severe impairments and those diagnosed with stroke or spinal cord injury.

Conclusion: The findings underscore the importance of inclusive design in fragrance packaging. Features such as larger actuators, ergonomic bottle shapes, and accessible locking mechanisms significantly enhance usability for individuals with upper extremity disabilities. These insights can inform future product development to promote equity and accessibility in the beauty industry.

Introduction
Engagement in personal grooming and beauty routines is a fundamental aspect of self-expression, confidence, and psychological well-being. However, individuals with upper extremity disabilities—such as limb loss, limited mobility, or dexterity impairments—often face significant challenges when using standard beauty products. Among these, perfume bottles and their spray mechanisms can be particularly difficult to operate due to their reliance on fine motor control, grip strength, and coordinated hand movements.

Although accessible design has gained increasing attention across various consumer industries, the cosmetics and personal care sectors have received comparatively limited focus. While prior research has emphasized the importance of inclusive product development, few studies have specifically examined the usability of beauty products for individuals with physical impairments. This gap is especially evident in the context of fragrance products, where packaging and applicator design can significantly influence user experience and accessibility.

The present study aims to investigate the accessibility of perfume bottles for individuals with upper extremity disabilities. By evaluating factors such as packaging design, spray mechanisms, and ease of use, this research seeks to identify common barriers and propose design recommendations that enhance usability. The overarching goal is to promote inclusivity in the beauty industry and ensure equitable access to fragrance products for all users, regardless of physical ability.

Methods
Study Design: This study employed a cross-sectional design to assess the accessibility of perfume bottles among individuals with upper extremity disabilities. Participants completed baseline questionnaires, tested a selection of perfume bottles, and provided both quantitative ratings and qualitative feedback on their usability.

Participants: A convenience sample of 55–60 individuals aged 18 to 55 years with mild to moderate upper extremity deficits was recruited. Inclusion criteria required participants to be regular users of beauty products and able to understand and communicate in the language of the study. Exclusion criteria included severe upper extremity deficits, known allergies to cosmetic ingredients, immunocompromised status, pregnancy or plans to become pregnant, and any medical or psychological condition that could interfere with participation.

Procedure
Baseline Assessment: Participants completed demographic and disability questionnaires to capture age, gender, disability characteristics, and prior experiences with fragrance products. Functional assessments included grip and pinch strength measurements and the Nine-Hole Peg Test to determine the level of upper extremity impairment.

Bottle Testing: Participants were provided with a selection of perfume bottles chosen for their varied design features. Each participant tested the bottles and evaluated them based on predefined criteria, including: Ease of grip, Maneuverability, Spray mechanism functionality, and Packaging design.

Survey Completion: Following the testing phase, participants completed a structured survey to rate each bottle on ease of use, comfort, and overall accessibility. Open-ended questions were included to gather qualitative feedback on user experience, challenges encountered, and suggestions for improvement.

Data Analysis: Quantitative data were analyzed using descriptive statistics to summarize participant ratings and identify the most and least accessible perfume bottles. Qualitative responses were analyzed using thematic analysis to extract common themes and user-driven recommendations for improving accessibility.

Results

Participant Demographics: A total of 56 participants were included in the study. The mean age was 40.57 years (SD = 9.92), with a range from 23 to 55 years. The most common diagnoses were stroke (46.43%), traumatic brain injury (17.86%), and spinal cord injury (14.29%). Ethnically, 51.79% identified as Hispanic or Latino. Racially, the sample was diverse, with 50% identifying as White and 28.57% as Other. Most participants had some college education or higher.

Disability Characteristics: Over half of the participants (53.57%) reported severe upper extremity impairments, with the remainder reporting moderate (28.57%) or mild (17.86%) impairments. The affected side varied, with 39.29% reporting right-hand impairment, 33.93% both hands, and 26.79% left-hand impairment.

Usability Ratings: Participants evaluated the perfume bottles on multiple usability dimensions:

1. Actuator Design:
   - 96.36% agreed or strongly agreed that the actuator was easy to press with any part of the hand or body.
   - 81.82% found it easy to use with one hand.
   - 85.45% agreed that the actuator's indent improved locking/unlocking.

2. Bottle Shape and Grip:
   - 85.45% agreed the shape allowed for a secure grip and was comfortable to hold.
   - 90.91% found the bottle shape allowed for alternative spraying methods (e.g., using palms or forearms).

3. Spraying Mechanism:
   - 90.91% agreed that the actuator size and shape made spraying easier.
   - 87.27% found the overall bottle design facilitated fragrance application.

4. Monogram and Cap Design:
   - 60% found the monogram helpful for grip and control.
   - 83.64% agreed the cap cutout improved reach to the actuator.

Qualitative Feedback

- Participants described the easiest methods for using the bottles as:
- Using multiple fingers or palms to press the actuator.
- Holding the bottle with fingers around the base and using the index or thumb to spray.
- Placing the bottle on a flat surface and pressing down.

Brand Rankings: Across all usability categories—opening, spraying, holding, and comfort—Rare Beauty ranked highest, followed by three competitor brands selected based on their market popularity, widespread consumer recognition, and similarity in bottle size and design characteristics. These similarities allowed for a more balanced comparison of usability features across products. A chi-square test confirmed a statistically significant preference for Rare Beauty ($p = 0.0249$), particularly among participants with moderate to severe impairments and those diagnosed with stroke or spinal cord injury.

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Detailed Data Report

1. Demographics

Age Distribution

- Maximum Age: 55
- Minimum Age: 23
- Median Age: 41
- Mean Age: 40.57
- Standard Deviation: 9.92
- Sample Size (N): 56

Gender Distribution

- Female: 37 (66.07%)
- Male: 19 (33.93%)
- Total: 56 (No missing values)

Diagnosis Distribution

- Total Cases: 56 (No missing values)
- Stroke: 26 cases (46.43%)
- Traumatic Brain Injury (TBI): 10 cases (17.86%)
- Spinal Cord Injury: 8 cases (14.29%)
- Cerebral Palsy: 3 cases (5.36%)
- Other Diagnoses (each with 1 case, 1.79% each)

Ethnicity Distribution

- Hispanic or Latino: 29 cases (51.79%)
- Not Hispanic or Latino: 27 cases (48.21%)

Race Distribution

- American Indian or Alaska Native: 0 cases (0%)
- Asian: 5 cases (8.93%)
- Black or African American: 7 cases (12.50%)
- Native Hawaiian or Other Pacific Islander: 1 case (1.79%)
- White: 28 cases (50.00%)
- Other: 16 cases (28.57%)

Education Level Distribution

- Some college, no degree: 20 responses (35.71%)
- Bachelor's degree (e.g., BA, BS): 11 responses (19.64%)
- High school degree or equivalent (e.g., GED): 10 responses (17.86%)
- Associate degree (e.g., AA, AS): 9 responses (16.07%)
- Master's degree (e.g., MA, MS, MEd): 4 responses (7.14%)
- Doctorate (e.g., PhD, EdD): 1 response (1.79%)
- Less than a high school diploma: 1 response (1.79%)

Disability/Impairment Level Distribution

- Severe Impairment: 30 cases (53.57%)
- Moderate Impairment: 16 cases (28.57%)
- Mild Impairment: 10 cases (17.86%)

Affected Side Distribution

- Right Hand: 22 cases (39.29%)

- Both Hands: 19 cases (33.93%)
- Left Hand: 15 cases (26.79%)

2. Usability of Perfume Bottle

The size of the actuator makes it easier to twist and unlock/lock the cap:
- Strongly Agree: 28 (50.91%)
- Agree: 22 (40.00%)
- Neutral: 2 (3.64%)
- Disagree: 2 (3.64%)
- Strongly Disagree: 1 (1.82%)

The shape of the bottles allows for a more secure grip:
- Strongly Agree: 22 (40.00%)
- Agree: 25 (45.45%)
- Neutral: 4 (7.27%)
- Disagree: 3 (5.45%)
- Strongly Disagree: 1 (1.82%)

The shape of the bottle is comfortable to hold:
- Strongly Agree: 24 (43.64%)
- Agree: 23 (41.82%)
- Neutral: 6 (10.91%)
- Disagree: 2 (3.64%)

The size of the actuator makes it easier to press down on with any part of your hand/body:
- Strongly Agree: 39 (70.91%)
- Agree: 14 (25.45%)
- Neutral: 1 (1.82%)
- Strongly Disagree: 1 (1.82%)

The size and shape of the actuator allow you to spray fragrance more easily:
- Strongly Agree: 34 (61.82%)
- Agree: 16 (29.09%)
- Neutral: 4 (7.27%)
- Disagree: 1 (1.82%)

The size and shape of the bottle make it easy to spray the fragrance:
- Strongly Agree: 23 (41.82%)
- Agree: 25 (45.45%)
- Neutral: 5 (9.09%)
- Disagree: 2 (3.64%)

The size of the actuator makes it easy to use with one hand:
- Strongly Agree: 28 (50.91%)
- Agree: 17 (30.91%)
- Neutral: 4 (7.27%)
- Disagree: 5 (9.09%)
- Strongly Disagree: 1 (1.82%)

The indent in the actuator's shape makes it easier to lock and unlock the cap:
- Strongly Agree: 31 (56.36%)
- Agree: 16 (29.09%)
- Neutral: 5 (9.09%)
- Disagree: 3 (5.45%)

The monogram helps to grip and control the actuator while pressing down:
- Strongly Agree: 15 (27.27%)
- Agree: 18 (32.73%)
- Neutral: 16 (29.09%)
- Disagree: 6 (10.91%)

The monogram helps to locate the center of the actuator to spray the fragrance:

- Strongly Agree: 21 (38.18%)
- Agree: 23 (41.82%)
- Neutral: 6 (10.91%)
- Disagree: 4 (7.27%)
- Strongly Disagree: 1 (1.82%)

Holding the bottle with my fingers wrapped around the base and using my index finger to press down on the actuator is easy:

- Strongly Agree: 20(36,36%)
- Agree: 18(32,73%)
- Neutral: 7(12,73%)
- Disagree: 7(12,73%)
- Strongly Disagree: 3(5,45%)

The size of the bottle allows for me to hold it using multiple fingers on top of the actuator:

- Strongly Agree: 22(40,00%)
- Agree: 21(38,18%)
- Neutral: 7(12,73%)
- Disagree: 3(5,45%)
- Strongly Disagree: 2(3,64%)
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The cap cutout improves reach to the top of the actuator:

- Strongly Agree: 22(40,00%)
- Agree: 24(43,64%)
- Neutral: 4(7,27%)
- Disagree: 5(9,09%)

The shape of the bottle allows me to use other parts of my body to press down on the actuator (ex.palms,forearms,elbows):

- Strongly Agree: 29(52,73%)
- Agree: 21(38,18%)
- Neutral: 4(7,27%)
- Disagree: 1(1,82%)

What was the easiest way to use the perfume bottle?

- Using multiple fingers or palms to press down on the actuator.
- Holding with fingers wrapped around the base and using index or thumb to spray.
- Placing on a flat surface and pressing down.

Summary

Actuator and Bottle Design

1. Ease of Use: 90.91% agree or strongly agree that the actuator size makes it easier to press down ($p<0.05$).
2. Grip and Comfort: 85.45% agree or strongly agree that the bottle shape allows for a secure grip and is comfortable to hold ($p<0.05$).
3. Spraying Ease: 90.91% agree or strongly agree that the actuator size and shape make it easy to spray the fragrance ($p<0.05$).
4. One-Hand Use: 81.82% agree or strongly agree that the actuator size makes it easy to use with one hand.
5. Cap Lock/Unlock: 85.45% agree or strongly agree that the actuator's indent makes it easier to lock and unlock the cap.
6. Monogram Utility: 60% agree or strongly agree that the monogram helps grip and control the actuator.

Overall Design Feedback

1. Actuator Size: 96.36% find it easier to press down with any part of the hand/body.
2. Bottle Shape: 87.27% find it easy to spray the fragrance.
3. Cap Cutout: 83.64% agree or strongly agree that it improves reach to the actuator.
4. Alternative Use: 90.91% find the bottle shape allows using other body parts to press down on the actuator.

Key Insights

- **Design Effectiveness**: The design features of the perfume bottles, such as the actuator size, shape, and monogram, were generally effective in improving usability for participants with higher level of impairment.
- **Inclusivity**: The findings highlight the importance of inclusive design that accommodates users with different ability levels, ensuring ease of use and comfort.

3. Ranking of Perfume Bottles in Each Area

- Opening
  1. Rare Beauty
  2. Control 1
  3. Control 2
  4. Control 3
- Spraying
  1. Rare Beauty
  2. Control 1
  3. Control 2
  4. Control 3
- Holding
  1. Rare Beauty
  2. Control 1
  3. Control 2
  4. Control 3
- Comfort
  1. Rare Beauty
  2. Control 1
  3. Control 2
  4. Control 3

Selection Rationale for Control Bottles

The three control bottles were selected based on their relevance and diversity in design features within the fragrance industry. Control 1 was chosen for its market popularity and widespread consumer recognition. Control 2 was selected for its distinctive bottle shape, which offered a unique ergonomic profile. Control 3 was included due to its unconventional spray mechanism, providing a contrasting usability experience. All control bottles were comparable in size and general design characteristics to Rare Beauty, allowing for a balanced and meaningful comparison across usability domains.

Key Insights

- Rare Beauty consistently ranked highest across all usability categories-opening, spraying, holding, and comfort-indicating it was the most preferred bottle in terms of accessibility and user experience.
  A statistically significant preference for Rare Beauty was observed ($p = 0.0249$), based on a chi-square test.
- Participants with moderate to severe impairments showed a marked preference for Rare Beauty, suggesting its design features were particularly effective for individuals with higher levels of physical limitation.
- Participants diagnosed with stroke and spinal cord injury also favored Rare Beauty, highlighting its accessibility benefits for users with specific neurological and motor impairments.