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The Effect of Inclination on the Perceived Usability of Washing Machine Interfaces

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***Abstract*—**Usability is significantly influenced by the perceptual characteristics of interfaces. This study investigates the effect of the inclination of elements in a physical interface on the evaluation of perceived usability. In the first experiment, a psychophysical methodology was employed to measure the perceived usability of 15 different washing machine interfaces. A model of perceived usability was adopted, which incorporates four factors: understandability, ease of use, safety, and attractiveness. The results indicate that participants were able to discriminate between the stimuli based on the factors considered. In the second experiment, the inclinations of the interface elements (buttons, LEDs, icons and text labels) were systematically modified. The findings reveal that inclination significantly affects three perceived usability subcomponents: understandability, ease of use, and attractiveness.

***Keywords*—**Perceived usability, perceptual properties interfaces, inclination, washing machine.

I. Introduction

IT s a well-established fact that, in product design, the choice of perceptual properties of interfaces has a considerable influence on the perceived usability of the products themselves. This influence also has a significant impact on actual usability [1]-[3]. For example, color in interfaces can improve user interaction performance [4]. Several studies have investigated the influence of colors on the usability of web design [6]-[9]. For instance, it has been shown that websites with triadic color schemes are more usable than those with non-standard color schemes [6]. Other studies have explored the impact of website color on users' cognitive processes. Bonnardel et al. [10] demonstrated that color affects website navigation, information storage, and retrieval. This finding aligns with other research [11], which highlights the effect of text/background color contrast on readability, retention, aesthetics, and behavioral intention. Specifically, increasing the level of color contrast enhances readability (see also [12]). Mugge and Schoormans [13] also examined the influence of color on perceived usability. Using washing machines and digital cameras as stimuli, they found that the degree of novelty is closely related to color. Their results revealed that products with a high level of novelty appeared more difficult to use. Another study on the effect of lightness contrast on user responses in washing machine interfaces was conducted by Sinico [14], who demonstrated how lightness contrast influences the perception of interface attractiveness.

The effect of other visual properties on usability has also been studied. For instance, graphical object size influences task completion times [5], demonstrating that the size of items included in graphic structures significantly impacts the efficiency of interface use. In a further investigation [15], the manipulation of the shape of an electronic phonebook simulator revealed that perceived usability was positively influenced by the aesthetics of the product. When studying the apparent usability of mobile phone interfaces, Seva et al. [16] varied several variables, including body shape (regular-asymmetric), number button arrangement (close-widely spread), display area (big-small), and length-to-width ratio of the body (high-low). Their findings confirmed that product properties related to form are crucial for eliciting strong affective responses and perceptions of usability, particularly those directly tied to functionality and aesthetics. Many studies in the literature highlight the effect of curvature versus angularity in product design. The pioneering research by Kastl and Child [17] on typography demonstrated that round letters are perceived as more pleasant than angular ones. Beyond typography, curvilinear forms in products and spaces have the potential to induce feelings of joy, harmony, and well-being [18]. These forms are also perceived as pleasant and stress-reducing [19]. Bar and Neta [20] explored preferences for curved shapes using both abstract shapes and images of familiar objects, which were modified to appear more or less angular. Their study also employed functional magnetic resonance imaging to measure activity in the amygdala [21]. Significant bilateral activation in the amygdala for acute-angled shapes supports the claim that angles are automatically associated with threat. Furthermore, a universal preference for curvatures has been demonstrated through cross-cultural comparisons [22], [23].

A perceptual variable that has been little studied but is nonetheless interesting from a design perspective is inclination. Inclination is relevant because it has functional effects documented in the literature and discussed, among others, by Arnheim [24]. Arnheim argues that inclination directly affects visual weight—an effect that cannot be explained semantically or by referencing past experiences, as these effects are perceived even in the absence of prior exposure. The variable of lightness is also highly relevant to the perception of products. For example, research on mobile phones by Van Rompay et al. [25] demonstrated that lightness significantly influences price expectations.

In the present research, two experiments were conducted to investigate the effect of the inclination of elements in a physical interface on the evaluation of perceived usability. The term "perceived usability," often defined in the literature as

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"apparent usability," is a complex construct that encompasses several subcomponents. In this research, the perceived usability model considers the following four components:

1. *Perceived understandability*: Defined as the user's ability to translate the information provided by the artifact into effective and efficient actions.
2. *Perceived ease of use*: Defined as the result of multiple subcomponents, including efficiency, effectiveness, and comprehensibility of use.
3. *Perceived safety*: Refers to the user's sense of safety while interacting with the artifact.
4. *Attractiveness*: Concerns the positive tension, as a perceptual valence, that the artifact elicits in the user, which is connected to the user's willingness to engage with the artifact.

Fig. 1 Three examples of interfaces used in Experiment 1

II. General Method

A. Participants

The participants included 50 volunteers (25 females and 25 males), aged between 18 and 76 years, all with normal or corrected-to-normal vision.

B. Apparatus and Stimuli

The presentation of stimuli and the recording of responses were managed using the PsychoPy software. The stimuli consisted of 15 images (see examples in Fig. 1), each with the longest side subtending a visual angle of 16°. The images were displayed at the center of a computer screen with a resolution of 1024 × 748 pixels.

C. Procedure

At the beginning of the experiment, each participant was seated in front of a screen and received oral instructions. A 7-point rating scale was displayed below the stimuli. Using a mouse, participants rated four usability determinants: (i) understandability, (ii) ease of use, (iii) safety, and (iv) attractiveness of the interfaces. The ratings were completed across four separate, randomized sessions. Each trial was presented to participants in an individually randomized order.

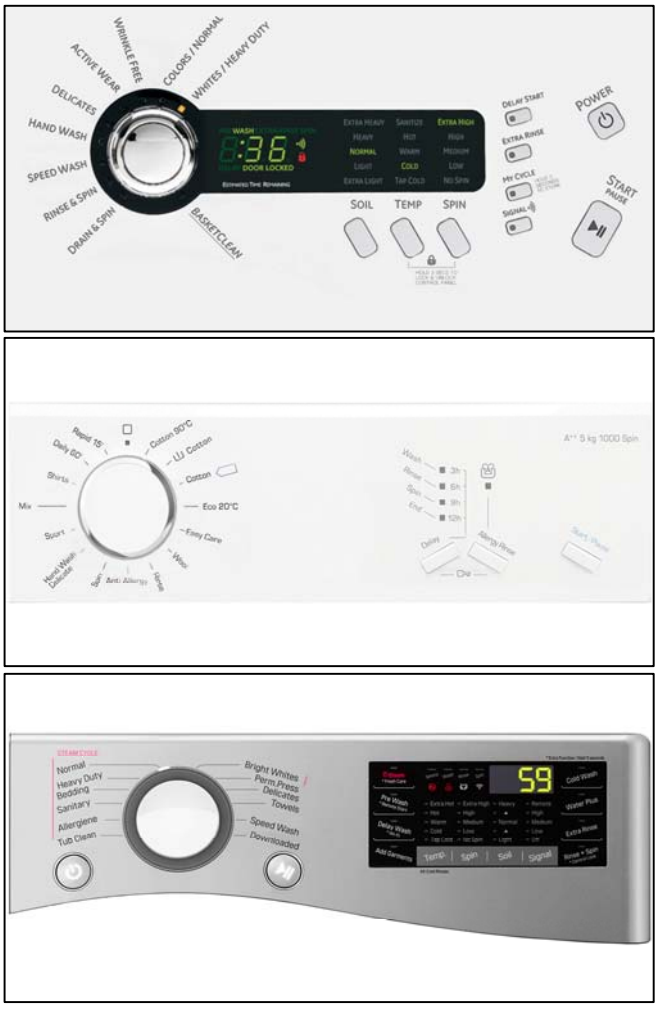

Fig. 2 Stimuli used in Experiment 2; some elements of the interfaces are inclined

D. Data Analysis

A multivariate analysis of variance (MANOVA) was conducted with four dependent variables: (i) understandability, (ii) ease of use, (iii) safety, and (iv) attractiveness. This

analysis was performed to assess the effect of inclination on the four subcomponents of perceived usability.

III. Experiment 1

The first experiment aimed to measure the perceived usability rating of 15 different interfaces of washing machine.

A. Results

The results are shown in Fig. 3. The analysis of variance revealed that the main effect was significant, $F_{(1, 14)} = 10.98$, $p < .001$, $\eta p2 = 0.45$. This finding indicates that, in the evaluation of perceived usability across the four aggregated subcomponents, the different models of washing machine interfaces were rated significantly differently. In other words, participants identified varying levels of perceived usability across the different washing machine models.

IV. Experiment 2

The second experiment was identical to the first in every way except that the interfaces had been manipulated by modifying the tilt of certain elements (see Fig. 2). None of the participants (50 volunteers: 22 females and 28 males, aged 18–67) had participated in the first experiment. The goal of the second experiment was to test the effect of the inclination of elements.

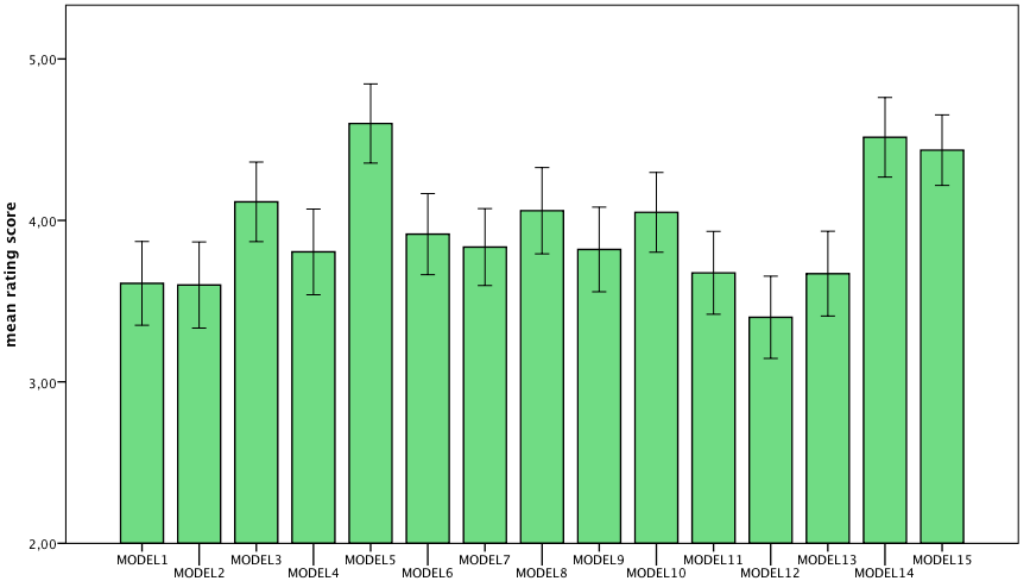

Fig. 3 Results of Experiment 1: Mean values of the ratings for the four aggregated perceived usability subcomponents are reported on the ordinate; the 15 models of washing machine interfaces are listed on the abscissa; the error bars represent standard errors

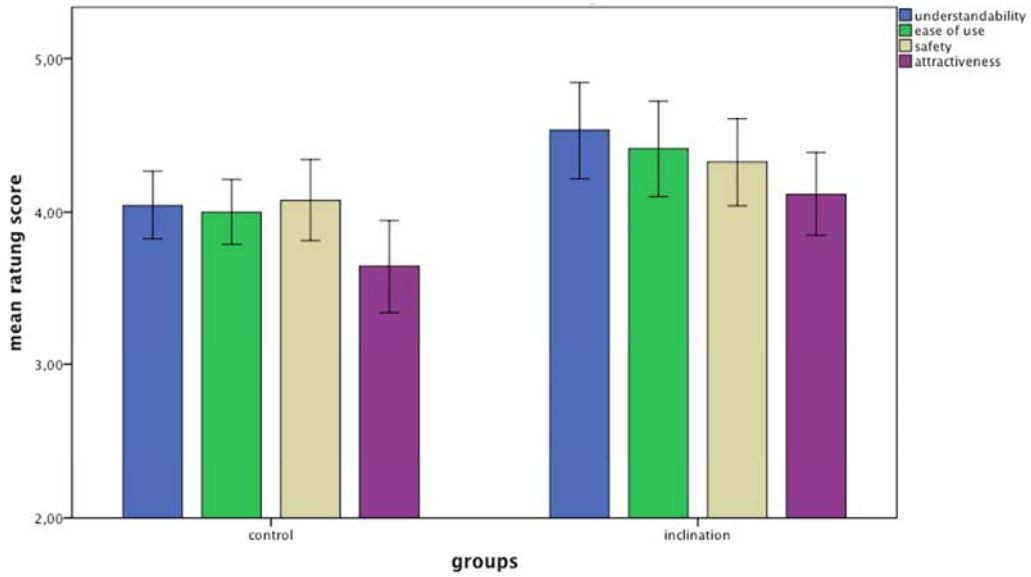

Fig. 4 Results of Experiment 2: Mean values of the ratings for the four subcomponents of perceived usability: understandability, ease of use, safety, and attractiveness; on the abscissa, the ratings of the control group are shown on the left, and the ratings of the group who were presented with interfaces containing some tilted elements are shown on the right; the error bars represent standard errors

A. Results

Fig. 4 shows the results of Experiment 2. The MANOVA revealed significant differences between the control and manipulated conditions for three of the four subcomponents: *understandability* ($F(1, 98) = 6.57$, $p < .05$, $\eta p^2 = .063$), *ease of use* ($F(1, 98) = 4.82$, $p < .05$, $\eta p^2 = .047$), and *attractiveness* ($F(1, 98) = 5.47$, $p < .05$, $\eta p^2 = .053$). However, no significant difference was found for *safety* ($F(1, 98) = 1.67$, $p = .21$, $\eta p^2 = .017$). These results indicate that manipulating the inclination of the elements does not affect perceived safety but does enhance perceptions of understandability, ease of use, and attractiveness.

V. Conclusions

The results of this study demonstrate that the inclined design of interface elements (buttons, LEDs, icons, and text labels) significantly improves perceived understandability, ease of use, attractiveness compared to the straight design. This primarily suggests that the visual orientation of elements is not merely an aesthetic choice but plays a crucial role in user experience, influencing cognitive perception and ease of interaction.

Explanatory hypotheses can be made regarding the perceived understandability and ease of use. Buttons, LEDs, and especially text, may stand out more when inclined. This observation aligns with Rosh's [26] research, which suggests that an object slightly inclined from its prototypical form may appear more salient to the observer, as this deviation acts as a signal of novelty or attention. The same observation also agrees with studies showing that inclined targets, among vertical distractors, are detected more quickly compared to the opposite, suggesting an advantage for oblique orientations [27].

At the same time, an aesthetic effect, meaning greater pleasantness, as confirmed by the higher attractiveness rating of the interface with tilted elements, could have an impact on perceived understandability and perceived ease of use. In this sense, it can be hypothesized that, as reiterated in the literature, "attractive things work better" [28]-[31]. Just as much as the impact can affect actual usability, it can also affect perceived usability.

These findings have important implications for the design of both graphical and physical interfaces, particularly in contexts where simplicity and ease of use are critical, such as in medical devices, professional tools, or accessible technologies.

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