

The Influence of Different Hand Tool Designs on the Perception of Aesthetics, Ergonomics and Usability

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Abstract

The perception of products in terms of ergonomics, usability and beauty remains to be important issues in product design. A positive impression must be made for consumers. A product must be ergonomic and visually appealing in order for the product to be used safely and effectively. Therefore, understanding the perception of ergonomics, usability and aesthetics is an important issue for product designers. Apart from being visually appealing, the product must be perceived as ergonomic and usable, as the ergonomic design of hand tools may alleviate the occurrence of upper limb musculoskeletal disorders. In this study, the perception of ergonomics, usability and aesthetics were evaluated for an existing hand tool (R1) and a proposed design (R2). Questions related to ergonomics, usability and aesthetics were combined to form a survey. A sample of 50 undergraduates were chosen as the respondents. The results indicated that R1 was rated less visually appealing than the new design, R2. Participants perceived the new design, R2 to be more ergonomic and usable than R1. Furthermore, a weak correlation between perception of ergonomics, usability and aesthetics were observed for this study. In general, ergonomic design factors are hard to be perceived by consumers. Possible ramifications of this relationship are discussed in this paper.

Keywords: *usability, hand tool ergonomics, tongs, perception*

1.0 Introduction

Hand tools are commonly encountered; and it has caused our daily tasks to be performed with ease and effectiveness. The design of hand tools has a significant influence in the development of upper limb musculoskeletal disorders. By improving the ergonomic properties of hand tools the health of users and their job satisfaction might be positively affected (Kadefors et al., 1993). Hand tools have been ergonomically evaluated extensively by the following researchers (Chang et al., 1999; Fellows & Freivalds, 1991).

Any hand tool design must consider the users' limitations, and provide a right fit for the users. Tongs are not excluded from these requirements. This study looks at hand tool designs, namely tongs. Tongs are often used to handle hot objects. A typical example would be in metal forming industries where workers need to use tongs to retrieve workpieces from ovens. Ideally, the tong should be able to grasp objects easily, with a minimum amount of gripping force. In reality, many people may find tongs to be awkward to use as the ability of tongs to grasp objects are generally poor. In addition, workers may use tongs to retrieve workpieces from machines. Tongs are essential in removing the need from reaching into hazardous area of machines.

Undesirable tong design may lead to low user acceptance of tongs, which can lead to catastrophic accidents. Initially, the hand tool must be perceived to be usable, ergonomic and visually appealing in order for the users to benefit from the tools. In this study, the perception of ergonomics, usability and aesthetics will be assessed for two different tool designs, R1 (traditional tong design) and R2 (proposed design alternative).

2.0 Background

2.1 Perception of hand tools

The way that consumers or users perceive a product has a significant impact on the success of a particular product. Perception, as defined as "... the process of attaining awareness or understanding of the environment by organizing and interpreting sensory information." (Pomerantz, 2003). Certainly, the value of perception cannot be underestimated as first impressions of a product will be etched on the user's mind for a long time. Perception is strongly related to aesthetics. Visual aesthetics remains to be one of the important characteristics that influence buying decisions when selecting from a variety of products (Bloch 1995).

The rest of the judgments about the product come from the first initial impression that the product makes to the user (Bloch et al 2003). According to Norman (1988), ease of use impressions may be made by the product appearance itself. A mismatch between the user perception and the actual performance of the product may be detrimental to the product's future success and survival as the connection between the consumer perception and the actual performance of products is a domain that has yet to be fully understood.

2.2 Upper limb disorders and hand tool ergonomics

The ergonomic characteristics of hand tools can never be underestimated as it has been proven that there is a connection between the design of hand tools and the occurrence of upper limb disorders (Aghazadeh and Mital, 1987; Chao et al., 2000). An upper limb musculoskeletal disorder (ULD) is chronic in nature, and it occurs gradually over time. Several causes of ULD are; repetitive tasks, forceful exertions, vibrations, or sustained or awkward positions. ULD is the general term that is used to describe any disorder experienced in upper limbs. ULD also is used to describe the types of tissue injuries such as carpal tunnel syndrome and tennis elbow. An overuse syndrome is also associated with ULD. Examples are work associated activities such as using keyboard and mouse. The term includes a group of disorders that most commonly develop in workers using excessive and repetitive motions of the head and neck extremity. The other causes of ULD are remaining in a fixed postures and poor workplace ergonomics. ULD happens when excessive and repetitive motions, coupled with high forces are exerted by the upper limbs. ULD may cause disability, to workers, resulting in loss productivity and other serious consequences. Recovery from ULD may take years, and even then complete recovery may not be possible. The most effective intervention that takes place would be workplace redesign. As the old saying goes, prevention is better than cure, therefore the design of hand tools are of paramount importance.

2.3 Usability

Usability, as defined by Shackel (1991) is “the capability to be used by humans easily and effectively”. Other definition includes the one by ISO, which defines usability in terms of three dimensions, effectiveness, efficiency, and satisfaction, whereby the users can achieve their desired goals in particular environments (ISO, 1998). In the context of physical products, ease of use, effectiveness, efficiency and satisfaction are the important characteristics that needs to be met in order for a product to be successful in the market. Fewer errors will be made with a usable product or system, and a task can be performed reliably as well. A product with high usability will be easier to learn and ultimately, with the combinations of effectiveness, efficiency, ease of use, the product would be more satisfying for the users.

3.0 Methods

3.1 Materials

As there are many types and designs of tongs in the market, it is difficult to narrow down exactly the best tong design as that will depend on the type of objects being handled, and the nature of the task itself. Therefore, instead of evaluating every single type of tong, a particular type of tong was chosen to be evaluated (Figure 1). R1 is used in a materials engineering lab, where round, cylindrical steel specimens ranging from 2-3 cm in diameter, and 1 cm in height are handled. Sometimes, R1 is used to handle semi circular work pieces with the same diameter and height. Figure 2 shows the proposed design. In the proposed design, instead of having a single tool, the proposed design has two parts, a tray and a gripper. The tray is specially designed for the gripper to securely hook the tray. In this way, instead of directly gripping the workpiece, the workpiece would be placed on the tray and the tray would then be inserted into the furnace or oven using the gripper.

3.2 Assessment method

The proposed design (R2) and the existing design (R1) were evaluated in terms of ergonomics and usability using a questionnaire that consisted of several questions listed in Figure 3. Participants were shown the pictures of R1 and R2 in the questionnaire. Based on the pictures, the questions in Figure 3 were rated using a Likert type scale, ranging from 1 (least agreeable) to 6 (most agreeable). The neutral option was discarded to prevent participants from taking a neutral stance. While at the same time, the aesthetics aspect of the proposed design and the existing design were evaluated using a scale from 1 to 10, where 1 indicates least beautiful and 10 the most beautiful. The questionnaire was distributed to 50 students. The pictures of R1 and R2 were included in the questionnaire. The responses for each of the questions were then converted into agreement/disagreement percentage ratings, where responses from 1 to 3 were treated as a “disagreement”, and responses from 4 to 6 were treated as an “agreement”.

4.0 Results and Discussion

4.1 Evaluation results

The instrument used in this study (Figure 3) is fairly reliable, with a Cronbach alpha rating of 0.80. From Table 1, the agreement ratings are shown for R1 and R2. 72% of the respondents agreed that R2 will accomplish task more quickly than R1 (64%). This is also shown in the ratings for productivity, where 80% of the participants agreed that R2 will help them to increase productivity compared to R1 (66%). Productivity increase can be associated with a quick task accomplishment, and this is clearly evident in the results. The ratings for numbness and peak pressures on the hand are fairly consistent, where 64% of the respondents agreed that R1 will cause peak pressures on the hand compared to R2. The ratings for numbness did not exhibit that much difference, since perceiving numbness from pictures can be rather difficult (54% for R1 vs 50% for R2).

Other ratings given by the participants indicated their preference for R2 design. The statements “easy to operate tool” and “easy to perform handling task” were rated slightly different from each other, although the meaning of the question is quite similar. For the statement “easy to operate tool”, R1 was rated at 82% vs 84% for R2, in which the difference was very slight (2%). Whereas, in the statement “easy to perform handling task” a rating of 66% was given for R1, and 78% for R2. Perhaps, in the statement “easy to operate tool” was more ambiguous in its meaning, so the rating difference was small compared to “easy to perform handling task”, which indicated a bigger difference in the ratings. Questions concerning grip force supply and force transmission yielded a similar pattern; R2 is favored more by the participants, where 70% of the participants believed that R2 would require less gripping force compared to R1 design (58%). This is due to the fact that R2 has special hooks at the end that can be inserted into the sides of the tray allowing for a more secure grip compared to R1, where the grip force required for handling R1 would depend on the type of object being handled.

4.2 Ratings of aesthetics

The aesthetics rating for R1 and R2 were collected from the participants as well. From the pictures given to them, they had to gauge the beauty of the proposed design (R2) and the old design (R1). R2 was perceived to be more visually appealing, compared to R1. The mode rating for R1 was at 5 out of 10, while for R2 is at 7 out of 10. The influence of aesthetics on consumer buying decisions cannot be underestimated. Previously, the design of goods was only focused on the functionality aspect, and not on the appearance of the product. There has always been the tension between function and form previously in the past, where the function of a product is stressed more than the appearance of the product.

In the past, the designs of products were mostly devoid of any visual appeal. Two individuals, Loewy and Dreyfuss introduced the importance of visual appeal into mass produced commodities, as well as a marketing tool to gain competitive advantage. Ever since then, aesthetics appeal becomes an important priority for product designers. From the common household appliance, to highly sophisticated machinery, aesthetics remains to be of an utmost importance; until Norman (1988, 1992) pointed out that the importance of aesthetics has outgrown the importance of usability.

In the field of usability, a significant correlation is noted between beauty and usability, as supported by a phenomenon of social psychology “what is beautiful is good” (Hassenzahl, 2004; Tractinsky et al, 2000). Tractinsky’s study demonstrated a relationship between aesthetics and usability. Intuitively, one would generalize the findings of Tractinsky into hand tools. However, the correlation between perceived ergonomics ratings and perceived aesthetics for this study is very weak ($r= 0.229$). It is possible that the concept of perceived ergonomics and usability are two distinct constructs; but the similarities of the two remains, where the focus of ergonomics and usability is to improve the interaction between humans and machines. Since the participants evaluated only on the perception of ergonomics, it is highly possible that the perception of ergonomics has no connection with the aesthetics of a product.

The weak correlation between product aesthetics and the perception of ergonomics may be explained by the difficulty in perceiving ergonomic features. Ergonomic features are hard to perceive, for example grip force requirement and handle length. These two features can only be measured by physically touching and holding the tool itself. However, their understanding of product aesthetics does not need any further clarification. Consumers do know what a visually appealing product is by just looking at the product. On the other hand, there is no complete theory or model that can accurately predict how consumers come to perceive a product to be visually appealing or vice versa.

In light of the findings of this study, Helander (2003) pointed out that people are able to distinguish features of aesthetics and comfort, but they have difficulty in distinguishing ergonomic factors in chair designs. Helander's findings seem to support the results of this study where the perception of ergonomics and usability is weakly related to aesthetics. Furthermore, consumer's perception of ergonomics and usability will definitely depend on their prior knowledge of ergonomics and usability, but even then assessing the perception of ergonomics and usability may be an arduous task for users with some knowledge in ergonomics and usability. Without holding or handling the tool physically, consumers may not be able to distinguish ergonomic and usability features inherent in a certain product. Bearing this relationship, consumers may be driven purely by aesthetic considerations when buying hand tools or any other products. On the other hand, consumers with ergonomic knowledge may be more particular when purchasing hand tools.

Although, there is no connection between perceived ergonomics, usability and aesthetics as demonstrated in this study, good ergonomics is a pre requisite for a sense of well being, relief and satisfaction (Helander, 2003). Products with excellent visual appeal, but with poor ergonomics and usability will ultimately suffer in the long run. The solution is to integrate ergonomics, usability and aesthetics into one package for the future success of any product in the marketplace.

5.0 Conclusion

The study has shed some light into the relationship between perceived ergonomic, usability and product aesthetics. As there has yet to be an established connection between perceived ergonomics, usability and product aesthetics, buying decisions may be purely driven by aesthetics considerations, thus this may lead to usability and ergonomic problems in the future for consumers. Products that are deemed to be ergonomic and usable, has to convey that impression to the potential users. As there are a certain percentage of consumers purchasing products online, the products will have to convey the impressions of good ergonomics, usability, and aesthetics.

References

- Aghazadeh, F., & Mital, A. (1987). Injuries due to handtools: Results of a questionnaire. *Applied Ergonomics*, 18(4), 273-278. doi:10.1016/0003-6870(87)90134-7
- Bloch, P. H. (1995). Seeking the ideal form: Product design and consumer response. *The Journal of Marketing*, 59(3), 16-29.
- Bloch, P. H., Brunel, F. F., & Arnold, T. J. (2003). Individual differences in the centrality of visual product aesthetics: Concept and measurement. *Journal of Consumer Research*, 29(4), 551-565.
- Chang, S. R., Park, S., & Freivalds, A. (1999). Ergonomic evaluation of the effects of handle types on garden tools. *International Journal of Industrial Ergonomics*, 24(1), 99-105.
- Chao, A., Kumar, A., Emery, C. T. N. D., Nagarajarao, K., & You, H. (2000). An Ergonomic Evaluation of Cleco Pliers. *Human Factors and Ergonomics Society Annual Meeting Proceedings* (Vol. 441-442, p. 2). Human Factors and Ergonomics Society. Retrieved from <http://www.ingentaconnect.com/content/hfes/hfproc/2000/00000044/00000028/art00005>
- Fellows, G. L., & Freivalds, A. (1991). Ergonomics evaluation of a foam rubber grip for tool handles. *Applied Ergonomics*, 22(4), 225-230.
- Fellows, G. L., & Freivalds, A. (1991). Ergonomics evaluation of a foam rubber grip for tool handles. *Applied Ergonomics*, 22(4), 225-230.
- Hassenzahl, M. (2004). The interplay of beauty, goodness, and usability in interactive products. *Human-Computer Interaction*, 19(4), 319-349.
- Helander, M. (2003). Forget about ergonomics in chair design? Focus on aesthetics and comfort! *Ergonomics*, 46(13-14), 1306-1319. doi:10.1080/00140130310001610847
- ISO (1998). Ergonomic requirements for office work with visual display terminals (VDTs)-Part 11: guidance on usability—Part 11: guidance on usability (ISO 9241-11:1998).
- Kadefors, R., Areskoug, A., Dahlman, S., Kilbom, A., Sperling, L., Wikstrom, L., & Oster, J. (1993). An approach to ergonomics evaluation of hand tools. *Applied Ergonomics*, 24(3), 203-211.
- Kilbom, A., & Ekholm, J. (1991). Handgreppsstyrka (Hand grip strength, Swedish with English summary). *Stockholm MUSIC study group, Stockholm, Sweden*.

- Kodak, E. (1983). *Ergonomic design for people at work*.
- Konz, S. (1995). *Work design: industrial ergonomics*. Publishing Horizons, Scottsdale, Ariz.
- Napier, J. R. (1956). The prehensile movements of the human hand. *Surger*, 38(4), 902–913.
- Norman, D. A. (1988). *The psychology of everyday things*. Basic books.
- Norman, D. A. (1992). *Turn signals are the facial expressions of automobiles*. Addison-Wesley Longman.
- Park, S., & Freivalds, A. (1999). Ergonomic evaluation of the effects of handle types on garden tools. *International journal of industrial ergonomics*, 24(1), 99–105.
- Pomerantz, James R. (2003): "Perception: Overview". In: Lynn Nadel (Ed.), *Encyclopedia of Cognitive Science*, Vol. 3, London: Nature Publishing Group, pp. 527–537
- Shackel, B. (1991). Usability-context, framework, definition, design and evaluation. *Human factors for informatics usability*, 21–37.
- Tractinsky, N., Katz, A. S., & Ikar, D. (2000). What is beautiful is usable. *Interacting with computers*, 13(2), 127–145.



Figure 1: The existing tong design available (R1)

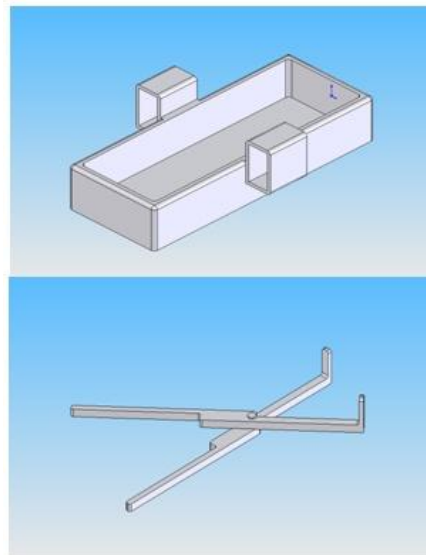


Figure 2: Proposed alternative design (R2)

1. Using this tool in my job would enable me to accomplish tasks more quickly
2. Causes peak pressures on the hand
3. Using this Tool in my job would increase my productivity
4. This tool causes numbness on my hand
5. Learning to operate this Tool would be easy to me
6. The tool will promote a comfortable hand posture.
7. The tool handle feels slippery
8. Needs low hand grip force supply
9. Has a nice-feeling handle
10. I would find it easy to perform handling task
11. I would find this Tool easy to use
12. Using this Tool would enhance my effectiveness on the job
13. Has a good force transmission

Figure 3: List of questions

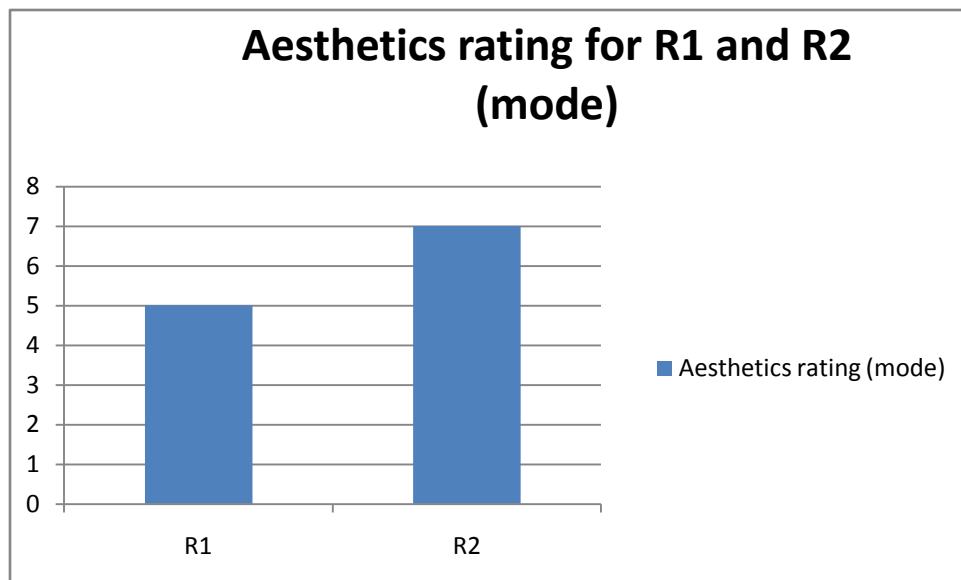


Figure 4: Aesthetics rating comparison between R1 and R2

Questions	R1	R2
Accomplish task quickly	64.00%	72.00%
Causes peak pressure on hand	64.00%	48.00%
Increase productivity	66.00%	80.00%
Causes numbness	54.00%	50.00%
Easy to operate tool	82.00%	84.00%
Comfortable hand posture	54.00%	70.00%
Feels slippery	62.00%	54.00%
Low hand grip force supply	58.00%	70.00%
Has a nice feeling handle	52.00%	60.00%
Easy to perform handling task	66.00%	78.00%
Tool easy to use	76.00%	76.00%
Enhance my effectiveness on the job	68.00%	86.00%
Has a good force transmission	66.00%	72.00%

Table 1: Agreement ratings for R1 and R2