The Differences between Subjective and Objective View of Linking PC Connectors

Yung-Hsiang Tu*, Chih-Fu Wu**, Yu-Hsiang Wang***, Hsin-Ting Chung***

*Assistant Professor, Department of Industrial Design, TATUNG University
**Associate Professor, Department of Industrial Design, TATUNG University
***Graduate student, Department of Industrial Design, TATUNG University
Taipei, Taiwan, e-mail: tys@ttu.edu.tw

Abstract: The tasks of linking PC connectors to a computer were studied in the Bother-study and the Solution-study; and each study was accomplished with subjective questionnaire and objective test. From 59 questionnaires in Bother-study, the ANOVA test found that the larger bother connectors to the users were USB-B, PS2; and the Mini-USB, VGA the second. At the objective test, 20 subjects were asked to plug the randomized 8 connectors into a wall in blindfolded situation, the paired comparison showed that the mean error-linking frequency were: Mini-USB>PS2>others; and the mean linking time were: Mini-USB, PS2>others. Four possible designs (Shape-idea, Dot-idea, Color-idea, and Hook-idea) which summarized from the Bother-study for improving the larger bother connectors (USB-B, Mini-USB, VGA, and PS2) were verified in the Solution-study. The ANOVA test found that the Dot-concept was considered to be the best solution in 134 questionnaires. Two types of Dot-idea with 1mm, 2mm dot height were proposed to 56 subjects for them to test the linking effect. The mean linking time were reduced for USB-B, Mini-USB and VGA but raised for PS2; the mean error-linking frequency were reduced for Mini-USB, but raised for the PS2. According to the results, the Dot-concept might be most suitable to the Mini-USB connector. The details of these different viewpoints were discussed in the end of this article.

Key words: PC connector, subjective opinion, objective test, Industrial design, connector linking task.

1. Introduction

In our daily life, there are a number of tasks that we have to face under faint light or no light condition, such as to search a flashlight on the black out situation, or to link connectors on the back or side of a computer by hands. On the condition like that, the perception about the surroundings from our sensors will be severely affected and certainly the decision of our following actions will be changed. Most of us have to use the sense of touch combines with the hearing; smell and taste to explore all of the clues surround us, and then vamp up all the information to make a decision for the next action. Facing the situation of no light, preexist experience on the task will be a contraposition to us for decision making. The subjective impressions for that situations are varied from person to person, and it might be hard to study the effects of the preexist thought under such situations. Normally the study about human performance can be categorized into two ways of methods, objective and subjective method. Researchers mentioned that the objective judgments are considered if they are used to reflect

the characteristics of an object being judged, and the subjective judgments are made when they are meant to reflect the attitudes and preferences of the observer confounded with the object's characteristics (Muckler and Seven, 1992; Gorenflo and Crano, 1989; Olson, Ellis, and Zanna, 1983). In order to know better of human performance issues (such as workload; fatigue; comfort; usability; etc.) researchers preferred to adapt both methods in order to have the objective evidences and subjective opinions from the participants. In most of these works, the objective measures were gathered by timer or other proper equipments and the subjective opinions were commonly collected from questionnaires.

There were many researchers concerned with whether subjective and objective measures tell a consistent story or not (Wierwille, Rahimi, and Casale, 1985; Derrick, 1988; Rehmann, Stein, and Rosenberg, 1983) at the workload issues. And these reports showed that subjective measures of workload do not consistently agree with performance-based measures well. Annett (2002) thought that the conscious experience may be described as a process of cognitive appraisal of the demands of the task and environment on the resources of the individual to be used in conjunction with aims and intentions to control the choice of strategies. So the subjective opinions by different subjects might tell the different 'face' of the rated object as the objective measures found, even though all of the data came from the same subject. There were many papers conducted both two methods with different measures for their study purposes, for example Kuijt-Evers et al. (2007) studied the performance of handsaws with comfort and discomfort measures (subjective view), compared with the EMG, contact pressure, and productivity (objective view). Their results showed that only the 'contact pressure' measure could be a good predictor on 'discomfort' but not on the 'comfort' experience of the subjects. Kim and Han (2008) conducted a study for developing a usability index which used the DVD player as a case study, and they found that subjective rating (subjective view) had a high correlation with the usability index (objective view). After an investigation of six computer keyboards, Rempel et al. (2007) advised that subjective rating should be taken with caution because the subjects were likely to select the designs which they were most familiar. Even so, as Sauer and Sonderegger (2009) mentioned, in the practical research the subjective opinions were usually collected for knowing the subjects' *satisfaction* or *attitude* about the rating product; and the *effectiveness* and *efficiency* were the major performance aspects of a product. Further on, the ISO standard (ISO 9241-11) had referred the three aspects as the usability tests to measure the user-product interaction.

In this paper, the subjective view and objective view methods were both investigated which the issue was the tasks of linking PC connectors to a computer. These tasks were largely performed by the consumers in their daily life. And the bother of error-linking, such as to turn the USB connector upside down in a few times for correctly link, were happened frequently but were not mentioned or claimed by the users. This was only possible because the users were customary in the few times of error-linking. As we know that each PC connector has its own mechanism on avoiding error-linking in order to keep the computer safe. But in these current ways, the user has to look straight at the socket to decide which side of the connector needs to be up to correctly plug it into the right socket. As you might see that sometimes the user had to reach to a socket only by his one hand for connecting some devices, to use only the sight to do such task might not be convenient for the user under the circumstances. The sensation of touch is then employed and challenged to gather information by exploring the invisible board in the backside of the computer. This is somewhat a little bother or a big trouble to different users. Never the less that users often have to try it out for more times in linking new standard connecters into the computer because the sockets are smaller ever than before which designed in the view of 'small size represent the new technology'.

Many studies have discussed the ability of our fingers, most of the studies towards to find the limitations of our sensation. Lowenfeld (1973) proposed that there are three limitations in the tactile perception and touch identification: (1) Experience and types of past, (2) touch mode, (3) interaction with the environment. There are two perception models in the fingers, one is Passive touch, which is the subject's hand is fixed and the object moved to touch the subject's finger and the subject is asked to respond the perception by oral or by other equipment. The other type of touch is the Active touch, which the subject actively touch the object and responses. Gibson (1962; 1966) also studied the differences between Active touch and Passive touch in his experiment, and they found that these two sorts of studies in touch might have the same sensitivity of perception. Lederman (1981; 1983), Kennedy (1993; 2003), Morley (1983) and Ekman (1965) observed the effect between the surface roughness of objects and the touch performance in a passive linear movement test, they believed that active touch was suitable for research applications, because the tactile feeling of object roughness is similar both in active touch and passive touch. The active touch is employed in the tasks of linking connectors because the sensation of all fingers is needed while one had to find out the direction for the connector to plug it into the right socket.

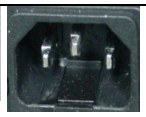
There were two parts of studies in this paper, and each of the two parts preceded a subjective questionnaire and an objective experiment. Firstly, the Bother-study was intended to see the differences between the subjective view and objective experiment in the issue of linking 8 PC connectors. Secondly, the Solution-study was prepared for understanding the differences between the subjective view and objective test with 4 proposed designs for the larger bother connectors.

2. Methods and Results

2.1 Bother-study

In order to see the bother of the linking tasks, our research team investigated the connectors under the current PC specification in the market and found that those 8 connectors (Mini-USB, Mic., PS2, VGA, USB-A, USB-B, Net), were frequently mentioned and included in a standard PC. In this **Table 1**, the paired connector and socket has its own way of preventing error-linking. When all of those sockets are put together on the backboard of a PC the user might have some bother on linking the paired connectors on the right sockets because some of them are similar not only at the shape but also at the size. But how much bother are the users felt? And which connector is the most bothered one? To understand what users might think of, a simple questionnaire was implemented to gather the subjective opinion of users in the Bother-study, and then a PC connector linking experiment was conducted in order to get the objective records from users.

Table 1 The 8 types of PC connectors in the Bother-study

Name	*Mini-USB*	*Mic.*	*PS2*	*VGA*	*Power*	*USB-A*	*USB-B*	*Net*
Socket								
Connector								

2.1.1 Subjective Questionnaire (1)

The subjective questionnaire was respond by 59 participants (university students recruited from TATUNG University), including 24 males and 35 females. They were asked to give their subjective opinions about the linking bother of those 8 connectors, in **Table 1**, in which the value from 1 till 6 represented the bother levels from 'extremely low, very low, low, high, very high, extremely high'; and the value '0' represented the level of 'no bother'. The ANOVA test showed that the mean bother score among those 8 connectors were significantly different, F (7,464) =18.720, p<0.001, and the *LSD* showed that those mean scores could be grouped into three groups (PS2, USB-B > Mini-USB, VGA > USB-B, Net, Mic., Power), see **Figure 1**.

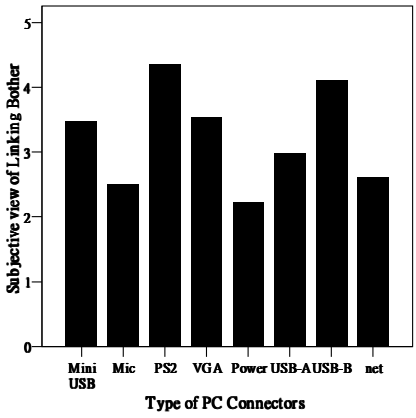


Figure 1 the plot of mean bother score in the Bother-study

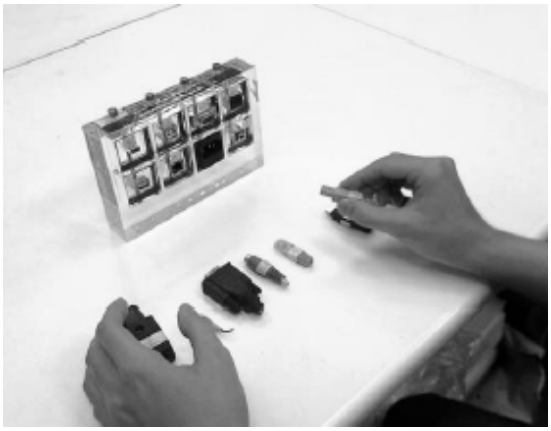


Figure 2 the environment for the objective test

2.1.2 Objective Experiment (1)

After the subjective questionnaires finished, the objective test was conducted for the comparison with subjective opinion of users. There were 20 students recruited from the Graduate School of Industrial Design in TATUNG

University, 10 males and 10 females, they had no injury on their hands and fingers reported by them. The subjects were blindfolded and were told to insert the 8 connectors one by one in a randomly assigned order into a simulated fixed PC backboard, see **Figure 2**. In this complete balanced experiment, the connector type was the independent variable; the error-linking frequency and the linking time were the performance variables recorded by the experimenter with video camera. The ANOVA test showed that the mean error-linking frequency among those 8 connectors were significantly different, F (7,152) = 5.402, p<0.001, and the *LSD* showed that the Power connector had the largest mean error-linking frequency, (Mini-USB>PS2>others), see **Figure 3 (left)**. At the mean linking time, the ANOVA test showed a significant evidence, F (7,152) = 4.297, p<0.001, that the Mini-USB and PS2 had the largest mean linking time, (Mini-USB, PS2>others), see **Figure 3 (right)**.

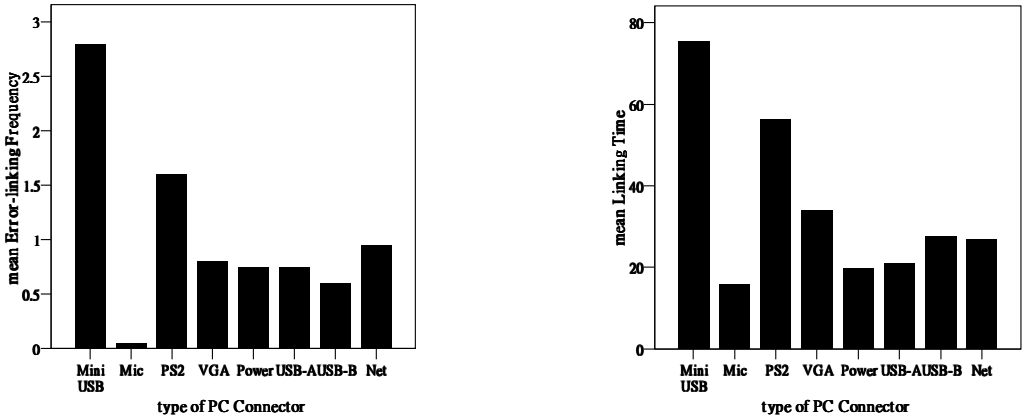


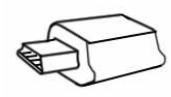
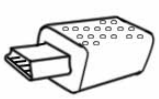
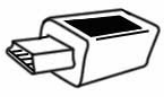
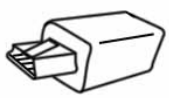
Figure 3 the plot of the mean error-linking frequency (left) and mean linking time (right) in the Bother-study

The objective opinions and the subjective experiment were compared and it was found that the USB-B, and PS2 connectors had the largest bother score and the Mini-USB, VGA the second in subjective response; and the Mini-USB and PS2 had the largest error-linking frequency and linking time in the objective test. In the next Solution-study, the authors decided to take the 4 larger bothersome connectors (USB-B, PS2, Mini-USB, and VGA) into account as the solution issue and developed some ideas for reducing the bother problem.

2.2 Solution-study

After several brain storming meetings, our design team decided to propose four ideas for those 4 bothersome connectors. Take the Mini-USB connector as example, see **Table 2**. The first idea, *Shape-idea*, was to reshape the form of the connector into the shape of its socket. It was supposed that if the shape of the Mini-USB connector was designed as a large Mini-USB socket the user might recognize the direction of the connector quickly by his first touch. The second idea, *Dot-idea*, was to add some small dots on the major side of the connector in order to hint the user that this side should be the top side to insert it into the socket. The third idea, *Color-idea*, was to make an obvious different in height with a bright color which differed from the connector itself on the major side of the connector. And the last idea, *Hook-idea*, was to add a paired of additional hooks on the major side of the connector and the paired face on the socket for the user to notice the paired position at the first insertion. In this Solution-study, the objective opinion and the subjective test were also applied. The subjective questionnaire was employed for understanding the preference of the respondents about the proposed four ideas. And the objective test was applied for testing which design performed better in a simulated linking task.

Table 2 the four possible ideas for reducing the error-linking problem (take USB-A connector as an example)

Solution idea	*Shape*	*Dot*	*Color*	*Hook*
Picture of the idea				
Design feature	Use the same shape of the socket.	Add some dots on the surface.	Make an obvious height with color.	Add a pair of hooks on the both parts.

2.2.1 Subjective Questionnaire (2)

In order to realize the objective opinions abut the four ideas from the users, a similar objective questionnaire as the one in the bother-study was employed. At this time, the respondents were showed a set of pictures that implemented each idea into the 4 most bothersome connectors and were asked to rate each idea on each connector. The question was that in the condition of the connector with one specific idea, how would they though the possibility of error-linking. A seven points Likert-scale which used the words of extremely low, very low, low, high, very high, extremely high and no comment, represented the score from 1-6 and 0 respectively, was accomplished. A total of 134 respondents (university students) who were selected from the different departments of TATUNG University replied this questionnaire. As the ANOVA test showed that the mean error-linking scores among the 4 different ideas were significantly different within each connector, all of the four *p* values were lower than 0.01. The *LSD* test showed that the Dot idea had the lowest mean error-linking in all connector types, **Table 3**, which meant that the 134 respondents tended to believe the Dot idea could be a better way of reducing the bother of linking connectors.

Table 3 the ANOVA test of the mean error-linking scores among the 4 different ideas within each connector.

Connector type	*F (3, 532)*	*p-value*	*LSD*
USB-B	34.457	< 0.01	Dot < Hook, Color < Shape
Mini-USB	5.624	= 0.01	Dot, Color < Hook, Shape
VGA	32.372	< 0.01	Dot < Color < Hook < Shape
PS2	24.461	< 0.01	Dot < Color < Hook < Shape

2.2.2 Objective Experiment (2)

In order to know whether the Dot idea was good for those larger bother connectors in reducing the bother of linking, the authors made two types of Dot idea, 1.0 mm and 2.0 mm in different height but in the same diameter of 2.0 mm and in the same pitch of 3.0 mm, for those 4 bothered connectors. There were 56 subjects (Graduate School students and university students) recruited from the same school, 28 males and 28 females, and they were asked to link the 8 PC connectors, 4 Connectors x 2 Dot heights, in a randomized order. The procedure of this subjective experiment was the same as the experiment in the Bother-study, but the sockets were rearranged before each linking task proceeded. Same as the experiment before in the Bother-study, the error-linking frequency and the linking time were recorded by a digital camera and counted by the experimenter after the tests had finished. The ANOVA test was employed to see the differences among the 2 types of Dot idea and among the 4 connectors in each measured variable. The result showed that there was no significant difference found at these two measured variables between the two Dot ideas. But there were evidences found among these four bothered connectors, F (3,444) =32.813, 35.747, p<0.001, at the mean error-linking frequency and mean linking time variable, respectively. The PS2 connector had the largest mean value at the two variables, and the VGA connector had the lowest ones, **Figure 4**.

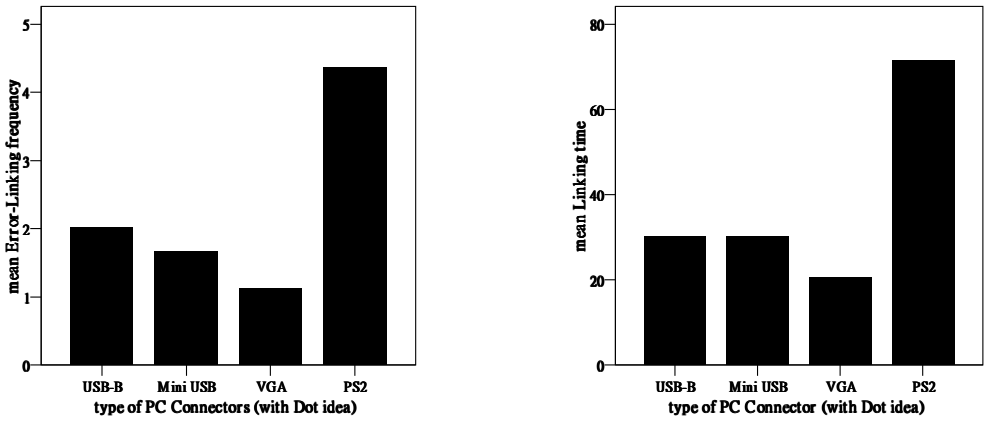


Figure 4 the plot of the mean error-linking frequency (left) and mean linking time (right) in the Solution-study

3 Discussions

3.1 Subjective view and Objective view

From the subjective questionnaires of Bother-study, the PS2 and USB-B had the largest bother score, followed by the Mini-USB and VGA connectors. But in the objective experiment the Mini-USB had the largest mean error-linking frequency, followed by the PS2; and the Mini-USB and PS2 had the largest mean linking time. So it

seemed that the opinions of users were insistent both in the objective view and the subjective evidence, the two views all showed the similar results that indicated the PS2 and Mini-USB were the most bothersome connectors to the users. As researchers, Sauer and Sonderegger (2009), said that the objective measurement should have two kinds of measures which were *Effectiveness* and *Efficiency*, and the subjective data should inform the *satisfaction* of the object from the subject. The 'error-linking frequency', 'linking time' and the 'bother level of the connector linking' were employed in this study, respectively. It seemed that the negative subjective question (linking bother) could be a proper substitute (or a sum up) measure of the objective test in the PC connector linking task.

In the Solution-study, though the Dot idea was the most preferred idea to solve the problem of linking bothers from those respondents, the results of the objective test showed that the Dot idea was not suitable for the PS2 connector because the linking time and the error-linking frequency were obviously raised when the Dot idea attached to the PS2 connector. It could be told that there were some differences between subjective view and object view in this Solution-study. On reading other research reports at the issue of the differences between subjective view and objective view, one of the important topics should be noticed that the equalization of those measured variables among subjective measures and objective variables. For example, Lee and Weng (1995) evaluated a handy tool the objective measures might be the 'posture data', 'performance time', 'success rate' and 'EMG responses', and the subjective measure for the participant are the questions of 'ease to grip', 'ease to maintain stability', and 'ease to complete the task'. These measures among two methods didn't mean the same thing at all, because in the insight of the subjects there might be a combination of many characteristics about the rated object. This could be the case of this study that make the two views differed. The subject was asked to rate 'the bother level' of each connector in the Bother-study, while in the Solution-study the question was to rate 'the level of error-linking possibility'. It might be the possible differential meaning of the words caused the inequality of rating.

To sum up the results which point to the two views, at the most time the users' opinions are consistent with the practical events in our case. It is a hint for designers that to have the opinions of users before starting to design is always a good policy. No matter the status of design is at realising design problem stage or at the solution verifying stage, it is helpful for the designer to raise a survey or a test to catch the users' though about the product or idea.

3.2 The 4 Connectors and the 4 Ideas

The shape and size of the connectors should be discussed to realize why the PS2, Mini USB, USB-B and VGA are the larger bother connectors. First of all, among these PC connectors the PS2 is the only connector which has round shape that users have to recognize the shape harder for his finger to catch the right angle before linking it into PC, so the connector has the largest bother score and larger linking time and error-linking frequency. Secondly, the Mini-USB is the smallest one in size that the finger could not tell the both sides for directly linking at the first sight. The third one, USB-B connector, has a rectangle shape which chamfered at two corners; this connector is thought to be the second bothered connector, but it is verified to be a lower bothered connector, see **Figure 3**. The last bother connector, VGA, has a large size and a specific mechanism for the user to link it into the PC socket and luck it on. The VGA has a similar situation with the USB-B connector because its bother score is high (subjective view) but the two measured variables in objective test are verified to be low. So it is proposed, by these results, to categorize the 8 connectors into three levels: the first level is the 'Good design' that a connecter which in both subjective and objective views is steady given good values, such as the Mic., Power, USB-A and Net; the second level is the 'False design' which a connecter has the inconsistent opinion in subjective and objective views, such as the USB-B and VGA; and the last level is the 'Bad design' that it is consistently valued to be bad in both views, such as the Mini-USB and PS2 connector. This phenomenon might be seen at many products in different designs but it is seldom argued by the consumers only because most of users found this kind of bother "several times" after they had already bought the product.

Though the four proposed ideas were not produced in this study except the Dot idea for the four most bothersome connectors, the subjective view had told the differences among these four ideas. The users preferred the Dot idea most and the Colour idea the second, and it seemed that the users wanted to have a clearly leading sign for them to catch the idea of insert direction that is the possible reason that these two ideas were significantly preferred than the Hook idea and Shape idea. While the Dot idea was most effective for the Mini-USB connector, all of the two measured variables were obviously reduced, and it also reduced the linking time of the VGA connector but not at its error-linking frequency, but it seemed that the Dot idea was not effective to the PS2 and USB-B connector at the error-linking frequency.

4. Conclusion and Suggestion

Through the Bother-study and the Solution-study each with subjective questionnaire and objective experiment in this paper, the authors propose a creative way of reaching much more insight of the users' thoughts. The comparisons between the subjective view and objective view will inspire the designers to catch the 'real' desire of users and develop a more precise product into the market. In this article, 8 PC connectors were survey and 4 ideas for reducing the bother of linking were also verified. The most bothersome connectors are the (PS2, Mini-USB, USB-B, and VGA) and the most preferred idea is the Dot idea which is to add a number of dots on the major surface of the connector to indicate the insert direction for the users. The way of adding dots on the surface is efficient depended on those 4 connectors, whether the location of dots or the design of the dots itself should be further developed.

The differences between subjective view and objective view in the problem of linking PC connectors showed that most of our thoughts about such problem come from the first image of the products, such thoughts might not be correct but it is prejudged. In our case, the bother of linking PC connectors was consistent between using questionnaire and by experiment. This might not be right all the time while discussing different problems. But it is a useful and a practical way to approach such problem in the manor of gathering the information both from subjective way and objective way, especially in a topic that normal people ignored or prejudged. The bother of Error-linking is such frequently happened in the daily life but by passed for their slightly effect on the main function of a product. This work highlights the issues that any problem causes only slightly bother should be taken into account from the end of the designer if it is neglected by the user.

Acknowledgment

This study was partially supported by the National Science Council (NSC97-2221-E-036-032-MY2) and TATUNG University (B97-D09-083), the authors would like to deliver our thanks for their fully support. This work was a scheduled research program of the Assistive Design Laboratory at the Department of Industrial Design in the TATUNG University, and it would be impossible of this achievement without the excellent teamwork from the research team.

Reference

[1] Annett, J., 2002, Subjective rating scales: science or art? *Ergonomics*, vol. 45, no. 14, pp 966-987.

[2] Derrick, W. L., 1988, Dimensions of operator workload, *Human Factors*, vol. 30, pp 95-110.

[3] Ekman, G., Hosman, J., and Lindstrom, B., 1965, Roughness, smoothness and preference: A study of quantitative relations in individual subjects. *Journal of E.xperimental Psychology*, vol. 70, no. 1, pp 18-26.

[4] Gibson, J. J., 1962, Observations on active touch, *Psychological Review*, vol. 69, pp 477-490.

[5] Gibson, J. J., 1966, *The senses considered as perceptual systems*, Houghton-Mifflin, Boston.

[6] Gorenflo, D. W. and Crano, W. D., 1989, Judgmental subjectivity/objectivity and locus of choice in social comparison, *Journal of Personality and Social Psychology*, vol. 57, pp 605-614.

[7] Kennedy, J. M., 1993, *Drawing and the blind*, (Ed.) Kilgour, A. R. & Lederman, S. J., New York.

[8] Kennedy, J. M., 2003, Drawing from Gaia, a blind girl, *Perception*, vol. 32, no. 3, pp 321-340.

[9] Kim, J. and Han, S. H., 2008, A methodology for developing a usability index of consumer electronic products, *International Journal of Industrial Ergonomics*, vol. 38, pp 333-345.

[10] Kuijt-Evers, L. F. M., Bosch, T., Huysmans, M. A., de Looze, M. P. and Vink, P., 2007, Association between objective and subjective measurements of comfort and discomfort in hand tools, *Applied Ergonomics*, vol. 38, pp 643-654.

[11] Lederman, S. J., 1981, The perception of surface roughness by active and passive touch, *Bull Psychonomic Soc*, vol. 18, pp 253-255.

[12] Lederman, S. J., 1983, Tactual roughness perception: Spacial and temporal determinants, *Canadian Journal of Psyehtilogw*, vol. 37, pp 498-511.

[13] Lee, Y. H. and Weng, J., 1995, An ergonomic design and performance evaluation of handy scanners by males, *Applied Ergonomics*, vol. 26, no. 6, pp 425-430.

[14] Lowenfeld, B., 1973, *The Handicapped in School*, John Day Company, New York.
[15] Morley, J. W., Goodwin, A. W., and Smith, D., 1983, Tactile discrimination of gratings, *Exp Brain Res*, vol. 49, pp 291-299.
[16] Muckler, F. A., and Seven, S. A., 1992, Selecting performance measures: 'Objective' versus 'Subjective' measurement, *Human Factors*, vol. 34, no. 4, pp 441-455.
[17] Olaon, J. M., Ellis, R. J. and Zanna, M. P., 1983, Validating objective versus subjective judgments: Interest in social comparison and consistency information, *Personality and Social Psychology Bulletin*, vol. 9, pp 427-436.
[18] Rehmann, J. T., Stein, E. S. and Rosenberg, B. L., 1983, Subjective pilot workload assessment, *Human Factors*, vol. 25, pp 297-301.
[19] Rempel, D., Barr, A., Brafman, D. and Young, E., 2007, The effect of six keyboard designs on wrist and forearm postures, *Applied Ergonomics*, vol. 38, pp 293-298.
[20] Sauer, J. and Sonderegger, A., 2009, The influence of prototype fidelity and aesthetics of desigh in usability tests: Effects on user behaviour, subjective evaluation and emotion, *Applied Ergonomics*, vol. 40, pp 670-677.
[21] Wierwille, W. W., Rahimi, M. and Casale, J. G., 1985, Evaluation of sixteen measures of mental workload using a simulated flight task emphasizing mediational activity, *Human Factors*, vol. 27, pp 489-502.