國立雲林科技大學
94 學年度博士班招生入學考試試題

所別：設計學研究所
科目：設計研究方法

說明：本試題共有四大題，請依序並標明題號，詳答於答案卷上，可以不用抄題。
可以中文或英文作答。

一、Please explain "quantitative studies" and "qualitative studies" (10%), and describe the implications of them. (15%)

二、何謂「Sociometry」？請闡述其定義及應用的範疇？(25%)

三、在設計學領域，測量(Measurement)是相當重要且常被運用在研究中，而量表(Scale)則爲測量所使用的工具。一份好的量表，必須考慮到「信度」與「效度」的問題，試說明：

(1) 何謂「信度」？如何表示信度？(10%)

(2) 何謂「效度」？列舉3種效度的基本類型，並說明之。(10%)

(3) 信度與效度的相關性爲何？(5%)

四、簡答題 (共計 5 題，每題 5 分，需抄題目作答；25%)

(1) Structured questionnaire

(2) Heuristic evaluation method

(3) Semantic differential scale

(4) Quasi-experimental design

(5) Historical study

進行作答時，需先將題目翻譯成設計研究領域的中文用語，並加以定義；另說明這些研究方法、分析技術或效標在設計研究領域之可能應用，請以案例說明之。

國立雲林科技大學
九十四學年度研究所博士班入學考試試題

系所：設計學研究所
科目：設計理論與文獻

說明：本試題共有四大題，請依序並標明題號，詳答於答案卷上，可以不用抄題。
可以中文或英文作答。

一、不同專業領域之設計工作與現今人類生活福祉習習相關，當今設計專業領域類別不斷的形成中。請就本土化(Localization)與國際化(Globalization)，提出適合台灣未來發展之新興設計領域？並請提出此新興設計領域，技職教育體系應提供那些設計知識與實務技能之課程架構。(25%)

二、地域性的要素基本上包括下列四個面向：(1)氣候風土的自然要素，(2)發展過程的歷史要素，(3)產業型態的經濟要素，(4)風俗習慣的文化要素；請試舉一實例以論證地域性要素對「設計」(視覺傳達設計，工業設計，空間設計三者擇一)的影響。(25%)

三、（1）請以中文說明下列文獻之要義(10%)；（2）請依下列文獻舉例說明你的論述(15%)。

Designing, has, until comparatively recently, been seen as a largely unproblematic process within the psychological literature that includes it as a category of problem solving (Greeno & Simon 1988). Problem-solving has been characterized in terms of the problem space model shown in Figure 1. In the problem space model, problems are regarded as occurring in a problem space that contains three elements. The first element is what is described as the problem state. This consists of all that is known of the problem at the start of problem-solving. For example, the inability to cross a river, the need to get to the other side, the width and depth of the river etc. might constitute the problem state of a problem that has a bridge as one solution. The second element is the goal state. The goal state is intended to represent the solution to the problem, and in the case above is the bridge, but might be a tunnel. The third element is the search space. The search space is taken to be all of the information the problem-solver has in their memory or can access from books, the Internet etc. that will help them solve the problem. In the river problem, the search space might include knowledge of bridges, construction methods, appropriate materials etc. Problem-solving is sometimes characterized as a journey with the 'space' constituting the territory the problem-solver 'navigates' to reach the goal state (Newell & Simon 1972).

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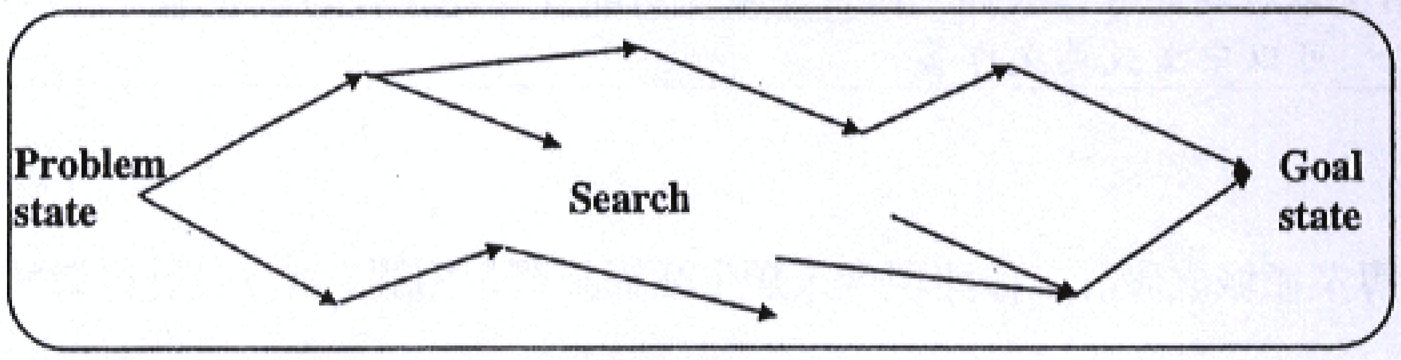


Figure 1. Model of a problem space (Newell & Simon 1972)

In characterizing design problems in terms of the problem space model above, it can be argued that the problem state is generally ill-defined and opaque. Ill-defined because the customer for the design and the designer do not generally have a clear idea of the dimensions of the problems, and some may not be apparent at the start of designing. In solving the design problem, there may be many possible paths to follow to achieve a solution and there may be complex and contradictory relations between particular paths. For example, to design a chair that is strong but light presents this contradictory relationship, which Schon (1990) describes as figurally complex. That is, if you change one aspect (strength) it will probably have an effect on the other (weight). Schon argues also, that the information processing explanation of problem-solving, derived from the problem space model, is unable to explain the fact that the processes involved in solving design problems, and indeed, possible solutions, often emerge during the course of designing. Table I provides a summary of the characteristics of design problems in terms of the problem space model.

Table I Summary of characteristics of the problem space of design problems (Middleton 1998)

| Problem state | Search and space | Goal state |
|---|---|---|
| Ill-defined | Numerous procedures | Ill-defined |
| Opaque | Figurally complex | Figurally complex |
| | Opaque | Contradictory criteria |
| | Emergent procedures | Emergent criteria |
| | Constructed procedures | Creative |

四、Please read the following paper and comment on its methodology and results (15%). Give some recommendations for improving this research. (10%)

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# Survey instrument for the universal design of consumer products

Valerie Beecher, Victor Paquet*

*Department of Industrial Engineering, University at Buffalo, State University of New York, Buffalo, NY 14260-2060, USA*

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**Abstract**

Universal design is a process intended to include all user groups in product or environmental design. The objective of this study was to develop a usability testing survey instrument to inform how well consumer products complied with established principles of universal design. Thirty-six adults, aging adults and adult wheelchair users performed standardized tasks with pens, food storage containers, pliers and calculators, and for each task responded to a preliminary set of survey items and rated task difficulty. Factor analysis of the survey responses produced an eleven-factor solution that accounted for 67% of the variance in scores and corresponded fairly closely to the principles of universal design. Analysis of scale scores developed from each factor showed that some of the scales were sensitive to product feature and user group differences, and were negatively associated with perceived task difficulty. Such a tool may aid designers who intend their products for user groups of diverse abilities and preferences.


*Keywords:* Universal design; Usability testing; Consumer products

## 1. Introduction

While the field of human factors engineering has been concerned with the usability of products for many years, a relatively small portion of this work considers the needs of alternative groups of users such as aging adults or people with disabilities. The human factors data generally available for design does not consider the needs of these user groups. Not surprisingly, many of today's consumer products are not designed to accommodate consumer groups who have functional limitations. For example, consumer products in the home are often unsuitable for the elderly due to a lack of relevant ergonomics data (Molenbroek, 1987).

Universal design is a process intended to promote the development of products or environments that can be used effectively by all without adaptation or stigmatization. Universal design is a process that is very similar to human factors engineering in that it attempts to consider the abilities and limitations of users when developing a product or building an environment. Story (1997) describes universal design as "design for people of all ages and abilities". Steinfeld and Mullick (1990) simply describe universal design as "designing products that all people can use easily."

Universal design differs, to some degree from conventional human factors engineering in which the intent is often to design for the vast majority of a target population rather than everyone. Such an approach leaves some reliant on assistive devices to perform at acceptable levels and completely excludes others. Those that are most likely to be excluded are those with the greatest physical or cognitive limitations, and may include, for example, those with temporary or permanent disabilities and the aging. In contrast, universal design places greater attention to designing mass-produced products or environments that can be used effectively without assistance by individuals with functional limitations. This may allow such individuals to benefit from design without the stigmatization that is

*Corresponding author. Tel.: +1 716 645 2357x2118; fax: +1 716 645 3302.
*E-mail address:* vpaquet@eng.buffalo.edu (V. Paquet).

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sometimes associated with use of assistive devices. Because mass-production is important, the aesthetics and marketability of the design are also considered. The slightly different emphasis among those that practice universal design may be attributed to the influence of the design and disability communities who originally conceptualized the discipline (Sanford et al., 1998).

The benefits of universal design have been promoted primarily through illustrative "success stories" of public, residential and occupational environments and products (Danford and Tauke, 2001; Mueller, 1997, 1998). While case examples may be informative they may unfortunately be limited in terms of generalizeablity to other designs or tasks. Design methods and criteria that can be applied systematically in a range of situations to encourage universal design are needed (Story, 1998).

A limited amount of work has attempted to provide a set of defined criteria to product designers to make their designs more usable by a larger proportion of the target user population. Vanderheiden and Vanderheiden (1992) published guidelines for consumer product design to increase the accessibility to people with disabilities or who are aging. Others have tried to summarize design guidelines and practices intended to accommodate those with functional limitations (Rahman and Sprigle, 1997). Recently, researchers have worked on developing ways to incorporate the actual concept of universal design into the standard design process (e.g. Connell et al., 1996; Steinfeld and Danford, 1999; Story et al., 2000).

A group of experts in the area of universal design have developed a set of simple principles that designers could use when developing products and environments (Story, 1997):

1. *Equitable use*—the design is useful and marketable to people with diverse abilities.
2. *Flexibility in use*—the design accommodates a wide range of individual preferences and abilities.
3. *Simple and intuitive use*—use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. *Perceptible information*—the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. *Tolerance for error*—the design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. *Low physical effort*—the design can be used efficiently and comfortably and with a minimum of fatigue.
7. *Size and space for approach and use*—appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

The seven principles are intended to guide the design process. The principles provide a framework that allows a systematic evaluation of new or existing designs and assists in educating both designers and consumers about the characteristics of more usable products and environments (Story, 1997, 1998). Exactly how these principles are incorporated into the design process, however, has been left up to the designer.

Some have worked to develop more systematic ways to evaluate products and environments by providing design guidelines for each of the principles. For example, some work has focused on developing performance measures in the form of consumer and designer surveys to aid in determining how well product designs meet the Seven Principles of Universal Design (Story et al., 2000). While some field studies have required consumers or designers to complete the surveys after using a given set of existing products for a few weeks in their home environments (Story et al., 2001), the surveys have not yet been used in controlled usability tests of products. In fact, recommendations have not yet been made regarding how to integrate measures of universal design into the product design process before the product is mass produced.

Usability testing is perhaps the most widely used technique for minimizing the mismatches between users and products before the product is produced (Green and Jordan, 1999). While some have performed product tests employing people who simulate disabilities or who have disabilities (Law and Vanderheiden, 1999, 2000), the principles of universal design or their guidelines have not been formally incorporated into these tests. In fact, participation among those with disabilities and the elderly is very rarely employed at all in the design process of mass produced consumer products (Sanford et al., 1998).

There exists a need for instruments that product developers can use to ensure their product can be used effectively by the widest range of potential user groups before it is mass produced. The purpose of this study was to develop a survey instrument used during usability tests that would allow the rating of a product in terms of how well it complies with the principles of universal design. The key research questions addressed included:

- Are the items on the survey descriptive of principles of universal design?
- Can such a survey be used effectively in usability testing to discriminate products with universal design features from those that violate the principles, i.e. is the measurement tool sensitive to design differences in similar products?

## 2. Methodology

This research first required the initial development of a comprehensive survey and a pilot study to identify a wide range of consumer products and product features. Usability studies were then conducted to refine and evaluate the survey. Based on the results of the usability studies, a new survey instrument containing only items that characterized universal design principles was developed. The sensitivity of the new survey instrument in identifying differences across products and user groups was evaluated.

### *2.1. Development of the initial survey*

The initial survey included a very comprehensive list of design guidelines related to principles of universal design. This survey was based largely on the Consumers' Product Evaluation Survey (The Center for Universal Design, 1999), and the Universal Design Performance Measures for Products version 1 (Center for Universal Design, 2000) (Story et al., 2000, 2001). Individuals complete the Consumers' Product Evaluation Survey after they have experienced a product. The Universal Design Performance Measures for Products is intended to provide a systematic way for designers to evaluate their design in terms of the principles of universal design. Both surveys require either the consumer or the designer to rate the level of agreement to four or five statements that are thought to be related to each of the seven principles of universal design (29 items total), but how well the survey items correlate to one another or correspond to the principles design has not been previously investigated. Items from these instruments were used in a new preliminary survey instrument in their original format, while others were modified or eliminated. Some items from the previously existing surveys were also modified to incorporate standard principles in questionnaire design; for example eliminating the use of complex statements (Sinclair, 1995). The next step involved reviewing literature related to universal design and human factors design (e.g., Story et al., 2001; Sanford et al., 1998) to refine any of the existing statement items, as well as to add new statement items describing other features of universal design or usability. The survey responses for each item were a five-point Likert Scale, ranging from "Strongly Agree" to "Strongly Disagree", as well as a "Not Appropriate" category. This allowed product users to rate their level of agreement to each of the survey items and identify items that were not appropriate to particular products.

After the first version of the preliminary survey was developed, five experts consisting of three engineers, one industrial designer and one architect, provided feedback about the wording and appropriateness of the items and response measures, as well as suggestions for additional statements. An example of the preliminary survey instrument used in this study is provided in (Appendix A).

### *2.2. Pilot study of products*

The pilot study required the identification of products with similar function but different design features. Potential products thought to vary in quality in terms of the principles of universal design were identified. This study was then conducted to confirm variability across products in terms of the principles of universal design. Twelve female and 12 male college students were recruited for the study. Participants were presented with four different types of consumer products: pens, food storage containers, pliers and calculators. Each participant was asked to experience the product as if they were interested in purchasing it. The participants were then asked to respond to 12 statement items taken from the preliminary survey covering each of the principles of universal design. The pilot study showed responses were extremely similar for two of the pens and two of the storage containers, and therefore one of each was replaced in an effort to increase the variability within survey responses needed for the testing and refinement of the survey. The products are shown in Fig. 1.

### *2.3. Testing and refinement of the survey*

The purpose of this phase of the research was to refine the initial set of survey items into measurement scales and evaluate the sensitivity of the scales in detecting design difference among similar products. The intent was to create a simple participant survey instrument for usability tests of consumer products that provided measures of product characteristics that were related to the principles of universal design. This involved a consumer product usability study of the products that were identified in the pilot study.

#### *2.3.1. Participants*

A total of 36 adults including 12 adults who used wheelchairs as mobility aides, 12 aging adults (age $\geq 65$) and 12 adults (between ages 18 and 64) participated in the usability study. Each group consisted of six women and six men. There were six power and six manual wheelchair users, ranging in age between 31 and 63 years. Their disabilities included spinal cord injury ($n = 6$), central nervous system disorders ($n = 4$), stroke ($n = 1$), and diabetes ($n = 1$). Of those with spinal cord injury, three were paraplegic and three were quadriplegic. The group of aging adults who reported no physical or cognitive disabilities ranged between 65 and 82 years of age, and did not require the use of a mobility aid. The wheelchair users and aging adults were recruited through a local independent living community center, which used an existing database to identify the participants. The adult participants who reported no physical or cognitive disabilities ranged in ages between

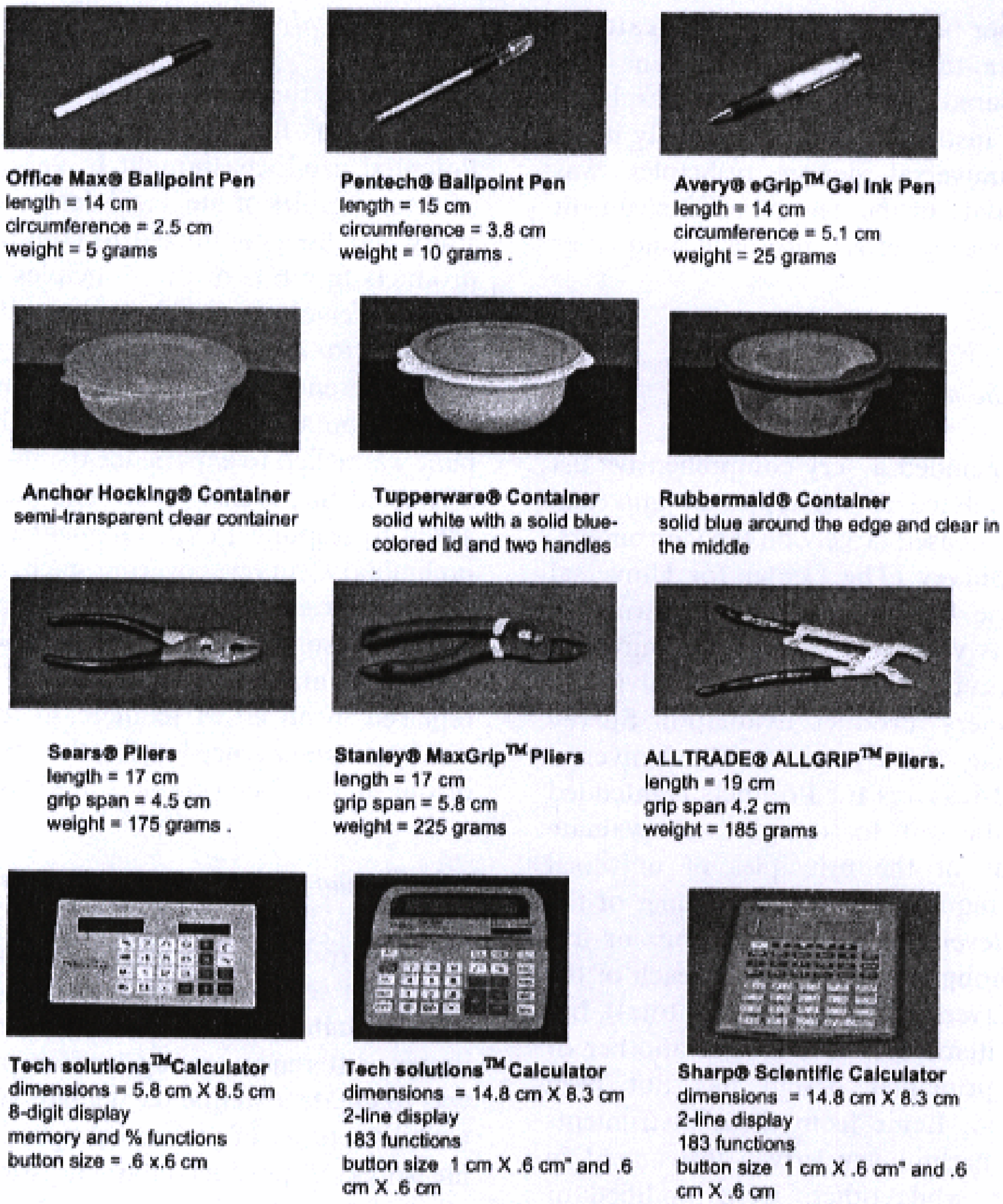


Fig. 1. The products used in the usability tests.

18 and 50 and were recruited from a university population. All were paid for their participation.

### 2.3.2. Products and usability tasks

Four product groups (or families), consisting of three products each, were evaluated in the usability tests. These product families included pens, containers, pliers and calculators that were used in the pilot study. The participants completed a short set of simple tasks for each product they used. The same sets of tasks were performed for each product family to allow direct comparisons of performance across products within each family. The task instructions were provided orally and sequentially while the participant performed each step of the tasks.

### 2.3.3. Study design

Each participant performed tasks with one product from each family. The participants did not encounter more than one product within the same family to eliminate biases in response caused by experience with multiple products of the same type. The order of products presented to the participant and the order of the statement items were randomized for each participant and product.

### 2.3.4. Procedure

The usability tests required participants to perform defined tasks with each of four different consumer products and respond to the 60 items of the preliminary survey. Before the usability test began, the experimenter provided a summary of the procedure. The participant was presented with the first product and any other materials needed to perform the tasks, and then performed the tasks.

Immediately after completing each set of tasks for each product, the participant responded to the 60 survey items of the preliminary survey, which were read aloud by a researcher. The participant also reported the level of difficulty she or he had completing the task using a modified version of the Difficulty Rating Scale (Steinfeld and Danford, 1999), a seven-point scale ranging from very easy (−3) to very difficult (3). The usability tests were repeated for the three remaining products.

*2.3.5. Refinement of survey instrument*

The first step in simplifying the survey was deleting items determined to be uninformative based on the response of the participants in the consumer usability study. Item response means were evaluated to determine whether a large percentage of participant responses created a floor or ceiling effect, which is observed when many of the individual scores are at one or both of the extreme ends of the scale suggesting that the scale may not have captured the actual variability in responses (Schwartz, 1998). Items with greater than 20% of the responses as "Not Applicable" were eliminated.

Exploratory factor analysis was then applied to recognize common themes among items and eliminate irrelevant items. The goal was to determine which statement items corresponded with the original Seven Principles of Universal Design and to identify additional design principles that emerged from the survey items. Pearson product-moment correlations for response scores were calculated. The correlation matrix was inspected to determine if the strength of the correlations among the items warranted factor analysis, since when there are only a few correlations higher than 0.30, factor analysis might not be a useful statistical approach (Tabachnick and Fidell, 2001). Items that did not have a correlation with any other item above 0.30 were removed from the list.

The factor eigenvalues contained in the unrotated factor matrix were used to determine the number of potentially interpretable factors contained in the data. The appropriate number of factors was determined by taking the number of factors for which the eigenvalue was 1.00 or greater, and the total variance described by these factors was calculated for those having eigenvalues of at least one. An orthogonal factor rotation was performed using the Varimax method in SAS (SAS, Inc.). Orthogonal rotation is typically desirable for instrument development because the researcher intends to create subscales that are independent of one another, and the Varimax method is the most frequently used and reported rotation option (Ferketich and Muller, 1990). Once the factors were identified, scales consisting of the unweighted scores of each of the items for each factor were constructed.

*2.3.6. Preliminary evaluation of survey scales*

The newly developed scales were evaluated in terms of their sensitivity to differences in product design features, different abilities of different user groups, and different levels of task difficulty. Analyses of variance (ANOVA) was used to identify differences in scale scores across products within family to determine if the scales were sensitive to design differences in similar products. ANOVA was also used to determine if there were significant differences among factor scale scores for the different status groups to determine if the scales were sensitive to design characteristics that place one or more consumer groups at a greater advantage when using the product. Lastly, Spearman-rank correlations were calculated to determine the relationship between each of the scale scores and the ratings of task difficulty.

## 3. Results

*3.1. Testing and refinement of the survey*

All of the survey items had mean responses greater than 1.5 and less than 4.5, therefore no items were excluded from additional analyses due to "floor" or "ceiling" effects. One item was deleted from the list because 27% of the responses to the item were "not applicable".

All of the correlations between item response scores were greater than 0.30, the factor analysis resulted in an 11-factor solution that accounted for 67% of the variance (Table 1). Names were given to the 11 factors based primarily on the items with the highest loading associated with each factor. The refined survey containing the factors and corresponding items for each factor (item loading greater than 0.35) used to construct the scales is found in Appendix B: Consumer Product Universal Design Scales.

*3.2. Preliminary evaluation of survey scales*

ANOVA on scale scores showed significant or near significant differences for seven out of 11 factors for at least one family of products. For example, the "Simple Use" scale scores for pliers designs differed significantly ($F = 3.42$, df = 2, 30, $p = 0.04$) and differences approached statistical significance for the "Reach and Access for Use" scale scores ($F = 3.23$, df = 2, 31, $p = 0.05$). The pliers that offered the greatest number of settings and were light scored the highest on these measures (Fig. 2).

There were significant or near significant differences in the factor scale scores across status groups (adults, adults who use wheelchairs as mobility aides and aging adults) for one or more product families for five out of 11 factors. For example, the disability status of a participant significantly affected the response score of the "Size for Use" factor for pliers ($F = 3.84$, df = 2, 33, $p = 0.03$). The adults who use wheelchairs rated the

Table 1
Summary of rotated factors. Note that factors 1, 2, 3, 5, 7, 8, 9, 10 and 11 correspond to the seven principles of universal design

| Factor | Subscale | Eigenvalue | Variance (%) | Cumulative (%) |
|---|---|---|---|---|
| 1 | Low physical effort | 19.22 | 33 | 33 |
| 2 | Perceptible information | 5.01 | 8 | 41 |
| 3 | Flexibility in use | 3.16 | 5 | 46 |
| 4 | Adaptability to user pace | 2.24 | 4 | 50 |
| 5 | Intuitive use | 1.81 | 3 | 53 |
| 6 | Reach and access for use | 1.66 | 3 | 56 |
| 7 | Simple use | 1.50 | 3 | 59 |
| 8 | Equitable use | 1.37 | 2 | 61 |
| 9 | Secure, safe and private use | 1.20 | 2 | 63 |
| 10 | Tolerance for error | 1.10 | 2 | 65 |
| 11 | Size for use | 1.00 | 2 | 67 |

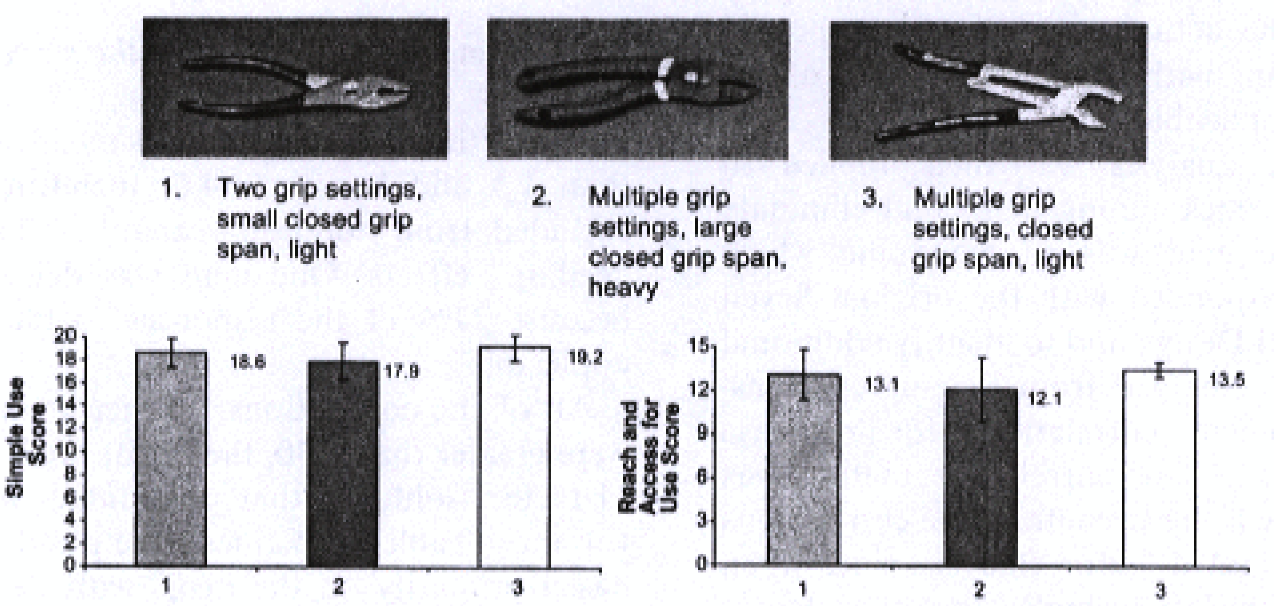


Fig. 2. Top: the three pliers used in the usability tests, which required research participants to fasten a threaded bolt to a vertical wall. Bottom: Simple Use and Reach and Access for Use Scores for each of the products. Pliers #3 scores higher overall on both scales.

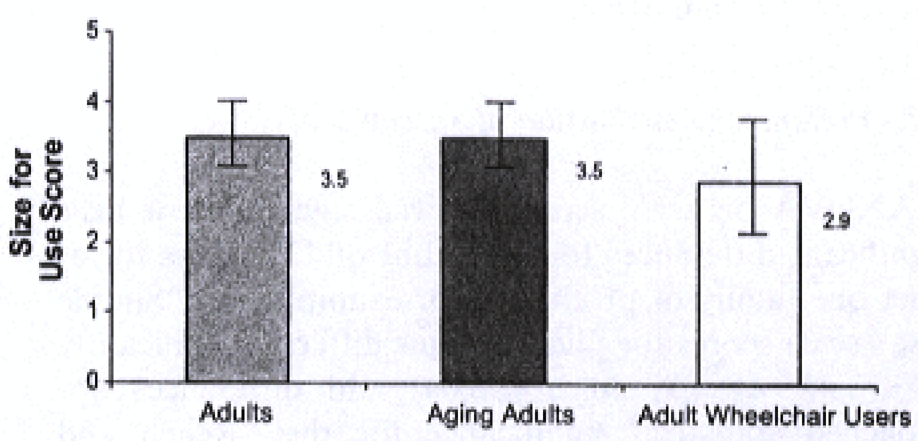


Fig. 3. "Size for Use" Scores for Pliers across user groups (5-Point Scale).

pliers differently overall than the adults or aging adults (Fig. 3).

Eight of the 11 factor scales had negative correlations with ratings of task difficulty that exceeded 0.3. The correlations were statistically significant for nine of the factors, indicating an overall negative relationship between the scale ratings of universal design and the ratings of task difficulty (Table 2).

Table 2
Correlations of universal design scale scores and ratings of task difficulty ($n = 144$)

| Scale | Spearman rank correlation with ratings of task difficulty* |
|---|---|
| Low physical effort | −.58* |
| Perceptible information | −.14 |
| Flexibility in use | −.40* |
| Adaptability to user pace | −.51* |
| Intuitive use | −.38* |
| Reach and access for use | −.48* |
| Simple use | −.52* |
| Equitable use | −.50* |
| Secure, safe and private use | −.27* |
| Tolerance for error | −.01 |
| Size for use | −.32* |

*Statistically significant at ($p<0.01$).

On average, the perceived ratings of task difficulty were highest for the adult wheelchair users and lowest for the young adults, but the ratings of task difficulty were not statistically significant across groups due to the large variability of ratings within user group.

## 4. Discussion

This newly developed measurement tool should allow designers to systematically evaluate their prototype products on a number of different dimensions that are related to the Seven Principles of Universal Design. The results of the factor analysis grouped survey items into 11 factors in ways that, for the most part, were quite similar to the design guidelines of the Seven Principles of Universal Design, showing that the 11 factors and Seven Principles are characterizing similar features of consumer product design.

There were some differences among the original principles and the 11 factors that are worth noting. The factor analysis split some of the original principles into multiple orthogonal factors, indicating that the original universal design principles may have actually embraced more than one design concept. For example, the factor "Secure, Safe and Private Use", was derived from a subset of survey items originally thought to describe the first universal design principle, "Equitable Use". Some of the items that were originally categorized by Story et al. (2000, 2001) under "Flexibility in Use" and "Equitable Use" were exchanged between these factors. These relatively minor differences were expected since principles and their corresponding design guidelines had not been previously tested in this manner.

ANOVA indicated that some factors were significant or near significant for differences across products, suggesting that these factors were sensitive enough to discriminate products with universal design features from those that violate the principles. This finding was encouraging since products within families were not selected because they were hypothesized to be largely different in terms of all the universal design principles and, in fact, there were many physical similarities across products within family. Additionally, given the diversity of the participants of this study and the experimental design, the statistically significant differences on some scale scores across products within family suggests that the scales are sensitive to even relatively small design differences in products.

There were cases where no significant differences were found, which may be attributed to the lack of variability of product design features within family or the small number and diversity of individuals in terms of functional abilities within user group who tested each product. The 12 products originally selected for the usability tests were judged to have a fair amount of variability in terms of the principles of universal design during pilot tests, but the variability across products within family may not have been very large. In some cases, it is possible that the private nature of the experiment may have also affected the results, particularly for the factor, "Equitable Use", which includes items that address how stigmatizing use of a product might be. For example, the largest pen and calculator were hypothesized to be stigmatizing because they were much larger than the other pens and calculators, and larger products are sometimes perceived to be "assistive". Since the products were used only in the presence of the experimenter, rather than among a group of co-workers or student peers, the potentially stigmatizing effect of these larger products may have been missed.

The ratings made by those who used the tool were inversely related to their perceptions of task difficulty. Since the task requirements were held constant across products of the same family the increased task difficult would be suggestive of design deficiencies in the products, which was indicated by the survey. However, Factor 2, "Perceptible Information", Factor 9, "Secure, Safe and Private Use" and Factor 10, "Tolerance for Error" were not strongly correlated with the ratings of task difficulty. It appears that the tasks completed by participants in this study, or the products themselves, may not have had much variability in terms of their cognitive requirements. Only the tasks involving the calculators required interpreting displayed information and/or correcting errors, and even these were simple calculations that could be performed with each of the calculators. None of the products, except possibly the pliers, seemed to be threatening to a participant's safety and none of the products seemed to be threatening to a person's security or privacy. Interestingly, while ratings of task difficulty were not statistically significant across user groups, statistical differences were found in some of the factor scale scores, suggesting that the survey may provide new information about the design characteristics of a product during usability tests that go beyond subjective measures of task difficulty.

## 5. Conclusions

The development and testing of this survey is one of the first attempts to formally apply principles of universal design to the consumer product design process. There are still many questions regarding the use of this or similar measurement tools to inform the design of consumer products. The survey should be tested for different user groups, consumer products and tasks to determine the degree of generalizability of the relationships between survey items and the sensitivity of the scales to systematically identify design deficiencies in products. The relationship between the item responses and other indices of tasks difficulty obtained through, for example, systematic direct observational ratings, has also not yet been explored. It is hoped that with further refinement, such a tool may lead to improved product that are more easily used by user groups with a wide range of abilities.

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## Appendix A

The preliminary survey used in the usability tests. The order of the items was randomized across participants and products. Many of the items were taken or have been modified from the Consumers' Product Evaluation Survey and the Universal Design Performance Measures for Products (Story et al., 2000, 2001).

| Participant 3—Product 1—Blue/Clear Lid Container | *SA A N D SD NA* |
|---|---|
| 1 This product is usable for me. | |
| 2 This product gives me helpful feedback as I use it. | |
| 3 I can find at least one way to use this product effectively. | |
| 4 The least important features of this product are not distracting. | |
| 5 Using this product does not make me need to rest. | |
| 6 The features of this product that I use the most are the easiest to access. | |
| 7 This product gives me an opportunity to undo errors. | |
| 8 I can use this product without overexerting myself. | |
| 9 This product prompts me to pay attention during a hazardous action. | |
| 10 This product helps me understand how to use it. | |
| 11 I feel competent using this product. | |
| 12 I can see all the important elements of this product from positions I would like to be in. | |
| 13 Any hazards of this product are hard to access accidentally. | |
| 14 There is enough space for me to use this product with the aids, devices, or techniques I use. | |
| 15 I can use this product in whatever way(s) are efficient for me. | |
| 16 I can use this product in whatever way(s) are satisfying for me. | |
| 17 I do not have to rest after using this product. | |
| 18 This product warns me about potential hazards. | |
| 19 I have choices in the way I can use this product. | |
| 20 I can use this product without uncomfortable postures. | |
| 21 I can easily identify the features of this product in order to use it. | |
| 22 If I make a mistake when using this product, it will not injure me. | |
| 23 I can use this product as slowly as I want. | |
| 24 I can use this product without having to repeat any motion enough to cause fatigue. | |
| 25 The most important features of this product are the most obvious. | |
| 26 I think this product looks attractive. | |
| 27 This product warns me about potential errors. | |
| 28 I can use this product as long as I want without causing pain. | |
| 29 I can use this product in whatever way(s) are effective for me. | |
| 30 I look good using this product. | |
| 31 I can use this product without having to repeat any motion enough to cause pain. | |
| 32 I can access all the important elements of this product from positions I would like to be in. | |

33 I can use this product in whatever way(s) are safe for me.
34 This product is simple to use.
35 I have a choice in the speed of use of this product.
36 I can use this product as quickly as I want.
37 I can use this product with the aids, devices, or techniques I use.
38 I can use this product as long as I want without causing fatigue.
39 This product gives me useful feedback as I use it.
40 I can use this product without awkward movements.
41 Using this product does not make me feel different.
42 This product does not threaten my safety.
43 I enjoy using this product.
44 If I make a mistake when using this product, it will not cause damage to the product.
45 The use of this product is straightforward.
46 I understand the language used in this product.
47 Using this product does not make me feel excluded.
48 I can reach all the important elements of this product from positions I would like to be in.
49 This product fits my hand size.
50 This product prompts me to pay attention during a critical action.
51 I do not need instructions to use this product.
52 This product does not threaten my privacy.
53 I can use this product at whatever pace I prefer.
54 I can use this product without sight.
55 I can use this product without hearing.
56 This product does not threaten my security.
57 I can use this product effectively with the hand (or foot) I prefer to use.
58 This product gives me an opportunity to correct errors.
59 This product works just like I expect it to work.
60 Using this product does not tire me.

SA—strongly agree, A—agree, N—neither agree or disagree, D—disagree, SD—strongly disagree, NA—not applicable.

## Appendix B

Consumer product universal design scales[1]

Title (range of scale values, maximum to 5 points per item)

*1. Low physical effort (10–50)*

1 Using this product does not tire me.
2 I can use this product without having to repeat any motion enough to cause pain.
3 I can use this product as long as I want without causing fatigue.
4 I can use this product without having to repeat any motion enough to cause fatigue.
5 I can use this product as long as I want without causing pain.
6 I do not have to rest after using this product.
7 Using this product does not make me need to rest.
8 I can use this product without awkward movements.
9 I can use this product without overexerting myself.
10 I can use this product without uncomfortable postures.

*2. Perceptible information*

1 This product gives me helpful feedback as I use it.
2 This product prompts me to pay attention during a critical action.
3 This product gives me useful feedback as I use it.
4 This product warns me about potential errors.
5 This product prompts me to pay attention during a hazardous action.
6 This product warns me about potential hazards.
7 This product helps me understand how to use it.

*3. Flexibility in use (5–25)*

1 I can use this product in whatever way(s) are efficient for me.
2 I can use this product in whatever way(s) are effective for me.
3 I think this product looks attractive.
4 I have choices in the way I can use this product.
5 I can find at least one way to use this product effectively.

[1]Some items in these scales came from the Consumers' Product Evaluation Survey and the Universal Design Performance Measures for Products (Story et al., 2000, 2001).

*4. Adaptability to user pace (4–20)*

1 I have a choice in the speed of use of this product.
2 I can use this product as slowly as I want.
3 This product works just like I expect it to work.
4 The use of this product is straightforward.

*5. Intuitive use (3–15)*

1 I do not need instructions to use this product.
2 I understand any language used in this product.
3 I can use this product without sight.

6. Reach and access for use (3–15)

1 I can reach all the important elements of this product from positions I would like to be in.
2 I can access all the important elements of this product from positions I would like to be in.
3 I can use this product with any aids, devices, or techniques I use.

*7. Simple use (4–20)*

1 This product is simple to use.
2 I can easily identify the features of this product in order to use it.
3 The most important features of this product are the most obvious.
4 The features of this product that I use the most are the easiest to access.

*8. Equitable use (2–10)*

1 Using this product does not make me feel different.
2 I can use this product with the hand (or foot) that I prefer to use.

*9. Secure, safe and private use (3–15)*

1 This product does not threaten my privacy.
2 This product does not threaten my security.
3 I can use this product in whatever way(s) are safe for me.

*10. Tolerance for error (2–10)*

1 This product gives me an opportunity to undo errors.
2 This product gives me an opportunity to correct errors.

*11. Size for use (1–5)*

1 This product fits my hand size.

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