Usability Testing of Repositionable and Customizable Locking Mounts with Rehabilitation Professionals

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ABSTRACT
New mounting devices under development were tested to determine how easy it was to discover, with no instructions, how to operate the mount and set it up for a consumer with a disability. The new mounting device includes a feature whereby the mount will lock in a specific position according to an individual's needs. Assistive technology specialists, those expected to set up assistive devices for their clients, were recruited for usability tests at a stage in which two different lock-setting interfaces and consumer controls had been developed and incorporated into working prototypes. Three configurations were tested to compare the usability of the interfaces. Statistical analyses found significant differences between the lock-setting interfaces in ease of operation and ease of setting the lock. The findings influenced changes in the design to improve the usability for those setting up the mount.

KEY WORDS:
mounting device, usability, ease of use, outcomes

BACKGROUND

Usability tests are often used when developing mainstream consumer products and typically focus on able-bodied end users.(1) In developing assistive technology, a product is designed to be used by people with disabilities, but the physical set up of the device may need to be done by others. The designer must take into consideration each of the end users.(2) First is the person who uses the technology to achieve greater independence. The designer must keep in mind a wide range of physical, cognitive and sensory abilities. Secondly, another person may set up the device to best suit the consumer. This could be an assistive technology or rehabilitation professional or a family member. Finally, there are others who assist the consumer on a daily basis. They may not need to understand the intricacies of setting up the device, but need to easily intuit how they might adjust it, as the consumer may be unable to communicate or direct their actions and instructions may not be available. The range of end users and potential lack of communication or instructions heightens the criticality of developing a product that is intuitive and easy to use.

In the research described, the mounts under development are designed to be independently operable by individuals with disabilities. They may be customized to lock in one or more positions, depending on an individual's positioning needs. Each joint has twelve possible locking positions. The end user releases the lock using controls which require minimal strength and dexterity. One control releases the shoulder and elbow joint, and the other releases the wrist. As the arm is moved, it automatically locks into positions set as "lock" positions. The lock-setting procedure is relatively easy once demonstrated, but not immediately apparent. The usability study sought to assess the usability of the mount and to compare the ease of use of different lock-setting mechanisms.

METHODS

Participants:

The subjects in this study consisted of eight individuals (six female; two male) who work in the field of assistive technology, including Assistive Technology Specialists and Speech Language Pathologists. Subjects were recruited through rehabilitation and assistive technology facilities. The requirement for

participation was that they worked with wheelchair users and were somewhat familiar with mounting devices.

Apparatus:
Three prototypes incorporating lock-setters and consumer interfaces used to unlock and move the arms were tested. Two arm styles were presented: a single arm version and a double arm version. Two different lock-setting interfaces were tested, the "twistlet" and the "tab lock". The prototypes are referred to as Single Arm Twistlet Lock; Double Arm Twistlet Lock; and Single Arm Tab Lock.

Photo 1. This photograph shows the Single Arm Twistlet Lock Manual Mount used during the usability testing.

Photo 2. This photograph shows the Double Arm Twistlet Lock Manual Mount used during the usability testing.

Photo 3. This photograph shows a close up view of the locking mechanism for the Single and Double Arm Twistlet Lock Manual Mounts.

Photo 4. This photograph shows the Single Arm Tab Lock Manual Mount used during the usability testing.

Procedure:
The University of Minnesota's IRB approved all procedures. Two to three subjects were tested individually at three different locations. Each subject signed consent forms and completed a survey prior to the actual testing.

A bird's eye view drawing of a person and/or an actual chair was set out to represent where a wheelchair user would be oriented relative to the mount. Various tools and objects (screwdrivers, Allen wrenches, pen, and paper clip) were set out on the table for the Subjects to use.

The testing order of the three mounts was randomized for each Subject. Each mount was set up on a post that was clamped to a table surface. The mounts were set up and locked in place as though they were "Out of Box" (see Photo 1).

Subjects were told the mount was set in a locking position, and to be gentle when working with the mounts as these were plastic prototypes. Subjects were instructed to talk and think out loud as they worked through the given tasks. Very little background information on the prototypes or concept was provided. Subjects were only told the mounts were able to be repositioned, to lock in positions and attach to wheelchairs. No labels, indicators, or cues were evident on the prototypes. No verbal or written instructions as to how they operated or how to set locking positions were given.

For each mount there were six tasks to be completed by each Subject. After completing each task, Subjects answered a set of written questions. Questions touched on topics such as, but not limited to, ease of use, likeability, suggestions and comments. Subjects then moved on to the next task. After all tasks were completed on that specific mount, Subjects could move on to the next mount, as instructed. Because of the similarity between the Single Arm Twistlet and the Double Arm Twistlet mounts, Subjects only had to complete Task #6 on whichever Twistlet mount they encountered first. All Subjects completed Task #6 for the Tab Lock mount, regardless of testing order. Subjects completed a total of seventeen tasks.

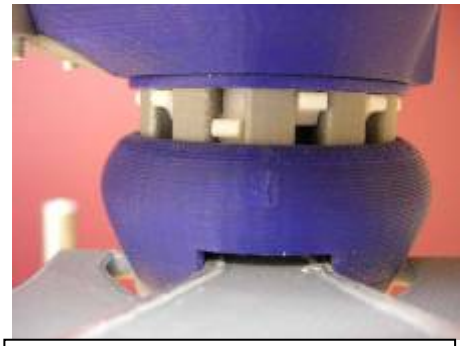

Photo 5. This photograph shows a close up view of the locking mechanism for the Tab Lock Manual Mount.

Photo 6. This photograph shows a Subject completing a task on the Manual Mount during the usability testing.

Analysis:

Descriptive and inferential statistics were used to analyze the data. Rank order of the three mounts was analyzed by means of Pearson's Chi-Square analysis along with basic descriptive statistics. Rank order, one through three, was given for each question. Lower scores indicate the favored mount. Time to complete tasks was analyzed with a one-way ANOVA as well as descriptive statistics. Time reported infers cognitive difficulty, thus a lower time indicates ease of use.

RESULTS

Overall Ease of Operation:

Overall rankings of the three mounts on Ease of Operation are provided in Table 1. Of the three mounts, Subjects reported the Single Arm Tab Lock the easiest to operate. The Single Arm Twistlet Lock was reported the second easiest to operate, followed by the Double Arm Twistlet Lock. Pearson's Chi-Square analysis confirmed statistical significance between the mounts (Chi-Square=12.00, df=4, $p<0.017$).

Table 1: Overall Ease of Operation Ranking Summary Statistics

Ease of Operation Ranking			
	Rank	N	SD
Single Arm Twistlet Lock	2.125	8	0.641
Double Arm Twistlet Lock	2.375	8	0.744
Single Arm Tab Lock	1.500	8	0.926
S = 3.25; df = 2; P = 0.197			

Note: Participants rank ordered "Ease of Operation" from 1-3, with 1 = Most Favorite to 3 = Least Favorite.

Overall Ease of Setting:

Overall Ease of Setting rankings for the three mounts are provided in Table 2. The Single Arm Tab Lock was ranked the easiest to set. The Double Arm Twistlet Lock was ranked second, followed closely by the Single Arm Twistlet Lock. Pearson's Chi-Square analysis confirmed statistical significance between the mounts (Chi-Square=11.202, df=4, $p<0.024$).

Table 2: Overall Ease of Setting Ranking Summary Statistics

Ease of Setting Ranking			
	Rank	N	SD
Single Arm Twistlet Lock	2.250	8	0.707
Double Arm Twistlet Lock	2.125	8	0.641
Single Arm Tab Lock	1.500	8	0.926
S = 3.16; df = 2; P = 0.206			

Note: Participants rank ordered "Ease of Operation" from 1-3, with 1 = Most Favorite to 3 = Least Favorite.

Overall Satisfaction:

Overall Satisfaction rankings for the three mounts are provided in Table 3. The Single Arm Tab Lock was the favored mount, followed by the Double Arm Twistlet Lock, and finally the Single Arm Twistlet Lock. No statistical significance could be concluded for overall satisfaction as not enough data points were collected.

Table 3: Overall Satisfaction Ranking Summary Statistics

Overall Satisfaction Ranking			
	Rank	N	SD
Single Arm Twistlet Lock	2.250	4	0.957
Double Arm Twistlet Lock	2.000	5	0.707
Single Arm Tab Lock	1.000	6	0.000

Note: Participants rank ordered "Ease of Operation" from 1-3, with 1 = Most Favorite to 3 = Least Favorite.

Combined Task Timing Results:

The average times to complete all six tasks for the three mounts are provided in Table 5. The Single Arm Tab Lock had the fastest average time, followed by the Single Arm Twistlet Lock, and finally the Double Arm Twistlet Lock. No statistical significance was found between the mounts (F=0.050; df=2; P=0.951).

Table 4: Average Time to Complete All Tasks for Each Mount Statistics

Average Time for All Tasks for Each Mount			
	N	Total Time	Average Time (Seconds)
Single Arm Twistlet Lock	41	5500	134.1
Double Arm Twistlet Lock	34	4724	138.94
Single Arm Tab Lock	48	5954	124.04
F = 0.05028; df = 2; P = 0.951			

This table shows the combined total and average times to complete all six tasks for each Manual Mount.

DISCUSSION

Subjects reported the Single Arm Tab Lock was the preferred mount across all three ranking questions, almost unanimously. Subjects liked that a tool was not required to set the lock, that a finger or fingernail could be used. They liked the tactile feedback and that it was visually obvious whether it was set to lock. The tab lock was familiar, similar to a dip switch. The Double Arm Twistlet Lock was the second preferred mount and finally the Single Arm Twistlet Lock. Some reasons Subjects preferred the Double Arm over the Single Arm Twistlet Lock are that the double arm increases flexibility in positioning and reduces the reach required. No subjects preferred the Twistlet Lock versions, due to several factors: a tool was needed to set the small screw-like lock, the twisting action is not intuitively a lock-setting action, and there was no tactile feedback so it was difficult to know whether they had set it or not. A screw implies a feature which tightens or loosens something, so Subjects did not initially realize the Twistlet was the locking mechanism.

Based on descriptive statistics, Subjects were able to complete all six tasks the fastest, on average, with the Single Arm Tab Lock mount. Because statistical significance was not found between the mounts, we are unable to say all tasks could be completed statistically faster on one mount compared to the others. This shows that all three mounts are equal in their design, no one design is better than the other. A reason the data may not show differences is, as Subjects were completing tasks, if they became stumped, investigators provided a clue to help them complete the task. Subjects only needed help on the Tab Lock mount 6.3% of the time, where as the Subjects needed help on the Twistlet Lock mounts about 18.8% of the time.

Because of the delicate nature of the prototypes, as they were made mostly of plastic parts – including the mechanical moving parts, there were instances when the mounts did not function properly, or worse, when they actually broke. This resulted in the Subjects completing modified tasks, or skipping tasks all together. The Twistlet Lock mount versions tended to have more breakage than the Tab Lock mount.

This may have contributed to the lower rankings given to the Twistlet Locking versions. Even if the prototype mounts were working properly, they are just that, prototypes. There may be extra "play" in the moving parts, components may be looser or tighter than how the actual product will operate, and proper feedback may not be provided with the prototypes. Some frustration from the Subjects stemmed from the delicate prototype versions being tested.

Many valuable observations and suggestions were collected during the usability testing. Some design improvements recommended for the next design iteration are as follows, in no particular order:
1) Allow the locking mechanism to operate, lock and unlock, not only when out of the desired locking position, but also while engaged in the desired locking position.
2) Reposition the lock-set location or point of reference from the arm side to the back of the joint for easier access and improved line of sight.
3) Have an indicator point to the Tab or Twistlet which needs to be adjusted to set or remove a lock position.
4) Recess the friction adjustability screw and have a stop point, so it does not stick out or completely come out of the mount.
5) Develop a lock mechanism that provides obvious and deliberate feedback – auditory and/or tactile.

In spite of the shortcomings of the prototypes, the feedback was useful and has been incorporated into the next design iteration. More durable prototypes will be built with the recommended changes and tests will be conducted with both professionals and consumers. Usability tests for each group will vary. Future plans include testing user guides and quick set up guides.

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