FREQUENCY OF USE OF AUTOMOTIVE STEREO CONTROLS

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The primary determinants of control location are human physiological limitations, spatial relationship to the functions controlled, functional groupings, sequential arrangements, and priority of usage/frequency of use. The first four of these are relatively easy to determine, whether through anthropometrics or task/function analyses, but the final consideration is often less straightforward. The relative frequency of use of a set of controls that are primarily driven not by need, but by user preference are often almost impossible to determine before a product is actually put into use. This paper describes a study designed to evaluate the relative frequency of use of the controls available on automotive stereo products. The study focused on experienced users over an extended period of time and a relatively wide age range. Results indicated that control usage fell into several broad groups, with volume control being the most commonly used function.

INTRODUCTION

Product usability and operator satisfaction are often largely a function of the appropriateness and intuitiveness of a device’s user interface design. This is particularly true in cases where there exist a number of available alternative products with almost identical capabilities and functionality. Most textbooks cite five primary driving forces in the design of such interfaces and the placement and interrelationship of the controls which operate them. These include: 1) physiological limitations, 2) the spatial relationship between the controls and the functions they control, 3) functional groupings, 4) sequential arrangements, and 5) priority of usage or frequency of use. The first four of these considerations are usually addressed during product design through the use of anthropometric tables and/or task and functional analyses. The frequency of use issue is also predictable for many products; however, this is not true when the frequency of use is determined not by some predictable requirement springing from the nature of the task being performed, but primarily by user preference. Automotive stereo equipment is a good representative of this class of device. Most of the controls (with the exception of power on or off) are set at the whim of the user and their usage patterns are difficult to estimate with any degree of accuracy. This issue is quite important in both determining an optimal control layout for such products and determining reliability test criteria for the individual components.

Past experience has shown that user questionnaires are not reliable sources of information in answering such questions. Operators simply seem to be unable to make an accurate estimate of their control use beyond the one or two most commonly operated controls.

Objective of the Present Study

The objective of the present study was to derive detailed information on the frequency of use of the most commonly available controls on automotive stereo equipment. This was accomplished in a operational environment over an extended period of time in order to address two primary shortcomings of usability testing under laboratory conditions: 1) the relative unfamiliarity of the user population with the radio controls on initial exposure; and 2) the relative artificiality of even the most realistic driving simulation. Two common radios with roughly similar feature sets were selected for evaluation—a 1995 Delphi Delco AM/FM/Cassette unit with Auto Tone Control (hereafter referred to as the standard radio) and a 1994 Delphi Delco AM/FM/Cassette unit with Equalizer (hereafter referred to as the equalizer radio) (Figures 1 and 2). The primary differences between the two units were the presence of a 7-band graphic equalizer on the 1994 unit versus the more common treble and bass controls on the 1995 unit, as well as the presence of Speed Compensated Volume and Auto Tone Control on the standard unit. Speed Compensated Volume allows
the user to select one of three preprogrammed compensation settings to automatically adjust the unit for increases or decreases in road noise stemming from vehicle velocity changes. The Auto Tone Control allows the user to select one of six preprogrammed equalization settings for the unit.

**Figure 1: 1995 AM/FM/Cassette with Auto Tone Control**

**METHOD**

**Participants**

Forty-one volunteer male drivers were selected from several locations around the United States. These subjects were all members of diverse groups who drove primarily fleet vehicles of one sort or another (Sheriff’s Departments, cab companies, salesmen, bank employees, etc.) For the equalizer-equipped radio, participants were recruited from Kokomo, Indiana, Pittsburgh and Alleghany, Pennsylvania, and Brevard County, Florida. For the standard radio, testing was performed in Kokomo, Indiana, Phoenix, Arizona, and San Diego, California. Age of the primary drivers in each case ranged from mid-30’s to late-60’s, with a mean age of approximately 44 and a median of 46. These numbers may be misleading; the vehicles were in the possession of the participants for an extended period and it was not possible to ascertain exactly who was driving at any given point (i.e., family members often had access to the vehicles as well as the primary drivers). The drivers were roughly selected to gain a cross-section of educational, professional, and socioeconomic backgrounds.

**Test Procedure**

Delphi Delco Electronics equipped 41 vehicles with specially modified car stereos designed to record the number of times users operated each control, as well as other parameters such as what playback mode the units were in and the amount of time spent with various listening options set. The stereos were then placed in fleet vehicles and were in continuous use for periods ranging from 3 to 6 months. Data were periodically collected from the units during routine dealer maintenance checks. This technique was selected for a variety of reasons: 1) it allowed users adequate time to become familiar with all of the audio system features and functions; 2) it provided the opportunity to collect data across the entire spectrum of normal driving (city, highway, local area, cross-country, etc.); and 3) it was largely non-intrusive with respect to the subjects’ normal driving behavior.

During the course of the study, the equalizer-equipped radios were used for an average of 127 hours across subjects (std. dev. = 80 hours). This ranged from a low of 39 hours to a high of 298. The data from the standard radios represents an average of 189 hours of use per participant (st. dev. = 146 hours). This ranged from a high of 658 hours to a low of 24 hours. Data collected from both radios represents almost 6300 hours of total use, approximately evenly split between the two types of unit.

Once collection was complete, the data were compiled, summarized, and analyzed. Since each subject used the vehicles and radios involved for a different amount of time, the data were normalized to number of control operations per hour of radio use. Summary statistics on frequency of use of various radio options and playback modes were also recorded.

**RESULTS**

Examination of the data revealed that frequency of use tended to break out into groups of controls with similar levels of usage, but not by individual control. The data were examined by performing an ANOVA on the number of activations per hour for all controls and then using Student-Newman-Kuels tests to identify patterns within the data when significant F-statistics were found. Since the two radios did have somewhat dissimilar options, the data were analyzed for each unit.
separately, and then combined to look for patterns of usage across platforms.

**Standard Radio**

Results for control frequency of use are presented below. Figure 3 shows the relative frequency of operation for each control and its associated 95% confidence interval. An ANOVA was performed on this data to discover whether any significant differences existed between controls in terms of frequency of operation \( F(23,384) = 25.536, \alpha \leq .001 \). Table 1 shows the results of the Student-Newman-Kuels tests which were used to define homogenous groups of controls \( (\alpha = .05) \). [Controls with asterisks in the same column do not differ significantly from one another.]

**Equalizer-Equipped Radio**

Results for control frequency of use are presented on the following page. Figure 4 shows the relative frequency of operation of each control and its associated 95% confidence interval. An ANOVA was performed and it was determined that significant differences did exist in patterns of use among the controls \( F(18,437) = 20.785, \alpha \leq .001 \). Table 2 shows the results of the Student-Newman-Kuels test indicating where significant differences existed at the \( \alpha = .05 \) level. Volume was again found to be used significantly more often than any other control, being accessed an average of more than 16 times per hour. Preset Operations (setting and recalling station presets) and the Seek function fell into a second tier of controls which were accessed on average between 4 and 5 times per hour, but did not differ significantly from one another. All of the remaining controls fell into a third tier whose usage ranged from 0/hour (Dolby and Theft Deterrent) up to almost 1.5/hour (Auto Tone Control).

Other data of interest from this study included such information as the frequency of use of various radio options such as Playback mode, Auto Tone Control and Speed Compensated Volume settings. Analysis of the data revealed that FM1 was used significantly more than any other playback mode (50% of the time) \( F(3,64) = 14.955, \alpha \leq .001 \), followed by AM (21% of the time), FM2 (16% of the time), and Cassette (13% of the time). None of the lesser used modes differed significantly from one another. The “Manual” Auto Tone setting was used significantly more often than any of the other modes (53% of the time) \( F(5,96) = 11.105, \alpha \leq .001 \), followed by Rock (19%), Pop (10%), News (8%), Jazz (6%), and Classical (4%) [none of which differed significantly]. The most frequently used Speed Compensated Volume setting was Level 3 (44% of the time), followed by Level 2 (25%), Level 0/Off (19%), and Level 1 (12%). The only significant differences between these levels lay between Level 3 and Level 1 \( F(3,64) = 4.199, \alpha \leq .009 \).
once per hour and which did not differ significantly among themselves. Optional settings on the equalizer-equipped radio were far more limited than on the standard unit. Analysis of the data revealed that FM1 was used significantly more often than the other playback modes (63% of the time) \([F(3,92)=26.421, \alpha < .001]\) followed by AM (19% of the time), and FM2 and Cassette (both at 9% of the time). None of the other modes differed significantly from one another.

![Figure 4: Control Operations Per Hour (Equalizer Radio)](image)

### Table 2: Homogenous Control Groups (Equalizer Unit)

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### Table 3: Homogenous Control Groups (Combined Data)

When the two radios were compared using MANOVA, significant differences were found in control use patterns \([F(17,23) = 2.449, \alpha = .031]\). Examination of the univariate ANOVAs revealed the following:

a) The volume control was used significantly more often on the standard radio than on the equalizer-equipped unit [16.36 times/hour versus 8.79 times/hour] \((F = 9.613, \alpha = .004)\).

b) The Seek control was used significantly more often on the standard radio than on the equalizer-equipped [3.83 times/hour versus .58 times/hour] \((F = 6.228, \alpha = .017)\).

c) The Fade control was used significantly more often on the standard radio than on the equalizer unit [.49 times/hour versus .12 times/hour] \((F = 9.022, \alpha = .005)\).

No other differences were noteworthy.

One of the minor objectives of this study was to evaluate the efficacy of using self-reporting techniques for similar studies in the future. When subjects were asked to subjectively rank order how often they felt they had used each control, it rapidly became apparent that...
they had only a very limited ability to accurately perform this task beyond the top two or three most commonly used features. As a result of this finding, it is not recommended that the self-report technique be used in future evaluations of this nature if alternatives exist. A scatterplot of subjects’ self-reported priority of use versus the actual frequency data derived from this study is shown in Figure 5.

Figure 5: Self-Reported vs. Actual Control Usage

**DISCUSSION**

The primary objective of this study was to derive objective frequency of use data to allow the designers of automotive stereo gear to locate the most commonly used functions in the most convenient locations for the operator and to determine which features are appropriate for inclusion in future audio components. It was disappointing not to find more significant differences in usage patterns for individual controls, but knowing which controls have more or less equivalent levels of usage is definitely helpful.

Analysis of the patterns of other mode and control use was also of great value. The fact that the standard radio showed significantly more adjustments to the volume control than did the equalizer version is a strong indicator that the algorithms used to compensate for road noise in the Speed Compensated Volume function were not optimally set. This problem has since been addressed, and a new version of this feature will begin appearing on 1999 vehicles. The difference in use for the Seek function between the two units is also interesting. The Seek control on the standard radio is a horizontal unit, with a press on the left side of the button causing the unit to seek down from the current frequency. A press on the right side results in the unit seeking up from the current frequency. The control on the equalizer unit is vertically orientated, employing a press on the top to seek up in frequency and the bottom to seek down. The difference in level of use between the two units could possibly indicate that the users’ mental representation of this function corresponded more closely to the horizontally sliding indicator used on older audio units, than to one analogous to an upward or downward shift in radio frequency. This could also simply represent an artifact in the study. The fact that the most commonly used setting for the Auto Tone Control was the “Manual” mode is also disturbing. This seems to indicate that the preset equalization settings do not closely match those preferred by the listening public.

The methodology in this study was largely effective in producing the desired information. The only major drawbacks were that in many cases, it was not possible to leave the radios in the subject vehicles for as long as had been planned (only 3 months average versus the 6 months originally called for) and that it was not always possible to tell who had been operating either the vehicle or the stereo (many vehicles were also driven at times by spouses and children of the participants involved). It is also possible that the low use of cassette playback functions may be an artifact of the study, rather than a true usage pattern. Subjects were not allowed to select their preferred type of playback unit; it is possible that, given the growing prevalence of CDs in the marketplace, a different pattern of use for these functions would have been detected had this type of unit been used. No unit of similar size is currently available which incorporates both types of playback (a priority for this study, since the units had to be adaptable to a variety of vehicles.) A similar study of control use with CD units is tentatively in the planning stages. Also, a series of similar studies designed to evaluate the intuitiveness of the radio displays and controls for naïve users is also being considered.

**REFERENCES**


