THE DEVELOPMENT AND APPLICATION OF A CHILD RESTRAINT USABILITY RATING SYSTEM

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ABSTRACT

This paper describes the development, validation and application of a usability or "ease of use" rating system for child restraints and the design changes that have evolved.

The rating system was developed in response to concerns about the high incidence of child restraint misuse and the potential for reduced protection during a collision. The objectives were to help consumers choose child restraints that are easier to use and to encourage manufacturers to improve the usability of their products.

A research program to develop the rating system was undertaken by RONA Kinetics with the support of the Insurance Corporation of British Columbia in Canada. It included participation by members of the ISO child restraint working group, regulatory authorities, vehicle and child restraint manufacturers, child passenger safety technicians, IIHS and consumers. A sample of some 30 child restraints (from N. America and Europe) was used to identify key child restraint use features that were ranked according to the risk of injury if misused. Objective criteria and tests for rating the individual features and a method for calculating the rating scores were developed.

The rating system was first used to rate 80 child restraints for ICBC consumer guides. It is the basis for the NHTSA child restraint ease of use rating program. It is being used in new ISO work related to the usability of ISOFIX (LATCH/UAS) features. Its current use and areas in which the rating system may be upgraded are considered.

The rating system provides an objective means of evaluating the usability of child restraints. It addresses features related to the safe use of child restraints that are not included in current regulations. Since its application, child restraint manufacturers have improved the usability of their products thereby reducing the risk of misuse and increased child passenger protection.

INTRODUCTION

In this paper, unless specified otherwise, the term "child restraint" is used to refer to rear-facing and forward-facing restraint systems as well as booster cushions as described in the Canadian Motor Vehicle Safety Act (RSSR). The effectiveness of child restraints in preventing or reducing collision trauma is well established. Their effectiveness depends, however, on their proper use. The misuse of child restraints is reportedly high and child restraint inspection clinics often report misuse of up to 90%. There is a shortage, however, of data on the type and nature of misuse. Misuse observed and reported at child restraint clinics ranges from minor errors, with no or little effect on safety, to gross misuse which is likely to significantly reduce the performance of child restraints in real collisions. Available data indicates that the incidence of "gross" misuse is relatively low and may be less than 5-10% of the observed misuse (Legault and Pedder, 1999). Field data demonstrates that the children who are most likely to be seriously injured in an otherwise non-injurious or survivable collision, are those who are either unrestrained or are secured in a restraint system too large for their size. Test data also shows that some of the types of misuse included in child restraint clinic reporting is relatively minor and will not have a significant effect on child restraint performance (Lalande et al., 2002).

In exploring how best to get all child occupants in an appropriate restraint, consideration was given to concerns about the complexity of using current child restraints properly. In a usability study conducted for Transport Canada in BC (Noy and Arnold, 1995) to identify features to determine which product features contribute to proper and prolonged use of child restraints, it was confirmed that some types of misuse were associated with poor instruction or complicated design features. The study was conducted so that such features may be addressed in the regulations governing restraint systems for children. It has been known for a long time that child restraints that are easier to use are more likely to be used correctly.

Current child restraints are often complicated or difficult to use properly.

In an effort to promote child restraints which are easy to use properly and to reduce the opportunity of misuse, the Insurance Corporation of British Columbia funded a project to develop objective tests and criteria to rate the usability of child restraints. The Insurance Corporation of British Columbia is a public agency in Canada which was established in 1973 to provide universal auto insurance to motorists in British Columbia, Canada. ICBC is also actively involved in provincial child passenger safety efforts.

DEVELOPMENT OF THE USABILITY RATING SYSTEM

The final rating system was developed by RONA Kinetics and Associates in North Vancouver, Canada in 1999 for the Insurance Corporation of British Columbia with input from local and international child restraint and safety experts. Initial work in the development of the usability rating system took place during two consecutive two-day meetings in July 1999 which were organised by RONA Kinetics and hosted by ICBC in Victoria, British Columbia, Canada. The first two-day meeting involved six invited members of ISO/TC22/SC12/WG1 (child restraint systems) and one safety restraint expert who was actively involved in the development and use of educational material for proper child restraint use. The primary purpose of this meeting was to identify child restraint use features and rank their importance according to risk of injury if misused. Samples of different types of child restraints as well as four vehicles (a 2-door and a 4-door car, van and sports utility vehicle) were used to assist in this work. Based on Misuse Mode and Effects Analysis procedures (Czernakowski and Müller, 1991) individual features pertinent to child restraint use were identified, their function noted and the potential misuse modes considered. The effects of the different misuse modes were then examined and according to the severity or effect on safety, the importance of each feature was ranked as A, B or C according to the risk of injury if misused. An “A” rating was used if the proper use of the feature was essential for the full protection of the child and if there was a high risk of injury if the feature was misused. In comparison, a “C” rating was assigned to features deemed less important to the proper use of the child restraint, with no or insignificant effect on safety if misused. At the same time, work was also initiated on the development of criteria and objective tests for rating the individual features.

The ranking of the level of importance of each feature was conducted by the team of experts based on their combined and considerable knowledge and experience of child restraint systems which included collision investigation, child restraint laboratory testing, vehicle and child restraint manufacturing as well as the use of child restraint systems by parents and caregivers. Reference was also made to published work by other authorities.

INPUT FROM INVITED CPS SPECIALISTS

The second meeting involved six invited safety specialists and consumers. The primary purpose of this meeting was to rate individual products using the usability criteria developed during the first meeting. A rating form based on the outcome of the first meeting was prepared and different versions of the form were tried during day one. The rating form included only three options for each feature. Initially, consideration was given to allowing for more options, however for many features it was difficult to provide more than three options and often they were no longer meaningful. It was decided that the ease of use characteristics were best rated according to three options, i.e. good, average, and poor. During day two, the rating form was used to rate individual restraints by three teams of two. Each restraint was rated by two or more teams and the results of the rating compared for repeatability. The rating form was revised to address repeatability problems. Not surprisingly, the repeatability of the features reflected the potential to objectively assess the features. For example, ease of tightening the tether was rated as good if it could be tightened by a simple pull with one hand and poor if otherwise. There was 100% repeatability in the rating of this feature. In comparison, the rating of the child restraint manual was initially less repeatable where it depended on the interpretation by the evaluator. To improve repeatability, brief descriptions of usability characteristics were included on the rating form within each rating category. Repeatability was further improved by the fact that the overall usability rating of each different usability category was calculated from the rating of several features pertinent to that category.

The rating form was finalised by RONA Kinetics after the meetings to ensure that the rating of different restraints was repeatable with at least a 95% confidence level. To further promote repeatability, a rating manual was prepared that included illustrations of examples of good, average and poor features.

USABILITY FEATURES

The child restraints were rated on the following features.

1. Ready to use

This rating was based on whether the restraint required additional assembly or if it was ready to use. A "good" rating was given to restraints which did not need any assembly (of safety features) before use.

2. Instructions for use

This rating was based on whether instructions were easy to understand, included clear illustrations and contained all the information necessary for securing the child in the child restraint and installing the restraint in a vehicle.

3. Ease of Conversion

Child restraints that could be used in different modes were rated on how easy it was to convert them from one mode to another. This included ease of changing the harness strap position. Also considered was the ease of removal and replacement of the seat cover or pad for cleaning.

4. Labelling on the child restraint

This rating was based on the clarity and completeness of the labelling on the restraint itself. A "good" rating included clear seat belt routing diagrams or markings, clear tether use illustrations, airbag warnings, usable harness slots and clear identification of the size of child that could use the restraint.

5. Securing the child in the restraint

This rating was based on the ease of tightening or loosening the harness, the number of harness height adjustment slots (more than one is better), whether the buckle could be released when secured in the correct or reverse position, whether the restraint had a belt positioning guide, and whether the guide could be used easily without causing belt slack.

6. Installation of child restraints

The child restraints were not installed in a motor vehicle, however consideration was given to such features as whether there was sufficient hand clearance or access to the seat belt routing path.

7. Tether straps

The ease of tightening or loosening the tether strap was an important feature as Canada requires forward-facing child restraints to meet head excursion limits that are typically met through the use of a tether strap. Tethers which tighten with a single pull were rated "good". Tether straps requiring tightening by threading through a buckle were rated "poor".

CHILD RESTRAINT RATING PROTOCOL

Three sets of forms were developed and colour-coded to rate each mode of use of each child restraint, viz. rear-facing, forward-facing with harness and tether, and booster seats. Each child restraint was rated independently by two evaluators. The rating of the child restraints was initially conducted at RONA Kinetics by technicians experienced in child restraint performance in collisions. The rating was later undertaken by child passenger safety (CPS) technicians who were given a one-day training in the completion of the rating forms. The rating by each evaluator was then compared and when a feature had been rated differently by the evaluators, the feature was re-examined and a decision made. If appropriate, the feature was documented and photographed for inclusion in the manual and consistent future ratings. Hard copies of the forms were preferred by the evaluators as it enabled them to annotate or comment on features that may be new or they were unclear how to rate. The data was then entered into an excel table for calculation of the final rating in each category.

CALCULATION OF RATING SCORES

As noted above, the importance of each feature was ranked as A, B or C according to the risk of injury and severity of misuse. In the calculation of the rating scores, this importance ranking was used as a fixed weighting factor for each feature. Each weighting factor was assigned a numerical value of A=3, B=2, and C=1. The individual features of each child restraint were then assessed using the rating form and rated as "good", "average", or "poor". These were also assigned a numerical value where good=3, average=2, and poor=1. The overall rating was calculated by multiplying the weighting factor by the score given during the rating of that feature by the evaluator. If a feature was not applicable for a given child restraint, both the rating and the weighting factor became zero and the feature was excluded in the calculation of the final rating. The final rating of each usability category was calculated from the sum of the weighted ratings of individual features divided by the total number of features.

ICBC CONSUMER GUIDE

The usability rating system was first used by the Insurance Corporation of British Columbia in the rating of child restraints for the ICBC consumer guide "Buying a Better Child Restraint" published in 1999. Based on the premise that a child restraint that was easy to use was more likely to be used and used correctly, the guide rated child restraints sold in Canada on their usability. The guide provided the individual scores for each of the rating category. The guide was published to help parents and caregivers make informed decisions when buying a child restraint. The guide included infant and child restraints as well as combination harness/booster systems and booster seats sold in British Columbia. The seats were also available across Canada. The guide also provided information to help consumers select the appropriate type of restraint for best fit and had a shopping checklist with key safety and usability features.

The ICBC "Buying a Better Child Restraint" was updated annually for four years with ratings on current and new child restraints products Informal feedback indicated that the guides were used by consumers when they purchased a new child restraint. The guide was used by some local retailers in the selection of child restraints to be offered for sale in British Columbia.

In the ICBC guide, the ratings were not combined to provide an overall rating of each child restraint. An overall rating was not provided out of concern for the possibility that consumers would assume a restraint with the "best" overall rating would be the best and safest restraint in their vehicle. Emphasis was given in the ICBC guide to ensure the restraint properly fits the consumer's vehicle.

At the time of publication, there were no child restraints sold with the universal attachment system (UAS). These systems are known as LATCH (Lower Anchors and Tethers for CHildren) in the United States and based on the ISOFIX concept. It was anticipated that when UAS became mandatory in Canada in 2002, the usability of these systems would be considered.

ISO CHILD RESTRAINT TASK FORCE

The same rating system model was adopted by the child restraint usability task force of ISO/TC22/SC12/WG1. The task force is currently developing a rating system specifically for ISOFIX features. It includes the rating of ISOFIX features on the child restraint and in vehicles, as well as the ease of installing an ISOFIX child restraint in a specific vehicle.

NHTSA RATING SYSTEM

In 2002, NHTSA introduced an ease of use child restraint rating system that was modelled in the rating system used by ICBC (NHTSA, 2002). The ratings are posted on the NHTSA website (www.nhtsa.gov).

The NHTSA rating system included most of the same features, however, child restraints were rated under four ease of use categories: assembly; evaluation of labels and instructions; securing the child; and installation in the vehicle.

The rating score for individual features was determined in the same manner (weighting factor x feature rating score). The weighted average for the category was calculated by dividing the sum of the feature rating score by the weighting factor. Each category was then given a rating based on the weighted average: A = 2.40 to 3.00; B from 1.70 to < 2.40; C < 1.70.

The ICBC website now links directly to the NHTSA ratings for those products sold in Canada (http://www.icbc.com). Only products that meet the Canadian Motor Vehicle Safety Standards are legal in Canada.

EFFECTIVENESS OF THE RATING SYSTEM

It is difficult to know what, if any, effect the ICBC child restraint usability rating guide had on products and buying trends. It did, however, provide a means of educating parents, caregivers, and educators on the importance of checking the ease of use of different features of the child restraints. It provided them with a guide in finding the appropriate restraint for their child. It also provided child restraint manufacturers with a tool for the assessment of the usability of their new and current products.

There appeared to have been an improvement in the labelling of some products since the first usability guide in 1999, although further enhancements will probably only be realised with regulatory revisions, such as the need to include pictograms for our multicultural population, many of whom can speak little English. Current French/English text

requirements may prevent the use of visible pictograms on the sides of the child restraint.

With the implementation of the NHTSA ease of use rating program, there was a noticeable improvement in the usability of the child restraint features that were rated. These improvements were observed on products sold in Canada and the United States. Some examples of the improvements that seem reasonable to assume were promoted by the ease of use rating system follow.

Ready to Use
Significant reduction in products that came disassembled or products that required harness removal to enable the child restraint cover to be fitted.

Instruction and Labelling
Increase in the use and clarity of illustrations including pictograms on both the child restraints and in the child restraint manual. Routine attachment of the manual to the child restraint at point of sale, so the manual remains with the child restraint itself when first purchased. Better consistency in the size and mass limits given on the child restraint labels compared to the manual.

Securing the Child in the Restraint
Harness height adjustment systems that could assume multiple positions without the need to re-route the harness.

Installation
Fewer belt positioning guides on boosters that could introduce inadvertent seat belt slack. Separation of the seat belt path from the harness system.

Tether Straps
The increase in easy to use tether straps that could be tightened with a single pull in replacement of tether straps requiring threading through the buckle to tighten.

AREAS FOR IMPROVEMENTS

The significant improvement of those child restraint features considered in the ease of use rating is reflected in the latest NHTSA rating where the majority of products were rated A or B. The rating system has clearly been successful in promoting some ease of use features, however, as observed by CPS advocates, many child restraints remain difficult to use and to use properly.

There is now a need to better discriminate between the ease of use of new child restraints. This includes the need to rate the ease of use of UAS/LATCH systems.

It is also important to recognise better and easier to use products that include such features as: easy to use manual storage pockets accessible in all modes of use; uniform harness adjustment; better size range to promote longer use of harness systems and discourage premature graduation to booster seats and seat belt systems; continued awareness of airbag related safety issues.

Issues of child restraint/motor vehicle incompatibility are not addressed by the ease of use rating system. In Canada and the United States, any child restraint can be bought and used in any motor vehicle. Even child restraint systems which are rated as easy to use may not be the best for the intended vehicle. It was hoped that some problems of compatibility would be overcome with the introduction of the universal anchorage system. Usability problems have been observed with some LATCH (UAS) systems (Decina, 2006). Hopefully, they will be addressed through improved design and also the possible introduction of criteria for rating LATCH (UAS) systems by NHTSA. It would probably be of benefit if the rating of these systems harmonised with the work of the ISO/WG1 task force on usability.

CONCLUSIONS

The usability rating system has provided an objective means for assessing the ease of use of different child restraints. The repeatability of the rating system was better than 95% among trained evaluators.

It addresses many features related to the safe use of child restraints that are not included in current regulations.

Since the introduction of the usability or ease of use rating system, the usability of child restraints has improved with a resulting reduced risk of misuse and increased child passenger protection.

The child restraint usability system provides an educational tool for parents and caregivers.

The rating system needs to be regularly updated to reflect new design features and to encourage manufacturers to continue to improve their products and make them easier to use.

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DISCLAIMER

The conclusions reached, and opinions expressed, in this paper are solely the responsibility of the authors.

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