Linking Human Factors and Reliability to Create Button Specifications for a Remote Control

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Abstract

This paper describes the successful linking of Human Factors and Reliability (QR) testing, to provide button specifications for remote control vendors. In a human factors test, participants provided qualitative feedback describing buttons as too sensitive, too hard to engage or lacking feedback (verification). This qualitative information does not provide a definitive measurement. Likewise, quality and reliability testing of the same remotes established the force to engage the buttons, providing a quantitative performance and reliability measure, with no link to perception. To give meaning to the data, we compared the analytical machine measurements of four remotes with subjective human analyses of the same units. Correlating the machine characterization with the qualitative human impressions resulted in meaningful button specifications. The primary benefit is the simplification of product design as these specifications can be reused. Additionally, being able to quantify human factors results becomes considerably more important in this increasingly outsourced world.

Reliability Testing Overview

For standard QR testing, a two part methodology is used.

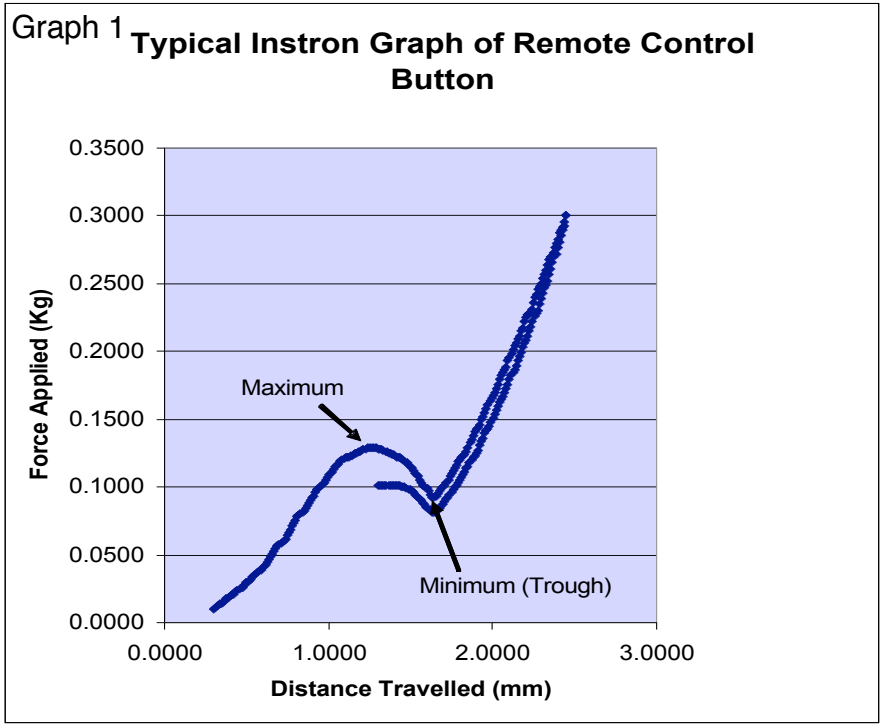
- First machine characterization of button response is found using an Instron Tester (Illustration 1).
  - The Instron tester has a probe which pushes on a button in order to measure:
    - the force applied to initiate an action (sensitivity)
    - and the point at which a button is fully engaged
    - the ratio between these points (verification)
    - the distance between these two points (crispness)
- After these characterization values are determined, another machine called the Remote Exerciser pushes the tested button thousands of times.
  - This machine stressing provides a reliability over time measurement.
    - At periodic intervals, the button is retested on the Instron tester.
    - If the characterization values remain the same then the button is shown to be reliable.

Illustration 1-Instron Tester

Instron Testing Methodology

- We decided that correlating the HF results with the results of the first step (Instron testing) would help us quantify such elusive feedback as:
  - "these buttons require too much force" and
  - "the buttons on this remote provide no feedback"
- The results of Instron testing are typically displayed in a force vs. displacement graph
- Graph1 is an example of typical results from the Instron tool
  - The height of the peak shows the force required to initiate an operation.
  - The trough indicates the force experienced when a button is completely engaged.
  - The ratio and distance traveled between the peak and trough affect the human perception of crispness and verification.

Graph 1 **Typical Instron Graph of Remote Control Button**

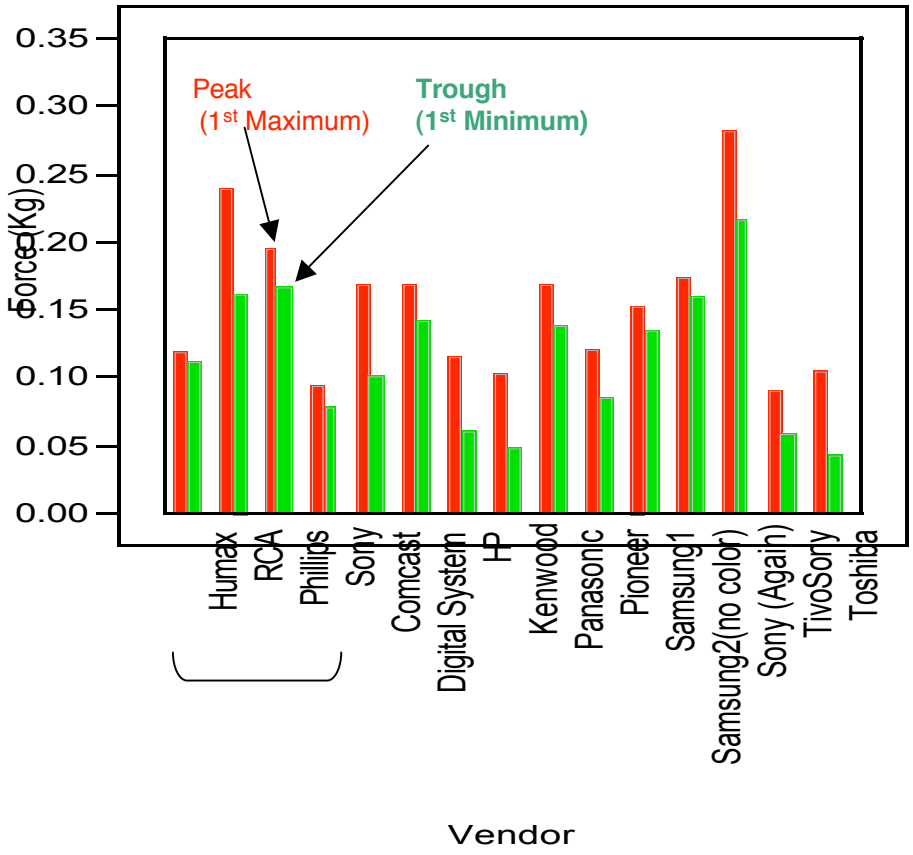


Typical force vs. distance traveled graph from the output of the Instron measurement tool. The x-axis is the displacement of the probe as it pushes the button. The y-axis is the force of the load placed on the button as it is pressed. The height of the maximum 1st (peak) is the force customers must apply to the button to initiate the operation (click). The minimum 1st (trough) is the force customers will experience when the button has reached its full operation. Important parameters for feel are the height of the peak & trough (i.e. force), the ratio of peak to trough and the difference between the distances traveled for the peak and trough.

Instron Testing Results

- All remote designs were characterized on the Instron button tool.
- For this test the channel button was used on all remotes.
- Initially single samples of many remotes were tested to determine variability among manufacturers
- The four test remotes represent the spectrum of values found across the individual sampling.
- Humax (Tivo), RCA, Phillips and Sony values (the four test remotes, shown in Illustration Two) were the mean of 5 remote samples each, while the other remotes were single samples.
- Initial peak and trough forces found for these remote buttons are shown in Chart 1a.
- The height of the peak is a measure of force to engage a button (or sensitivity) so higher values indicate that more force is required to engage.

Chart 1a- Force to engage button (Kg) and Crispness of button (ratio of Peak to Trough height)



Maximum-Peak (red) and Minimum-trough (green) force values are shown for several manufacturers using the Instron test tool. Note how the 4 test remote controls (shown by the bracket under the names) represent the spectrum of values

Illustration Two-Four remotes tested

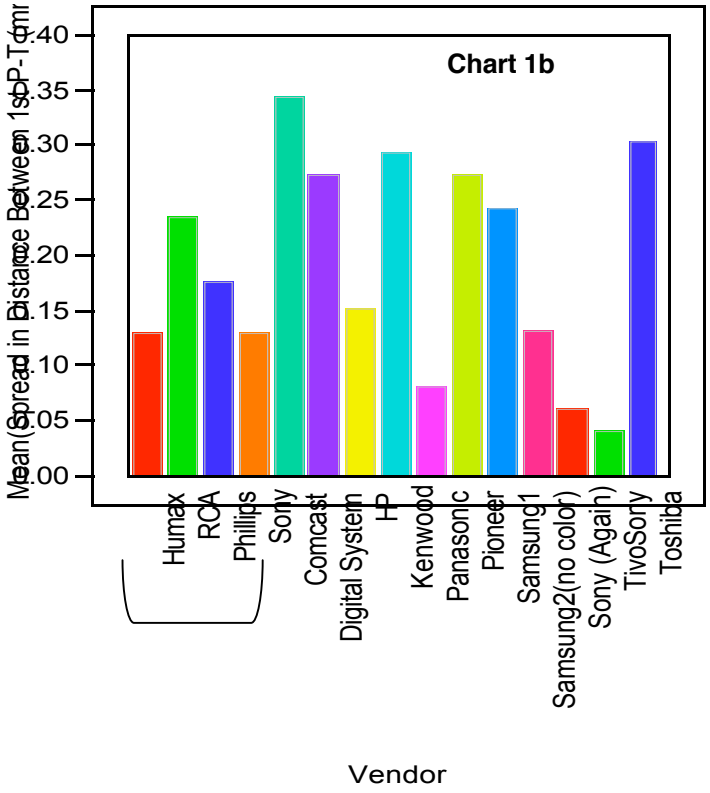
Sony RMV302 5 Device Universal Remote Control

RCA Remote Control RCU-300

Philips Magnavox PMDVR8 8-Device Universal Remote with Keys for TiVo and ReplayTV

NEW Series 2 Remote for Standalone TiVo DVRs

Instron Test Results



Distance traveled between the button peak and trough (spread) for several remote control vendors, shown in millimeters. The 4 test remote vendors are bracketed (Humax [Tivo}, RCA, Phillips and Sony). The spread values for the test remote vendors were the mean of 5 remote samples from that manufacturer while the other samples were single samples

- For these same remote controls, the spread in distance traveled between the maximum and minimum is shown in Chart 1b.
- Note how the amount of force required in the peak and the trough strength has no relationship to the spread in distance traveled.
- From a human perspective, this set of measurements is therefore a measure of button sensitivity to engage (crispness).

Human Factors Testing Overview

Illustration 3-A participant examines button layout of two DVR remotes, during post task discussion.

- Though we were able to use the data in a different way, the main objective of the Q/R tests were to establish reliability over time.
- Similarly the main objective of the Human Factors test was to examine ease of use for button layout and labeling.
  - A secondary objective was to gather preference data regarding tactile feedback of buttons.
- The HF test was conducted independently of the Reliability tests.
  - Results were analyzed independently and conclusions were not shared until both sets of tests were completed.

HF Testing Methodology

- In the HF study, user preferences of button attributes including shape, size, texture and tactile feedback were explored.
- Twenty participants participated in one hour individual sessions.
- Participants performed simulated tasks on the remotes (Illustration 4) prior to providing feedback.
  - Remote use was counter balanced.
- Representative tasks included
  - turning the TV on
  - adjusting channel and volume
  - using DVD/DVR controls
  - accessing and using the menu
  - using mute and previous channel
- Qualitative feedback regarding force required to engage the button (sensitivity) and feedback that an action has been initiated (verification) were gathered.
- Additionally, overall preferences of tactile feedback (crispness) and anecdotal descriptions of the buttons and button layout and labeling for each of the 4 remotes (see Illustration 2) were recorded.

Illustration 4-Performing Simulated Tasks

Results HF Test

- Preference data ranking button attributes

Button Attributes	1	2	3	4
Soft touch to engage	Humax	Sony	Philips	RCA
Strongest feedback	RCA	Sony	Philips	Humax
Best size	Sony	RCA	Humax	Philips
Clearest labeling	Sony	RCA	Humax	Philips
Crisp Feel	Sony	Philips	RCA	Humax
Best Texture	Sony	Philips	Humax	RCA
Preferred overall	Sony	Philips	RCA	Humax

Spontaneous Participant Comments

	RCA	Sony	Philips	Humax
Force	These are too hard. (2)	These are easy to push. (3)	These are too hard.	These are just too sensitive
	They require too much force. (2)	These have an easier touch.		These are too soft.
	Seems like this type of button would get stuck down because you press so hard.	These are easier to push but ….		
	….. I have to push too hard.			
Feedback/Verification	They give good feedback but…	….give less feedback than the first one. (RCA)	These provide an ok response but neither is very good. (referring to Humax)	I feel no response.
				There is just not enough feedback, it already feels pushed.
				...neither is very good. (referring to Pilips)
Crispness of response	Good response but it takes too long to complete(4)	I think it is a quick and clear response	Response is good but the hard buttons don't provide an easy snap. I prefer the Sony button response.	These move too much. (3)
				It is hard to tell when there is a response and if the action is completed because of the wiggling of the buttons.

Correlating Results

- Human factors testing found that participants:
  - Did not like the high force used to engage the RCA remote buttons (i.e. Force to push button to peak).
    - Did not like the minimal force or squishy feel of Humax buttons
    - The Sony was just about right.
  - Appreciated the validity of knowing that the button was successfully engaged
    - RCA remote buttons (ratio of peak to trough) gave the strongest indication of feedback
    - The Humax remote did not provide this kind of feedback.
  - Liked to have the distance traveled from the peak to the trough be significant but not too much.
    - The RCA was too much
    - Phillips and Humax too little.

Recommendations

- Correlating these qualitative human impressions with the machine characterization resulted in the following specification recommendations for remote control buttons:
  - Force to initiate the remote button operation should be somewhere between 0.15Kg and 0.2Kg (could be thought of as ‘Sensitivity’),
  - Ratio between remote button peak and trough forces should be at least 1:0.8 with a higher ratio being better (could be thought of as ‘Verification’),
  - Distance traveled between the peak and trough should be less than .25 mm (could be thought of as ‘Crispness’)

Conclusion

- This effort maximized the results of both Human Factors and Quality/Reliability testing
  - Instead of only affecting button size, shape, labeling and layout, HF customer input was used to determine product specifications
  - Additionally, instead of determining strictly the reliability of the buttons, QR results were able to create specifications that included human perceptions
- Correlating subjective qualitative human perceptions with quantitative machine analytics resulted in meaningful data for product design.
  - These results allowed us to create meaningful specifications for vendors.
- Finally, these button specifications can be reused for similar products requiring remote controls.

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