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A Study on Consumer Noticeability: Performance Differences of Portable Battery-Powered Devices

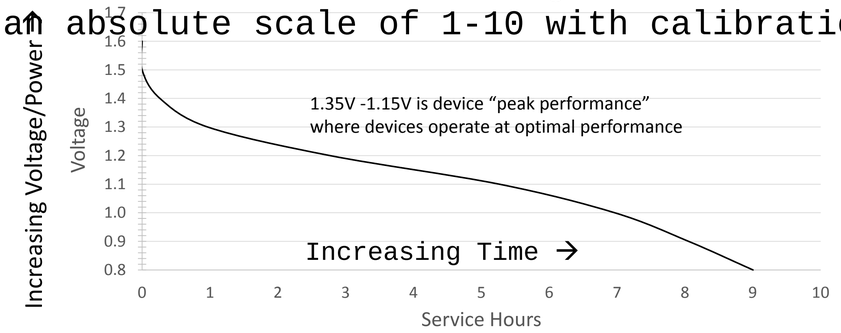
Jessica Joubert, Nancy Dempsey and Ray Iveson

Introduction

There are over 1.1 billion battery-powered devices in the US that use disposable batteries. About 1/3 of these devise are constant resistance devices whose performance is dependent on the load voltage provided by the battery. Users of these devices rate the performance and their satisfaction with these devices based on the intensity of the sensorial signals provided by the devices. These signals can include movement (as with motorized toys), vibration (as with toothbrushes and grooming devices), light intensity (as with flashlights), and sound (as with a multitude of devices). In typical constant resistance devices, these signals will change over time as the battery life and load voltage declines. The decline in load voltage can drive lower sensorial output which, in turn, can drive lower consumer satisfaction.

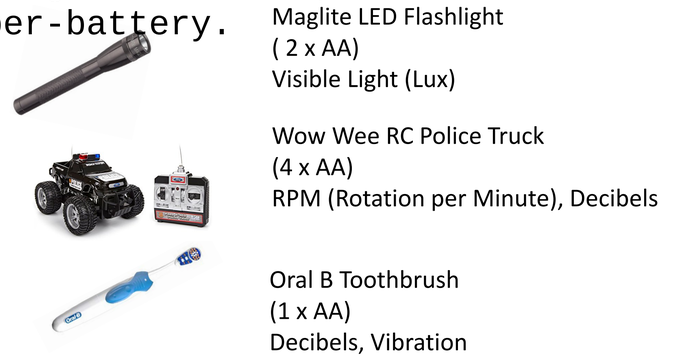
Methodology

To determine consumer response to a range of device performance that would be experienced by users, a range of load voltages was supplied to a commonly used set of constant resistance devices. Load voltages supplied by typical disposable batteries range from 1.5V-per-battery to a device cutoff of approximately 0.9V-per-battery. Given the relatively short times batteries perform at high load voltages, for this study, consumer response was measured for the load voltage range of 1.35V-per-battery to 0.8V-per-battery at roughly 0.05V increments. Although results were consistent across this entire range, data for the 1.35V-per-battery to 1.15V-per-battery range only are presented and discussed here. Three (3) devices were used as stimulus, demonstrating sensorial signals of movement, vibration, light and sound and load voltage and current was controlled by power supply to minimize variation that might be experienced using batteries. Users were asked to grade device performance on an absolute scale of 1-10 with calibration to each device's performance at 1.5V-per-battery.





Keithley Model 2200 DC Power Supply



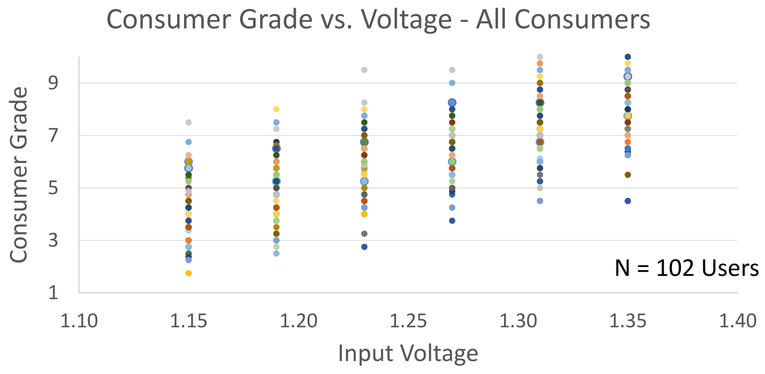
Maglite LED Flashlight
(2 x AA)
Visible Light (Lux)

Wow Wee RC Police Truck
(4 x AA)
RPM (Rotation per Minute), Decibels

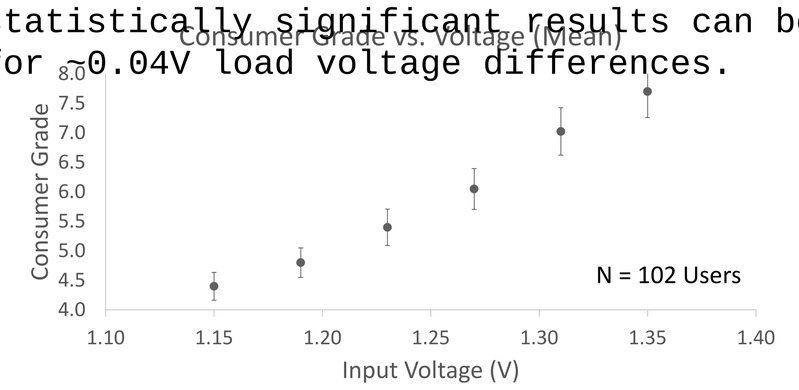
Oral B Toothbrush
(1 x AA)
Decibels, Vibration

Results

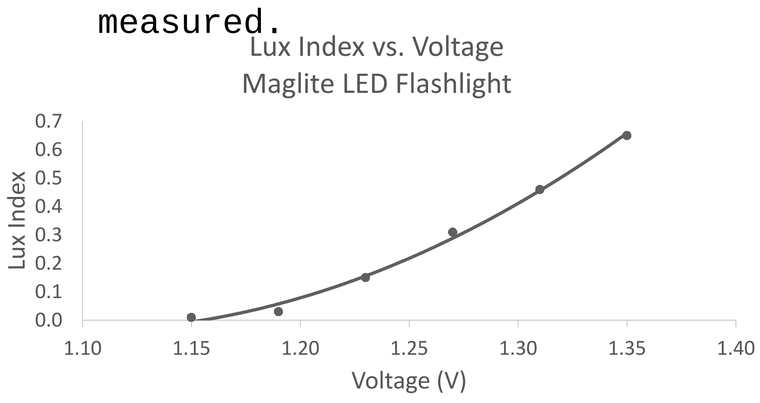
Figure 1 shows wide variation among panelists in the absolute grades judged for device performance at each load voltage. This "noise" is inherent in any user test involving untrained graders and has been demonstrated repeatedly in home-use testing.

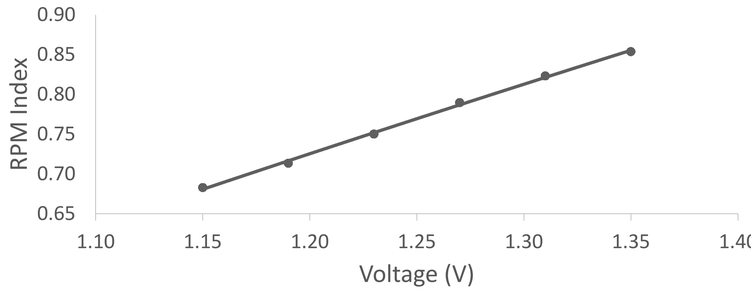


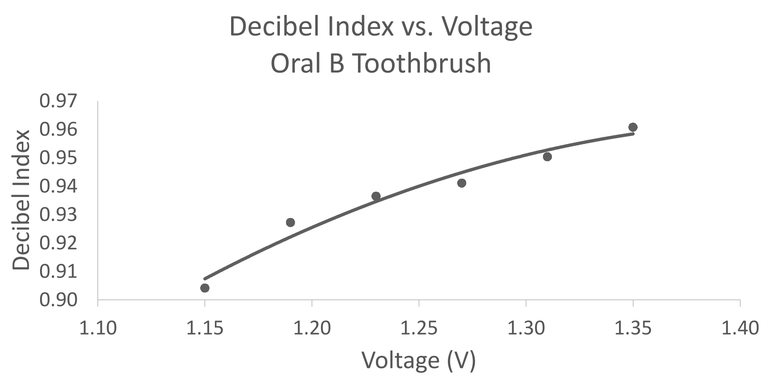
However, when the panelists' scale usage is considered as a factor in the statistical analysis, very small confidence intervals are achieved for average grades determined at each load voltage level (Figure 2). In fact, our data suggests statistically significant results can be achieved for ~0.04V load voltage differences.



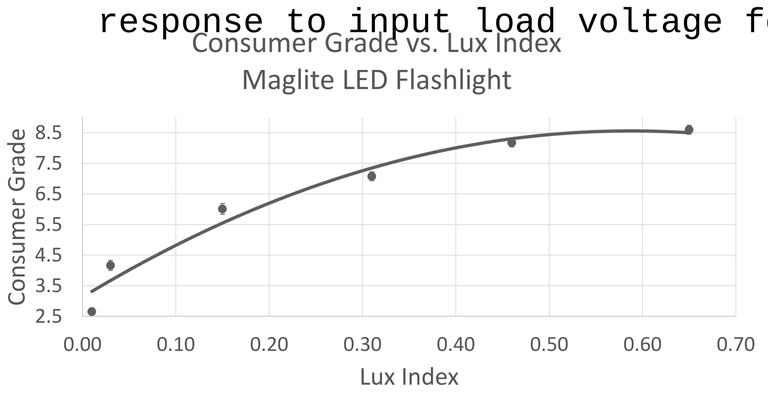
To understand device response to input load voltage, the prominent sensorial output of each device (*e.g.*, light, rotation speed and sound level) was measured by instrumental reading vs input load voltage. As seen below, the 3 devices provided >1, 1 and <1 gamma response to input load voltage depending on the output measured.

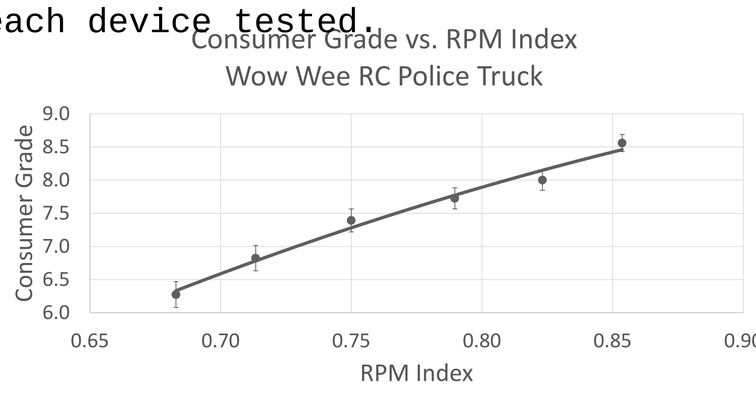


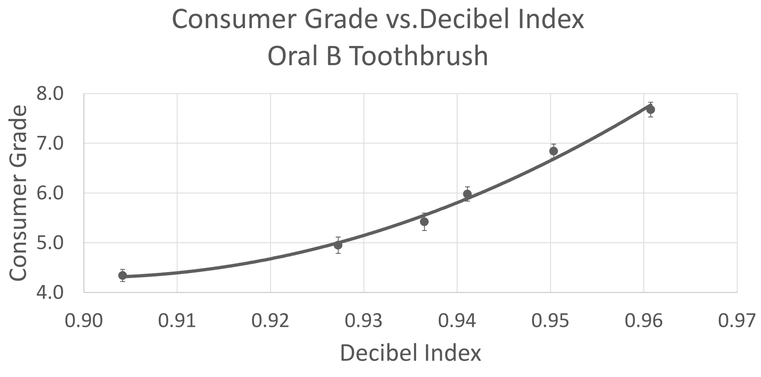




User response was then measured against each of these sensorial outputs and coincidentally showed inverse gamma response to the output measured. The combination of these responses produced a near-linear user response to input load voltage for each device tested.







Conclusion

This study demonstrated that sensorial signal differences produced by relatively small load voltage differences (~0.04V) can provide meaningful perceptual differences to device users. This finding has potential implications for both the device manufacturers or Original Equipment Manufacturers (OEM) and the disposable battery manufacturers in terms of product design to optimize device performance and consumer experience.