Human Factors and Systems Interaction, Vol. 52, 2022, 442–449
https://doi.org/10.54941/ahfe1002187

The Influence Factors of Standby Sign on User Shutdown Behavior

Weiyi Li, Sha Liu, and Zichen Zhang

College of Engineering, China Agricultural University, Beijing, 100083, China

ABSTRACT

Nowadays, laptop is getting popular but its standby power cannot be ignored. We mainly studied the influence factors of laptop standby sign on user shutdown behavior, mainly including: 1. In the preliminary experiment, through the subjective feeling test survey and analysis, we found the reasons why users do not shut down the laptop in time after use and that the laptop standby sign can promote users to shut down the laptop in time after use. 2. In the formal experiment, through progressive subjective feeling tests and data analysis, we found influence factors of the laptop standby sign striking degree, including shape, size, position, flashing and text prompt, and these influence factors can significantly influence user awareness of the sign and change user shutdown behavior. We finally designed a standby sign of enough striking degree according to these influence factors, which can reduce battery damage and standby power due to behavior of not shutting down laptops in time.

Keywords: Laptop standby sign, Standby power, Striking degree, User awareness, Shutdown behavior

INTRODUCTION

Electronic devices consume power in standby state, known as standby power, which is the power used by the electrical equipment in the lowest power mode (Chen and Lin, 2019). The standby power of a single electronic device is not much, but the sum will cause a significant expense: According to investigation of the International Energy Agency (IEA), in developed country, the typical standby power accounts for 3% to 11% of total annual electricity consumption (Solanki et al., 2013).

As a typical electronic device with standby function, laptop has become necessary for study and work. But for some reasons, some users do not shut down their laptops in time after use, which makes laptops standby for a long time and causes extra power consumption that cannot be negligible (Imai et al., 2012). In addition to forgetting to turn off laptops in time, some users do not turn off laptops after use because they hope to use laptops conveniently, but keeping standby is not conducive to battery maintenance although it is convenient to use (Zhang, 2010).

At present, there are two methods to improve the ineffective power consumption of household appliances: One is to strengthen the linkage between users' behavior and energy consumption information (Han and Lim, 2010, Lee et al., 2014), which mainly adjusts electrical power consumption by

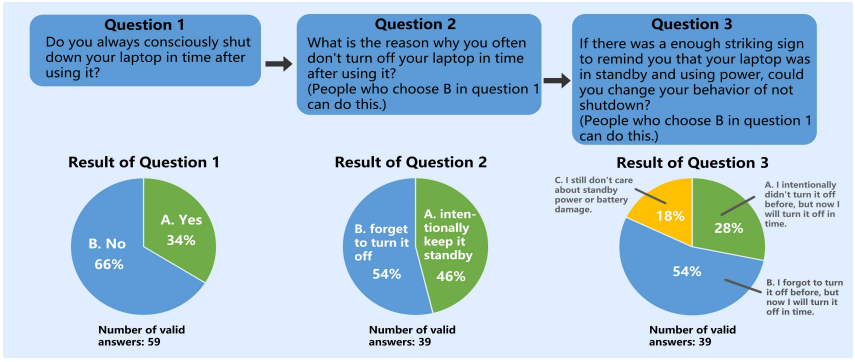

Figure 1: Subjective feeling test and results of preliminary experiment.

detecting user behavior; the other is to provide how the energy being used through power management method, and it uses active information to assist users in reducing the consumed power (Sung and Ko, 2015, Chen and Lin, 2016). The second method is applicable to some common household appliances, but whether it's applicable to laptops remains to be studied. We will not explore it in this paper. The first method does not extend the "linkage" to using striking standby sign to remind users of standby of laptop and information of still consuming power. Besides, some users are not aware of standby power, or they often forget to shut down laptops in time. In preliminary experiment, we will discuss the reasons why users don't shut down laptops in time and whether an enough striking standby sign can prompt users to shut down laptops in time.

We want to know the factors that influence the laptop standby sign striking degree(user awareness degree). For public sign, to take geometry graphic language such as circle, square, triangle, polygon, square can make the sign more striking, and the striking degree is also influenced by signs' number and position (Lei and Song, 2013). For safety sign in underground coal mine, eye-movement research shows that the striking degree of triangular safety sign is greater than that of round, while rectangular safety sign is the worst, and the larger the safety sign is, the easier it is to identify it. However, when the safety sign is too large, we need more time to fully extract the information of the safety sign (Tan, 2021). Therefore, oversized safety sign is not the best. The above shows the influence factors (shape, position, size, etc.) of sign striking degree in some specific situations. However, whether the influence factors are the same for laptop standby sign striking degree remains to be explored, which will be studied in our formal experiment.

PRELIMINARY EXPERIMENT

In order to explore the reasons why users keep their laptops in standby after use, and whether enough striking standby sign can reduce standby power, we set three subjective feeling test questions and got results from 59 users (see Figure 1).

Figure 2: Five commonly used shapes of laptop standby sign.

We made the following analysis: 1. More than 60% users keep their laptops in standby after use, and less than 40% shut down laptops timely after use; This shows that standby power is widespread. 2. Among those who leave their laptops standby, 54% users agree that they forget to shut it down, with some of them noting that they want to be reminded of shutdown. 46% users agree that they leave laptops standby intentionally, with some noting that they think it's convenient and that they think it's no harm to do so. 3. If there is an enough striking sign to remind users that "the laptop is still in standby and using power", users who forget to shut down laptops agree that they will shut down laptops timely; And more than half of those who leave laptops standby intentionally agree that they will shut down laptops timely.

Therefore, we determined that most users will change the behavior of not shutting down laptops timely after use (whether they forget to shut down or leave it standby on purpose) if the standby sign is striking enough to users. In order to promote users to shut down laptops timely after use, we conducted the formal experiment on how to ensure that user awareness degree of standby sign is enough, that is, the striking degree influence factors of laptop standby sign.

FORMAL EXPERIMENT

In the formal experiment, we studied striking degree (user awareness degree) influence factors of laptop standby sign, including shape, size, position, flashing and text prompt. We adopted progressive subjective feeling tests for some users, and conducted data analysis, and finally designed the best striking laptop standby sign.

Shape Test

We chose five commonly used shapes of laptop standby sign to carry out the subjective feeling test of the 10-point scale, including triangle, ring, circle, diamond and square, so that users could rate striking degree of the five shapes (see Figure 2).

We received 50 valid answers. The triangle has the best striking degree, with an average score of 8.58, and it is followed by the ring at 7.32; The circle is 6.74, less than the ring; Diamond and square are lower at 4.62 and 3.96 respectively (see Figure 3). According to one-way anOVA, p-value $=3.91182E\text{-}30 < 0.05$, indicating that shape has significant influence on sign striking degree (see Figure 4).

Therefore, different shapes significantly influence laptop standby sign striking degree, and the triangle is the most striking. In the following experiment, we would test other influence factors with triangle as a fixed value.

Shape	Average	variance
Triangle	8.58	2.90
Ring	7.32	3.98
Circle	6.74	4.56
Diamond	4.62	3.26
Square	3.96	4.16

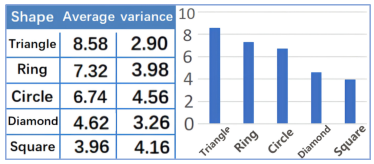

Figure 3: Shape test result.

Source	SS	df	MS	F	P-value	F crit
Inter Group	735.736	4	183.934	48.75032995	3.9118E-30	2.4084 8837
Intra Group	924.38	245	3.77297 9592			
Total	1660.116	249				

Figure 4: Shape test one-way anOVA.

Pixels in the sign	48	190	468	710	2336	4672	9344
Ratio	1/60000	1/15000	1/6000	1/4000	1/1200	1/600	1/300

"Pixels" refers to "the number of pixels occupied by the screen or sign within the images"

Figure 5: Images of laptop standby signs of seven sizes.

Ratio	Number of times selected as the best size
1/60000	1
1/15000	2
1/6000	3
1/4000	8
1/1200	24
1/600	10
1/300	1

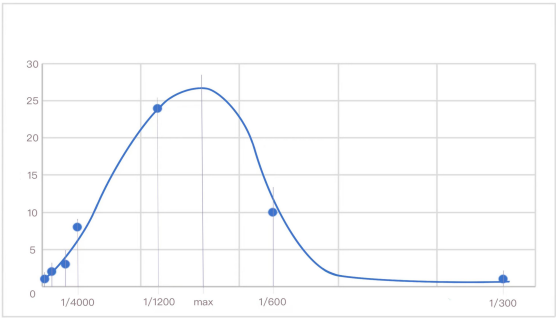

Figure 6: Size test result and the curve fitting.

Size Test

We used triangle to create images of laptop standby signs of seven sizes, and users were asked to subjectively choose sign of the best size that they happened to be aware of in a short time (see Figure 5). In the images, seven sizes were set based on the ratio of the pixels in the sign to the pixels in the laptop screen, and the total number of pixels in the laptop screen is about 2839770.

We received 49 valid answers and the results showed that the largest number of respondents thought 1/1200 was the best size, followed by 1/600, and we conducted a simple curve fitting and found that the extreme point of the best sign size ratio should be between 1/1200-1/600 (see Figure 6). That is to say, when the ratio of the triangle standby sign size to the size of the laptop screen is between 1/1200-1/600, the striking degree is just right.

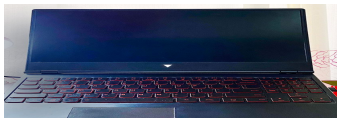

Figure 7: Position one.

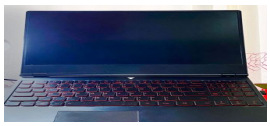

Figure 8: Position two.

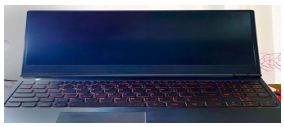

Figure 9: Position three.

Group	Average	variance
the bottom center of the screen	8.18	2.232245
the center of the keyboard	7.28	4.817959
the left side of the keyboard	4.62	5.097551

Figure 10: Position test result.

Therefore, in subsequent tests, the shape of laptop sign is triangle and the ratio of the sign size to the screen size of the laptop is 1/1200 as fixed values.

Position Test

We have determined that the shape of laptop sign is triangle and that the ratio of the sign size to the screen size of the laptop is 1/1200. Based on this, we studied the influence of standby sign position on striking degree. We put the sign in three positions including "the bottom center of the screen" (see Figure 7), "the center of the keyboard" (see Figure 8) and "the left side of the keyboard" (see Figure 9), and then let 50 users answer the subjective feeling test question to give striking degree scores(scale of 10 points).

The striking degree of the sign at "the bottom center of the screen" is the best, scoring 8.18, followed by "the center of the keyboard", scoring 7.28, and "the left side of the keyboard", scoring 4.62 (see Figure 10). According to one-way anOVA, p-value =3.07E-15 < 0.05 (see Figure 11), indicating that position has significant influence on laptop standby sign striking degree. In addition, some users may close laptop to keep laptops standby. So we also asked the 50 users whether they thought it was necessary to add a standby sign on the back of the laptop to remind them. The results showed that 92% of users thought it was necessary to add a standby sign on the laptop back.

Source	SS	df	MS	F	P-value	F crit
Inter-group	342.6533	2	171.3267	42.3107	3.07E-15	3.057621
Intra-group	595.24	147	4.049252			
Total	937.8933	149				

Figure 11: Position test one-way anOVA.

Results of paired T test with or without standby sign flashing					
NAME	Pairing (Average±standard deviation)		Difference value	*t*	*p*
	Pairing 1	Pairing 2			
Flashing *Pair* not flashing	4.50±0.76	1.72±0.68	2.78	15.142	0.000**
* $p<0.05$ ** $p<0.01$					

Figure 12: Paired T test 1.

In-depth analysis - effect size metrics			
Name	Mean difference	Standard deviation of difference	Cohen's *d* Value
Flashing *Pair* not flashing	2.78	1.039	2.677

Figure 13: In-depth analysis 1.

Therefore, position has significant influence on the striking degree of the sign, and the sign striking degree is best at the bottom center of the screen. In addition, adding a standby sign on the back of the laptop can effectively remind users to turn off the laptops in time. These would also be used as fixed values in subsequent tests.

Flashing Test And Text Prompt Test

Firstly, we studied the flashing of the standby sign on the striking degree based on the previous test results. We developed a five-point scale subjective feeling test, in which two scenes with standby signs were attached (one with flashing effect and one without flashing), and 41 users rated the striking degree of standby signs in the two situation. The results showed that the flashing standby sign had a score of 4.5, higher than the 1.72 score without flashing.

We conducted paired T test, and found that flashing or not has different influences on the striking degree of standby sign ($P < 0.05$) (see Figure 12). And the Cohen's d value is greater than 0.80 (see Figure 13), which means that the difference is large. Therefore, we can determine that flashing or not has significant influence on the striking degree of standby sign.

Secondly, We used the same method to test whether the standby sign is more striking with a text prompt near it (see Figure 14). It turns out that the text prompt makes the sign more striking ("with text prompt" scored 4.53

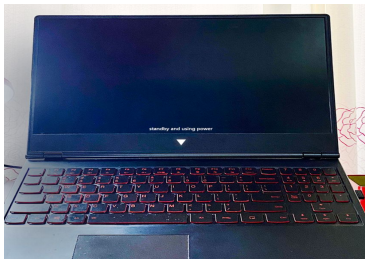

Figure 14: Text prompt.

Results of paired T-test with or without text prompt					
NAME	Pairing (Average±standard deviation)		Difference value	*t*	*p*
	Pairing 1	Pairing 2			
With text prompt *Pair* Without text prompt	4.53±0.88	1.78±0.83	2.75	11.182	0.000**
* $p<0.05$ ** $p<0.01$					

Figure 15: Paired T test 2.

In-depth analysis - effect size metrics			
Name	Mean difference	Standard deviation of difference	Cohen's *d* Value
With text prompt *Pair* Without text prompt	2.75	1.391	1.977

Figure 16: In-depth analysis 2.

Figure 17: Optimal laptop standby sign design.

and "without text prompt" scored 1.78). And whether there is a text prompt has significant influence on the striking degree of standby sign ($P < 0.05$, Cohen's $d = 1.977 < 0.80$) (see Figure 15 and Figure 16).

Optimal Laptop Standby Sign Design and Verification

According to the tests result, the standby sign with the best striking degree should be shaped like a triangle, occupying about 1/1200-1/600 of the laptop screen size, located at the bottom center of the screen, capable of flashing, with text prompt nearby, and with another standby sign at the back of the laptop (see Figure 17).

Finally, we reviewed the 39 users of not shutting down timely in the preliminary experiment. 37 users (about 95%) think our result sign is striking

enough, and 35 users(about 90%) think they will change the behavior of not shutting down timely. This proved the accuracy of our experimental results.

CONCLUSION

Laptop standby sign can influence user shutdown behavior. When the laptop standby sign is striking enough to make the user aware that the laptop is still standby and is using power, the vast majority of users (whether they have forgotten or intentionally left it standby) will change their behavior of leaving it standby after use. And influence factors (shape, size, position, flashing and text prompt) of laptop standby sign striking degree can significantly influence user awareness of the sign and then change user shutdown behavior. And the standby sign with the best striking degree(user awareness degree) should be triangle, sized about 1/1200-1/600 of the laptop screen size, at the bottom center of the screen, with text prompt nearby, capable of flashing, and with another standby sign at the back of the laptop. Our conclusion can provide some reference for standby sign design and a solution to standby power reduction.

REFERENCES

Chen, M., and Lin, C. (2016), "Development of a smart home energy saving system combining multiple smart devices." *2016 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW)*, 1–2.

Chen, M., and Lin, C. (2019), "Standby Power Management of a Smart Home Appliance by Using Energy Saving System With Active Loading Feature Identification." *IEEE Transactions on Consumer Electronics*, 65(1), 11–17.

Han, D., and Lim, J. (2010), "Smart home energy management system using IEEE 802.15.4 and zigbee." *IEEE Transactions on Consumer Electronics*, 56(3), 1403–1410.

Imai, T., Tsukamoto, Y., and Araki, N. (2012), "Automatic control of computer standby state by predictive algorithm in computer usage." *The 1st IEEE Global Conference on Consumer Electronics 2012*, 525–529.

Lee, H., Park, W., and Lee, I. (2014), "A Home Energy Management System for Energy-Efficient Smart Homes." *2014 International Conference on Computational Science and Computational Intelligence*, 142–145.

Lei, G., and Song, Z. Z. (2013), "How to improve the design eye-catching degree of public sign recognition system." *Grand View of Fine Arts*, (1), 135.

Solanki, P. S., Mallela, V. S., and Zhou, C. (2013), "An investigation of standby energy losses in residential sector: Solutions and policies." *International Journal of Energy and Environment*, 4(1), 117–126.

Sung, M., and Ko, Y. (2015), "Machine-learning-integrated load scheduling for reduced peak power demand." *IEEE Transactions on Consumer Electronics*, 61(2), 167–174.

Tan, H. S. (2021), "*Study on Visual Recognition Eye-Movements of Safety Sign Design in underground Coal Mines*." Xi'an: Xi'an University of Science and Technology.

Zhang, X. X. (2010), "Notebook battery use tips." *Science & Technology Information*, (34), 261.