

POWER SWITCHES: SOME USER EXPECTATIONS AND PREFERENCES

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ABSTRACT

Three brief studies were conducted by the IBM Boca Raton Human Factors department to investigate user expectations and preferences regarding power switches. In the first study, 24 IBM employees were surveyed by showing them a power supply with a paddle switch in front. The results indicated that if the power switch was mounted vertically, 100% of the sample expected UP to be ON. When the switch was mounted horizontally on the front, 25% of the sample expected LEFT to be ON, and the other 75% expected RIGHT to be ON. Ninety IBM employees participated in the second study. The purpose of this study was to investigate the way people expect a rocker switch to work when it is located on the side of the machine. Overall, 46% of the sample expected the switch AWAY from the operator to be ON, and 54% expected the switch TOWARD the operator to be ON. In the third study, 49 IBM employees responded to a mailed questionnaire, and 24 participants from a temporary employment agency completed the same questionnaire. The results for the six items were:

1. For UP/DOWN switch: UP=ON:97% , DOWN=ON:03%
2. For LEFT/RIGHT switch: LEFT=ON:29% , RIGHT=ON:71%
3. For AWAY/TOWARD switch: AWAY=ON:52% , TOWARD=ON:48%
4. Style preference (IBM Employees) , (Agency Personnel)
 UP/DOWN:94% UP/DOWN:58%
 LEFT/RIGHT:02% LEFT/RIGHT:29%
 AWAY/TOWARD:04% AWAY/TOWARD:13%
5. Location preference: FRONT:72% , SIDE:25% , BACK:03%
6. Side preference: LEFT:10% , RIGHT:90%

Since it appears that virtually 100% of users have the same expectation regarding the operation of a vertical power switch, designers should avoid using other power switch orientations. This is not a critical design issue, but it is better to design machines the way that users expect them to work.

OBJECTIVE

The purpose of these three studies was to investigate the way that users expect power switches in different orientations to work, and to collect information regarding preferred power switch design and orientation.

LIMITS TO GENERALIZATION

These surveys were conducted only in Boca Raton, Florida. It is particularly important to note that all participants were U.S. citizens, and that the expectations in other countries may be different.

STUDY 1

Purpose

The purpose of this study was to investigate the way that users expect a power switch to work on the front of a machine depending upon whether it is mounted vertically or horizontally.

Method

Participants

Twenty-four IBM employees were surveyed in this study. Participants were selected from different floors of different buildings at the Boca Raton site.

Materials

The participants were shown a power supply taken from an IBM PC. The ON/OFF (i.e., bar/circle) label had been removed. The participants only viewed the power supply from the front.

Procedure

Participants were approached in their offices and asked to say whether, from the position of the power switch, the unit would be on or off. They were asked once with the switch mounted vertically, and once with the switch mounted horizontally. Switch orientation and position were both counter-balanced in this study.

Results

The results are shown in Table 1, where N is the number of responses, PER is the percentage of responses, and 95% CI is the 95% confidence interval on the percentage:

Table 1. User Expectations for Front-Mounted Paddle Switches

	Horizontal	
	LEFT=ON	LEFT=OFF
N	6	18
PER	25	75
95% CI	10-45	55-90

	Vertical	
	UP=ON	UP=OFF
N	24	0
PER	100	0
95% CI	86-100	0-14

When the power switch was mounted vertically, the user expectation was perfectly consistent. When it was mounted horizontally, the expectation was not consistent, but was stronger for LEFT=OFF / RIGHT=ON.

STUDY 2

Purpose

The purpose of this study was to investigate the way that users expect a rocker power switch to work on the side of a machine when it is mounted horizontally. The expectations for technical and non-technical groups were compared.

Method

Participants

Ninety IBM employees selected from different floors at different buildings at the Boca Raton site participated.

Materials

The participants were shown an Industrial Design model of a display with a rocker switch. The ON/OFF (i.e., bar/circle) label had been removed. The participants only viewed the model from the front.

Procedure

Participants were approached in their offices and asked to say whether, from the position of the power switch, the display would be on or off. They were also asked the kind of job they were currently doing for IBM. If they were a programmer or engineer, they were categorized as Technical. Other participants (secretaries, planners, writers, etc.) were categorized as Non-technical.

The following location and switch setting counter-balancing was used to control for potential biases since the switch was a wooden model that the participant could not move:

Number of Participants	Switch Location	Switch Setting
30	Right	Away from user
30	Left	Away from user
15	Right	Toward user
15	Left	Toward user

Results

There were no significant differences detected between the response rates for left and right mounted switches, so the samples were combined. There were significant differences depending upon whether the participant was presented with the switch set toward or away from the front of the machine and whether the participant was Technical or Non-technical. These results are shown in Table 2:

Table 2. User Expectations for Side-Mounted Rocker Switches

Category	When shown the switch away from the operator, switch away from operator means:		
	ON	OFF	Totals
Technical	12 (52%)	11 (48%)	23
Non-tech	7 (19%)	30 (81%)	37
Subtotal	19 (32%)	41 (68%)	60

Category	When shown the switch toward the operator, switch away from operator means:		
	ON	OFF	Totals
Technical	7 (50%)	7 (50%)	14
Non-tech	11 (69%)	5 (31%)	16
Subtotal	18 (60%)	12 (40%)	30

The effect of the different switch settings on the different user groups is illustrated in the tables below, analyzed with Fisher tests.

Table 3. Effect of Switch Set Toward/Away From User

	Technical	
	ON	OFF
Set AWAY	12	11
Set TOWARD	7	7

$p=.68$

	Non-technical	
	ON	OFF
Set AWAY	7	30
Set TOWARD	11	5

$p=.0008$

The response rates for the Technical group were constant regardless of the switch setting, while the response rates for the Non-technical group were greatly affected by the switch setting. This suggests that the Non-technical group was more influenced than the Technical group by the example presented to them.

Since the sample sizes in the TOWARD and AWAY groups were different, the percentages are averaged in Table 4 in order to control for the bias illustrated in Table 3. The responses were about evenly divided.

Table 4. Overall User Expectations for Side-Mounted Rocker Switches

Percentage of Responses	AWAY=ON	TOWARD=ON
		46
95% Confidence Interval	34-58	42-66

STUDY 3

Purpose

The purpose of this study was to collect data with a six item questionnaire to see if the results were consistent with those obtained using the more concrete methods of Studies 1 and 2. A secondary purpose was to collect information regarding preferred power switch design and location.

Method

Participants

The participants were 49 IBM employees and 24 employees of temporary help agencies.

Materials

The materials were four forms of a six item multiple choice questionnaire. In two forms the questions asked how to turn power on and in the other two the questions asked how to turn power off. Two different orders of answers were used.

Procedure

Equal numbers of the four forms were mailed to the first 100 IBM employees in the IBM phone directory. After one week, 49 forms had been returned. Equal numbers of the four forms were individually administered to the agency personnel after they had participated in an unrelated study.

Results

Chi-squared tests indicated that there were no differences in response rates due to the different forms of the questionnaire, so the samples were combined. Table 5 shows the responses for the six items for both the IBM employees and agency personnel.

Table 5. Responses to Questionnaire

1. Turn power on by moving the switch:

	<u>UP</u>	<u>DOWN</u>		RESPONSE:	<u>UP</u>	<u>DOWN</u>
IBM:	47	2		PERCENTAGE:	97	3
Agency:	24	0	95% CONF. INT.:		90-100	0-10
	p=.45					

2. Turn power on by moving the switch:

	<u>LEFT</u>	<u>RIGHT</u>		RESPONSE:	<u>LEFT</u>	<u>RIGHT</u>
IBM:	13	36		PERCENTAGE:	29	71
Agency:	8	16	95% CONF. INT.:		19-41	59-81
	p=.81					

3. Turn power on by moving the switch:

	<u>TOWARD</u>	<u>AWAY</u>		RESPONSE:	<u>TOWARD</u>	<u>AWAY</u>
IBM:	23	26		PERCENTAGE:	48	52
Agency:	12	12	95% CONF. INT.:		36-60	40-64
	p=.81					

4. Preferred style of power switch:

	<u>UP/DOWN</u>	<u>LEFT/RIGHT</u>	<u>TOWARD/AWAY</u>
IBM:	43	1	2
Agency:	14	7	3
	Chi-squared=13.9, p=.001		

	<u>IBM Employees</u>		
RESPONSE:	<u>UP/DOWN</u>	<u>LEFT/RIGHT</u>	<u>TOWARD/AWAY</u>
PERCENTAGE:	94	2	4
95% CONF. INT.:	75-95	0-12	0-14

	<u>Agency Personnel</u>		
RESPONSE:	<u>UP/DOWN</u>	<u>LEFT/RIGHT</u>	<u>TOWARD/AWAY</u>
PERCENTAGE:	58	29	13
95% CONF. INT.:	39-77	13-49	3-32

5. Preferred location of power switch:

	<u>FRONT</u>	<u>SIDE</u>	<u>BACK</u>		RESPONSE:	<u>FRONT</u>	<u>SIDE</u>	<u>BACK</u>
IBM:	35	13	0		PERCENTAGE:	72	25	3
Agency:	17	5	2	95% CONF. INT.:		60-82	10-28	0-10
	Chi-squared=4.26, p=.12							

6. Preferred side if switch placed on side:

	<u>LEFT</u>	<u>RIGHT</u>		RESPONSE:	<u>LEFT</u>	<u>RIGHT</u>
IBM:	4	44		PERCENTAGE:	10	90
Agency:	3	21	95% CONF. INT.:		4-19	81-96
	p=.81					

Since only Item 4 showed a significant difference in response rate due to employment, the rates in Items 1-3 and 5-6 have been collapsed in order to show the approximate percentages of responses and 95% confidence intervals on the percentages. The difference seen in Item 4 is quantitative rather than qualitative, since both groups prefer an UP/DOWN switch. Note that the responses for Items 1 and 2 are consistent with those presented in Study 1, and the responses for Item 3 are consistent with those presented in Study 2. The 2x2 matrices have been analyzed with Fisher tests and the 3x2 matrices have been analyzed with Chi-squared.

This design issue is not critical if the power switch is only a two position switch; the switch positions are labeled with the international symbols for ON and OFF; and there is a separate power-on indicator. However, on many products, the power switch is also the Emergency Power Off (EPO). While these additional design features minimize the probability that a person in an emergency situation might delay powering the machine off (due to confusion caused by the orientation or location of the power switch), it is a better design practice to make the switches work in the way and be placed in the locations that users expect.

RECOMMENDATIONS

Based on these studies, the following recommendations are made:

1. Since it appears that virtually 100% of users have the same expectation regarding the operation of a vertical power switch, but have different expectations regarding the operation of power switches in other orientations, designers should use vertically mounted switches.
2. An UP/DOWN switch should be designed to work with UP=ON and DOWN=OFF.
3. Switches which operate left and right are better than those which operate toward and away from the user, since the population stereotype is stronger for LEFT/RIGHT switches.
4. A LEFT/RIGHT switch should be designed to work with LEFT=OFF and RIGHT=ON.
5. The results indicate that there is no strong user expectation regarding the operation of switches toward and away from the user. If this style is used, the decision about the operation should be based on other considerations. Again, this style of switch should be avoided.
6. The strongly preferred location of power switches is on the front of the machine.
7. If the switch must be placed on the side of the machine, it should be placed on the right side.