



ISB 2013
BRAZIL

XXIV CONGRESS OF THE INTERNATIONAL
SOCIETY OF BIOMECHANICS

XV BRAZILIAN CONGRESS
OF BIOMECHANICS

INCONSISTENCY BETWEEN OBJECTIVE AND SUBJECTIVE DIFFICULTY OF BUTTON-PRESS TASK

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SUMMARY

In this paper we conducted analysis of button-press task to find out the physical quantity representing the objective and subjective difficulty of the task. For this purpose, we measured button-press task under 18 different button configurations, 3 conditions for the maximum push force (20 N, 30 N and 40 N), 3 conditions for the push stroke (7.5 mm, 10.0 mm and 15.0 mm) and 2 conditions for the diameter of the button (7.0 mm and 10.0 mm). A total of 110 children (55 boys and 55 girls) from 3 to 8 years old participated in this study. For all subject, self-reported physical load as well as success and failure of the task were obtained. The result of the analysis strongly suggests that there was inconsistency between the physical quantity of the objective and subjective difficulty of the button-press task. The objective difficulty of the task is determined by the mechanical work, product of the maximum push force and the push stroke, necessary to make the full-stroke position, while the subjective difficulty of the task is solely determined by the maximum push force.

INTRODUCTION

Child resistance and child friendly are contradictory ideas but the designer have to always keep this idea in mind in the process of the product design. This is because, in many cases, the products have to satisfy both ideas simultaneously for ensuring product safety for young children, while making the product easy to use for school children.

In this research, we analyzed physical performance of children from 3 to 8 years old. Especially in this paper we focused on the button-press task and tried to find out the physical quantity representing the objective and subjective difficulty of this task since it is common user interface of industrial products.

METHODS

A total of 110 children (55 boys and 55 girls) from 3 to 8 years old participated in this study. The number of subjects in each age is listed in Table 1. All the children participated in this study were in good health condition and were free from any lesion or impairments in their upper limbs. The children were encouraged to do their best when performing the button-press tasks. The protocol of this study was approved by the Review Committee at the Research Institute of Human Engineering for Quality Life, Japan.

Table 1: Number of subjects in each age.

Gender	3 y	4 y	5 y	6 y	7 y	8 y	Total
Boys	12	5	6	10	11	11	55
Girls	11	5	5	12	11	11	55

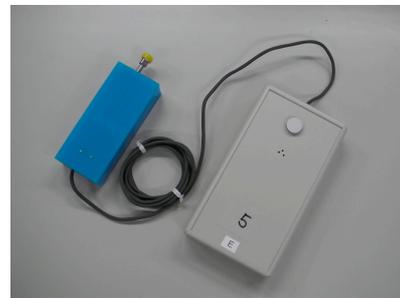


Figure 1: Apparatus for the button-press experiment.

Button-press task was measured by using a custom-made push-button apparatus shown in Figure 1. This apparatus has a cuboid gripper (Figure 1 left) with push-button at the top and a battery box (Figure 1 right) with electric buzzer connected by a wire with the cuboid gripper. When the push-button was pushed until the full-stroke position, the buzzer made electric sound to let the tester know that the button had been successfully pushed. There were 18 conditions in total for the configuration of the push-button, 3 conditions for the maximum push force: 20 N, 30 N and 40 N, 3 conditions for the push stroke: 7.5 mm, 10.0 mm and 15.0 mm, and 2 conditions for the diameter of the button: 7.0 mm (small button) and 10.0 mm (large button). Since the push-button was composed of a linear coil spring, the total mechanical work necessary to push the button is given by the product of the maximum push force and the push stroke divided by two.

At first, the subjects were asked to perform the button-press task for the apparatus with large button in the ascending order of the total mechanical work. In the case where there were more than two conditions that have the same total mechanical work, they were sorted in the ascending order of the maximum push force. If the subject failed to push the button, further experiments for this button size were canceled. After the experiments for this button size were completed, the subjects were asked to choose one condition with the smallest physical load from the last three conditions they could successfully push. This experimental procedure was repeated for the apparatus with small button to collect objective and subjective

response for the button-press tasks in the all button configurations.

RESULTS AND DISCUSSION

All subjects completed the button-press task satisfactory. Distributions of the rate of failure for 3 to 5 years old subjects when the maximum push force was in the horizontal axis and the push distance was in the vertical axis are shown in Figure 2 (small button) and Figure 3 (large button). In both figures, the contour lines of the mechanical work are also shown in every 50.0 Nmm. The red filled circles are corresponding to the measured conditions in the experiments. As is obvious from these figures, the rate of failure increases as the maximum push force as well as the push distance increases, and as a result the contour lines of the rate of failure have similar trend as the contour lines of the mechanical work. These results strongly suggest that the objective difficulty of the button-press task is not solely determined by the maximum push force or the push stroke, but determined by the mechanical works necessary to make the full-stroke position.

The difficulty of the button-press task is influenced by age of the subjects as well as button size. The effect of the button size on the difficulty of the button-press task is clearly demonstrated in Figure 2 and Figure 3. In general, as the button size get larger, the button-press task becomes easier. This tendency also holds for the difference in age. Distributions of the rate of failure for 6 to 8 years old subjects also show the similar trend as Figure 2 and Figure 3, however they have smaller rate of failure in every condition compared with the results for 3 to 5 years old subjects under the same button configuration (data not shown).

The self-reported button configuration with the smallest physical load is summarized in Figure 4. Figure 4 (a) shows the comparison among three button configurations with the same mechanical work. Interestingly the most of the subjects reported that the button with the smallest maximum push force imposes the smallest physical load to make the full-stroke position. On the other hand, Figure 4 (b) shows the comparison among three button configurations with largest mechanical work. Same as Figure 4 (a), large number of the subjects reported that the button with the smallest maximum push force imposes the smallest physical load, although the mechanical work that is speculated to be the determinant of the objective difficulty required for making the full-stroke position is not the smallest among these three conditions. These results strongly suggest that the subjective difficulty of the button-press task is solely determined by the maximum push force.

CONCLUSIONS

In this paper we conducted analysis of button-press task. The result of the analysis strongly suggest that the objective difficulty of the task is determined by the mechanical work necessary to make the full-stroke position, while the subjective difficulty of the task is determined by the maximum push force.

This study was supported by Kids Design Product Development Assisting Project of the Ministry of Economy, Trade and Industry (METI), Japan.

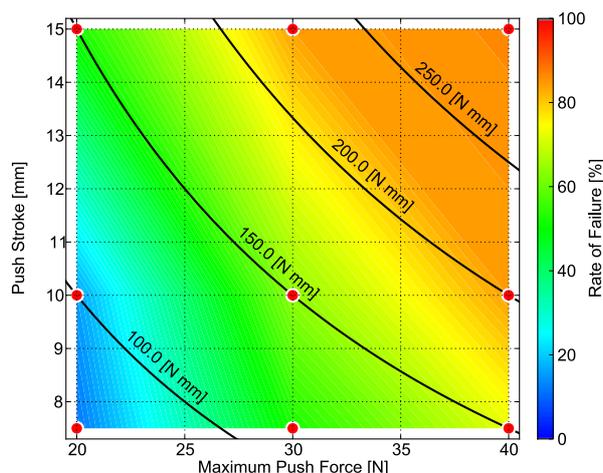


Figure 2: Objective response: rate of failure for 3 to 5 years old subjects with small button apparatus.

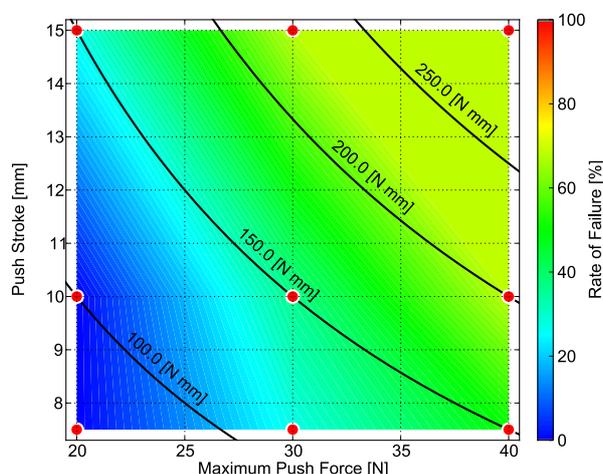
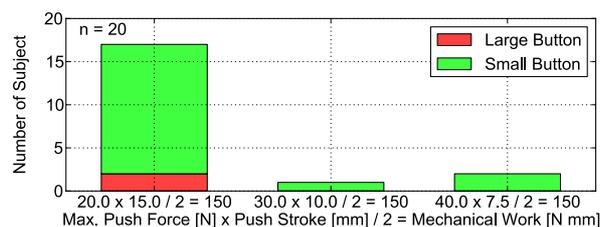
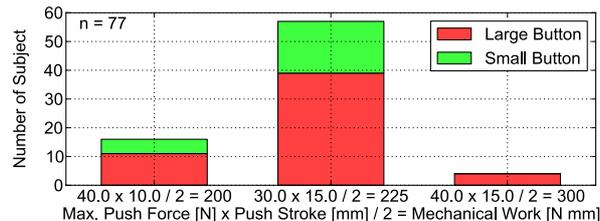


Figure 3: Objective response: rate of failure for 3 to 5 years old subjects with large button apparatus.



(a) Comparison among the same mechanical work



(b) Comparison among three largest mechanical work

Figure 4: Subjective response: self-reported button configuration with the smallest physical load.