Keyboard experimentation

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***Abstract*—This study investigates typing speed differences among three keyboard layouts: FITALY, OPTI, and QWERTY. We examined the effects of two independent variables: (1) visual access to the text while typing (a binary variable), and (2) experience using the same keyboard (an integer variable called trial). With an analysis of variance, we found that the effect of visual access on typing speed wasn't statistically significant ($F = 0.5$, $p > 0.05$). We also found that neither experience using the keyboard (trial) has a significant effect ($F = 0.5$, $p > 0.05$). The keyboard layout significantly influenced typing speed ($F = 50.415$, $p < 0.01$). Post-hoc analysis confirmed that QWERTY significantly outperformed both FITALY and OPTI layouts, while no significant difference was observed between FITALY and OPTI.**

***Index Terms*—Human Computer Interaction, ANOVA**

I. Methods

A. Experimental apparatus and design

The study is composed of 12 participants divided into three groups (G1, G2, G3), each consisting of four participants The participants have been divided into groups to adhere to the so-called counterbalancing that serves to control for order effects by systematically varying the sequence of conditions for each participant, thereby ensuring that the results are not biased by the order in which treatments are administered. The data is acquired using the java software SoftKeyboardExperiment [1]. This was implemented for testing soft or virtual keyboards rendered on a computer display. In our case user input is given to the software via mouse to three different keyboards shown in 1.

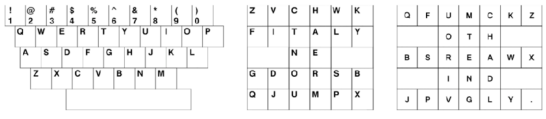

Fig. 1. Keyboards used in the experiment, left to right: QUERTY, FITALY, OPTI

Participants are asked to type sentences presented on the screen as quickly and accurately as possible. Each session consists of 10 phrases per keyboard under two different modes: in the first one the participant has visual access to the phrases during typing, in the second one the phrases disappear when the first letter is typed. Participants complete each session lasting approximately 30 minutes with a supervisor looking at data input process.

The experiment employs a within-subjects design with three independent variables: Group (G1, G2, G3), visual access to the keyboards during typing and how many times they typed on the same keyboard (*trial*). The effects of this variables are tested on typing speed (Entry Speed) measured in words per minute (wpm). As we say before the three groups have been choosen to counterbalance the effects of order in which the keyboards were presented according to the *latin square* principle:

- G1: QUERTY, FITALY, OPTI
- G2: OPTI, QUERTY, FITALY
- G3: FITALY, OPTI, QUERTY

The data collected was analyzed using R following a rigorous procedure to determine the effects of the independent variables. The steps undertaken in the analysis are detailed below:

B. Data processing and analysis

The initial step in data analysis involved preprocessing the raw output from SoftKeyboardExperiment to extract relevant metrics such as typing speed and accuracy. Data integrity checks were performed to identify and exclude outliers that could skew the analysis. Outlier detection was performed within each subgroup defined by keyboard, trial, and group combination, using robust statistical methods to ensure only representative data was analyzed.

Figure 2 shows the distribution of entry speeds before outlier removal, highlighting the initial skewness and potential extreme values that could affect the reliability of our statistical tests.

To confirm the appropriateness of ANOVA for our dataset, we conducted the Shapiro-Wilk test to assess the normality of the distribution of entry speeds. This was complemented by Levene's test to verify the homogeneity of variances across groups—a prerequisite for the validity of ANOVA results.

With assumptions validated, we applied a multifactorial ANOVA to discern the impact of keyboard layout, trial, and group on the typing speeds recorded. This was followed by a detailed post hoc analysis using Tukey's HSD test to understand pairwise differences between keyboard layouts under various conditions, helping to pinpoint specific factors influencing performance.

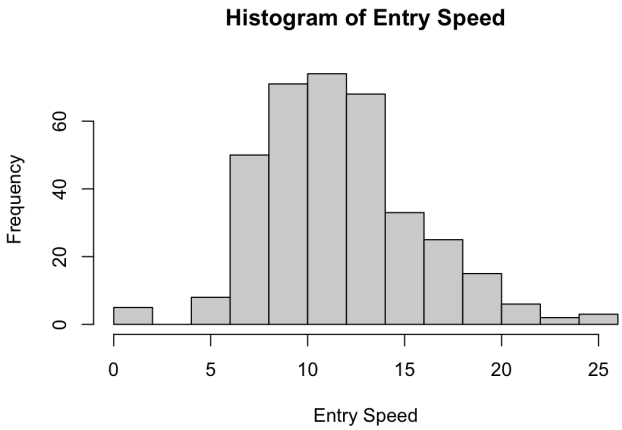

Fig. 2. Histogram of entry speeds illustrating initial data distribution and identified outliers.

C. Statistical software and reproducibility

All statistical analyses were conducted using R [2], a powerful tool for statistical computing and graphics. The script and data are archived in a publicly accessible repository to promote transparency and allow for replication of our findings by other researchers.

II. Results and Discussion

A. Data Description

Following the comprehensive methodologies outlined in the preceding sections, this section delves into the performance outcomes derived from the experimental setup as detailed earlier. The data analyzed herein is crucial for testing our hypothesis regarding the impact of different keyboard layouts on typing speed, efficiency, and accuracy.

Overall, the mean typing speed across the whole dataset was 11.62167 words per minute. The detailed mean values of typing speeds under various conditions are reported in Table I:

Testing condition	Words per minute
FITALY	10.49
OPTI	10.11
QUERTY	14.25
T1	11.07
T2	11.56
T3	11.75
T4	11.74
T5	11.99
Visual access granted	11.38
Visual access denied	11.79

TABLE I
Typing speed under various conditions

Figure 3 presents a histogram of entry speeds, illustrating the distribution across all conditions, which helps in visualizing the skewness or symmetry of the data related to typing speed.

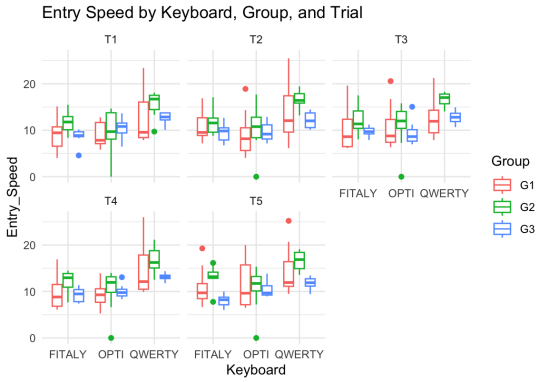

Fig. 3. Histogram of entry speeds across all testing conditions.

B. Impact of Prior Experience

While the results indicate that the trial (representing repeated use of the same keyboard layout) had no significant effect on typing speed, exploring the influence of participants' prior experience with these specific keyboard layouts could yield additional insights. Previous familiarity with a particular layout, such as QWERTY, which is commonly used, might account for quicker adaptation and increased efficiency during the trials. This aspect could be further investigated in future studies to determine if pre-exposure to keyboard layouts influences performance metrics beyond initial speed.

C. Verification of Statistical Assumptions

1) Normality Test: The Shapiro-Wilk test was applied to entry speeds for each combination of keyboard, trial, and group. The aim was to ensure that the data for each subgroup followed a normal distribution, a necessary condition for the valid application of ANOVA. Most subgroups displayed p-values significantly higher than the conventional alpha level of 0.05, suggesting that the assumption of normality was satisfied. Moreover by looking at 3 the overall plot suggests gaussianity of data which is a further confirmation of what the test performed suggested.

2) Homogeneity of Variances: Levene's test was conducted to assess the equality of variances across different group, keyboard, and trial combinations. This test is crucial as unequal variances can affect the validity of ANOVA conclusions. The test yielded a statistic of 1.53 with a p-value of 0.0209, indicating a violation of the homogeneity of variances assumption. This result suggests that variances across the groups are not equal, which might necessitate the use of more robust statistical techniques or adjustments in the ANOVA approach to accurately reflect the effects of keyboard layout, trial, and group on typing speeds.

D. Implications of Statistical Assumptions

The results of these tests inform our analytical approach, confirming that while the normality condition largely holds, the detected variance inequality must be addressed. This may involve using adjusted ANOVA techniques that are robust to

violations of homogeneity of variances, thereby ensuring the integrity and reliability of our findings.

These expanded explanations will provide a detailed insight into how the data met or did not meet the required assumptions, reinforcing the robustness of your study's statistical analysis framework.

E. Analysis of Variance (ANOVA)

An ANOVA was conducted to compare the effects of Group, Keyboard, Trial, and Condition on typing speed. The results are summarized below:

The result of the analysis of variance has shown that the groups are not statistically significant, thereby demonstrating that the within-subjects experiment has been correctly implemented, indicating that the order of keyboard presentation does not affect the independent variable.

The effect of Keyboard layout was highly significant ($F = 50.415$, $p < 0.01$). This result is most likely due to the user experience of using querty keyboards. No significant effect was found for the Trial variable ($F = 0.682$, ns), which was considered as the "experience" variable, but given the fairly small number of trials it might be intresting for further studies to explore its effect on a larger scale. The effect of Condition on typing speed was not statistically significant ($F = 1.189$, ns), to explain this phoenomenon better we noticed that during data acquisition most subject didn't need to look at phrases while typing. Even thought one would expect the eye movement to slow down the typing process, the overall change of focus of the subject from the keyboards to the phrases was negligible for the final data.

F. Post-hoc Analysis

1) Keyboard Layouts: A Scheffé post-hoc test was performed to further investigate the differences between keyboard layouts. The mean difference between OPTI and FITALY was -0.376, which was not statistically significant ($p = 0.729$). The mean difference between QWERTY and FITALY was 3.755, which was highly significant ($p < 0.01$). The mean difference between QWERTY and OPTI was 4.131, which was also highly significant ($p < 0.01$). These results indicate that QWERTY outperformed both FITALY and OPTI keyboard layouts significantly, while there was no significant difference between FITALY and OPTI.

2) Trial Effects: A separate ANOVA was conducted to evaluate the effect of Trial on typing speed. The results showed no significant differences across trials ($F = 0.5$, $p = 0.735$). The post-hoc Scheffé test confirmed these findings, indicating no significant differences in typing speed between any pairs of trials.

G. Summary

The study reveals that the keyboard layout has a significant impact on typing speed, with QWERTY showing a considerable advantage over FITALY and OPTI. However, neither the visual access to the text (Condition) nor the repeated use of the same keyboard (Trial) showed a significant effect on typing speed. These results suggest that while the choice of keyboard layout is important for typing performance, familiarity with the keyboard in the short term or visual access while typing don't substantially affect typing speed.

REFERENCES

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