What are you Looking at? Beyond Typing Speed and Formal Training for Assessing Typing Expertise

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Abstract

In this paper we introduce a novel way of quantifying typing expertise according to the ability to type without visual guidance from the keyboard (i.e., in a blind typing task). We present results of two experiments showing that performance in blind typing allows dissociating two profiles of typists, touch and non-touch typists. In Experiment 1, analyzing more than 100 typists, we show that performance in blind typing correlates with faster typing speed of lexical and non-lexical material, but not with low-level motoric skills. In Experiment 2, we show that touch and non-touch typists present differences in both written and spoken language production, but not language perception. Our results demonstrate that the characterization of "everyday touch typists" not only discriminates typing skills but may also capture distinct cognitive abilities. Spanning the fields of sensorimotor and linguistic processing, this study stresses the importance of considering language processing to understand typing skills.

Keywords: expertise; visual guidance; skilled performance; language processing; typing

Introduction

Definitions of typing expertise have relied on the use of the touch-typing system (Feit et al., 2016; Larochelle, 1983; Logan et al., 2016; Van Weerdenburg et al., 2019). This typing strategy is acquired through formal training and requires using all 10 fingers with both hands precisely positioned to minimize hand and finger movements required to reach each key, yielding the most efficient typing behavior. Formal touch-typing training consists in learning the positions of the keys on the keyboard and the standard finger-to-key mappings. It has been the focus of studies on skill acquisition in professionally trained typists, which have reported increased reliance on kinesthetic feedback over the course of training (Larochelle, 1983; West, 1967).

More recent studies, conducted since keyboards have become a part of daily life, reported that people who underwent formal training can present substantial deviations from the touch-typing system in their routine way of typing (Feit et al., 2016; Logan et al., 2016; Yechiam et al., 2003): they tend to deviate in the total number of fingers and the finger-to-key mapping they use. However, this does not prevent them from achieving high typing speeds and efficient typing.

Untrained or self-taught typists can also achieve a high level of performance, qualitatively similar to professional typists (Pinet et al., 2022). However, they tend to use less consistent finger-to-key mappings than trained typists (Feit et al., 2016). They also spend less time looking at the screen and seem to rely more on visual guidance (looking at the hands and keyboard) than trained typists (Feit et al., 2016).

A potential benefit of lower reliance on visual guidance is that attention can be kept on the screen, instead of constantly shifting from the screen to the keyboard. This might be critical for some tasks, such as error detection when typing (Pinet & Nozari, 2021; Snyder et al., 2015). Indeed, several studies have shown that reliance on visual guidance is negatively associated with typing performance (Feit et al., 2016; Logan et al., 2016; Pinet et al., 2022). Being able to type without visual guidance may also involve a significant change in cognitive processing, as different sources of feedback (e.g., visual, tactile, kinesthetic) must be combined during typing. Low visual guidance suggests a strong reliance on kinesthetic feedback, which has become sufficient to guide finger movements. In fact, learning a new feedback controller (i.e., detecting, interpreting, and reacting to new sensory information) has been put forward as a necessary step in acquiring a new motor skill from scratch (Krakauer et al., 2019).

We postulate that the ability to type when visual guidance from the keyboard is removed might be a relevant criterion to define typing expertise in self-taught typists. In previous studies, the ability to type without visual guidance was assessed through self-reports from participants (e.g., Dhakal et al., 2018; Pinet et al., 2022). Direct measures of the ability to type without visual guidance showed that self-reports only partially agreed with actual measurements, with participants tending to underestimating their reliance on visual guidance (Logan et al., 2016). In a case study of a professional typist, the removal of visual guidance decreased performance, but only for content that was less familiar, such as numbers or punctuation signs (Long, 1976). Moreover, typists that tended to deviate from the 10-finger system were more affected than standard typists when visual guidance from the keyboard was unavailable (Logan et al., 2016). Still, to our knowledge, no study has directly compared typists according to their ability to type without visual guidance from the keyboard.

Our population of interest is everyday typists, a population that is constantly evolving due to technological developments, and is likely to differ between countries and as a result of the school curriculum (e.g., inclusion of formal typing training or not). Several studies have already characterized this population (Dhakal et al., 2018; Feit et al., 2016; Grabowski, 2008; Pinet et al., 2022). Here, contrary to previous studies, we did not establish groups based on typing speed (Dhakal et al., 2018; Pinet et al., 2022), use of standard

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finger-to-key mappings (Logan et al., 2016), or formal training (Feit et al., 2016). Rather we categorized typists based on their ability to type without visual guidance from the keyboard (i.e., a blind typing task). For lack of a better word, we refer to them as touch and non-touch typists, to stress the fact that they are able to rely mostly on *touch*, although they were not necessarily formally trained on the touch-typing system.

We present results of such blind typing task and demonstrate the validity of categorizing everyday typists by their ability to rely on touch. In Experiment 1, we report an analysis of 132 typists who took part in the blind typing task and a standardized typing test (Van Waes et al., 2019). We show that performance in blind typing correlates with specific aspects of typing skills. In Experiment 2, we report data on a subset of participants from Experiment 1 and show that touch and non-touch typists also present differences in oral language processing.

Experiment 1

Method

Participants We recruited 132 participants, whose age ranged from 19 to 61 (average 27±9 years), 23 males and 109 females. They were all native speakers of Spanish and all tasks were conducted in Spanish using the standard Spanish keyboard layout. The experiments were approved by our local ethics committee and participants were compensated for their time.

Tasks and Procedure Participants performed two independent tasks, a standardized typing test then a blind typing task, in the same session. The blind typing task was used to categorize typists, while the standardized typing test was used to measure their typing skills in different contexts. The standardized typing test was run using InputLog, a keystroke logging online platform (Leijten & Waes, 2013). It was developed to assess several aspects of motoric and typing behavior (see Van Waes et al., 2019 for details), and comprises a tapping task, a sentence and short phrases copy-task, and a consonant strings copy-task. The tapping task consists in typing the letters "d" and "k" in alternation as quickly as possible for 15s and measures motor speed. The sentence copy-task consists in typing a sentence comprising high-frequency words repeatedly for 30s. The short phrases copy-task consists in typing four three-word combinations seven times in a row: the first three-word combinations contain mainly high-frequency bigrams, the last one contains mainly low-frequency bigrams. The consonant copy-task consists in typing four blocks of six consonants once. Visual feedback from the screen and visual guidance from the keyboard was available throughout this task.

In the blind typing task, participants had to type single words. For the whole duration of the task, the keyboard was covered by a cardboard box making visual guidance from the keyboard unavailable, while visual feedback from the screen was maintained. Words were presented auditorily and participants had 3s to type them. After each trial, a fixation cross appeared for 400ms before the next word was presented. Stimuli consisted of 34 high-frequency concrete 4- to 8-letter Spanish nouns, four of which were used as training trials and not analyzed further.

Data analysis For the standardized typing test, interkeystroke intervals (IKI, i.e., the amount of time between successive keystrokes) were extracted and averaged by participants for each task (tapping, sentences, consonant strings). In the short phrases copy-task, IKI on high and low-frequency bigrams were computed separately (following the procedure proposed in Van Waes et al., 2019).

For the blind typing task, overall accuracy was computed for each participant. A trial was considered correct if it contained all the correct letters in the correct order, whether they had been corrected by backspaces or not. Partial accuracy was computed using the Levenshtein distance between a target word and the given response. IKI was averaged over correctly typed trials only.

Linear mixed-effect models that included random intercepts of stimuli and participant were used for single-trial data (blind typing task) and non-parametric tests were used for comparing groups at the subject level (typing test) to account for unequal sample sizes between touch and non-touch typists (see below). The contrast between touch and non-touch typists was dummy-coded.

Results and Discussion

Blind typing task The distribution of accuracy is depicted in Figure 1 (top). Accuracy was positively skewed (median = 23.5%). Since our goal was to characterize participants that were able to perform well on the blind typing task, we used Q3 (60%) as an accuracy cutoff to define a group of touch (N = 35, 27%) compared to non-touch typists (N = 97, 73%). This ensured that the touch typist group above the threshold had good accuracy.

To further characterize error trials, we examined partial accuracy, i.e., the distance between the target word and the given response, computed as the number of insertions/deletions/substitutions needed to transform one string into the other. Overall, on top of making fewer errors, touch typists' errors were closer to the target words, as their partial accuracy was lower than non-touch typists, M(touch) = 0.34 ± 0.25, M(non-touch) = 2.9 ± 1.3, $ß = 1.5$, $t = 7.4$, $p < .001$. Moreover, touch typists' performance was not sensitive to word length ($ß = 0.18$, $t = 1.6$, $p = .12$), while non-touch typists' partial accuracy increased with word length, as revealed by a significant interaction between group and word length, $ß = 0.65$, $t = 5.6$, $p < .001$ (Figure 1, bottom).

In line with their better accuracy, touch typists also typed faster than non-touch typists with the keyboard covered, as revealed by a significant main effect of group on IKI, M(touch) = 200.7 ± 30 ms, M(non-touch) = 260.1 ± 60 ms, ß

= 49.9, t = 6.0, p < .001. Again, touch typists were not sensitive to word length, ß = -5.3, t = -1.5, p = .14, although there was a significant interaction between group and word length, ß = -10.3, t = - 3.5, p < .001, such that the mean IKI of non-touch typists decreased as a function of word length.

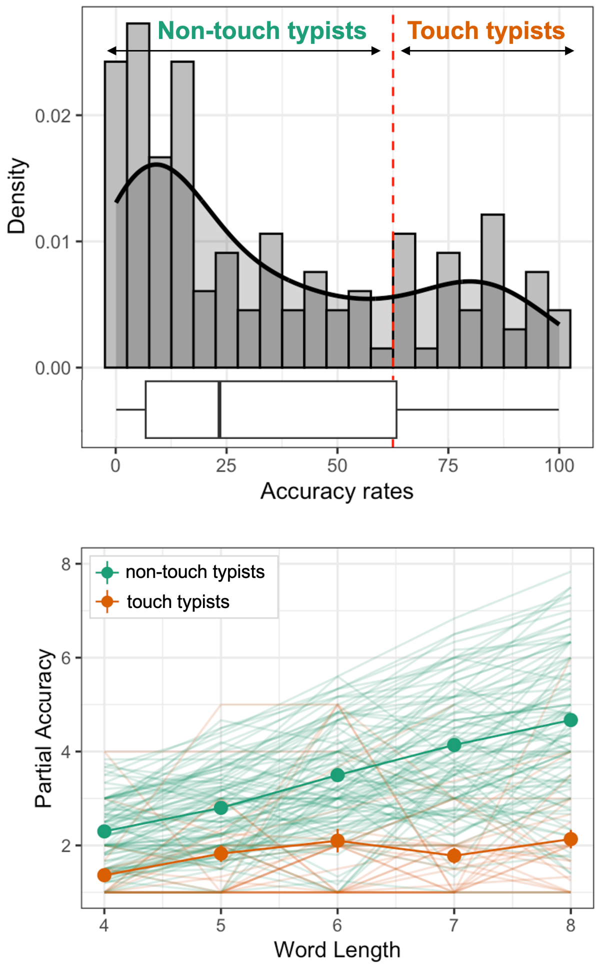

Figure 1: Top: Histogram of accuracy rates in the blind typing task, with density line and corresponding box-plot. Red dashed line represents the accuracy cut-off (at Q3). Bottom: Partial accuracy in the blind typing task by word length. Touch typists are depicted in orange, non-touch typists in green, individuals in light lines, group means in solid lines.

Typing test The two groups of touch and non-touch typists from the blind typing task were compared on the tasks of the standardized typing test (see Figure 2). As expected, touch typists were significantly faster in copying sentences, Z = 3.4, p < .001, d = 0.69. They were faster both on typing high-frequency bigrams, Z = 3.2, p = .002, d = 0.67, and low-frequency bigrams, Z = 4.4, p < .001, d = 0.83. They were also faster when typing non-lexical material such as consonant strings, Z = 5.01, p < .001, d = 1.0. All significant effects were of medium (Cohen's d above 0.6) or large size (for low-frequency bigrams and consonant strings). However, touch and non-touch typists did not differ significantly on a purely motoric tapping task, Z = 0.4, p = .69, M(touch) = 118.3 ± 32.0 ms; M(non-touch) = 130.2 ± 70.5 ms.

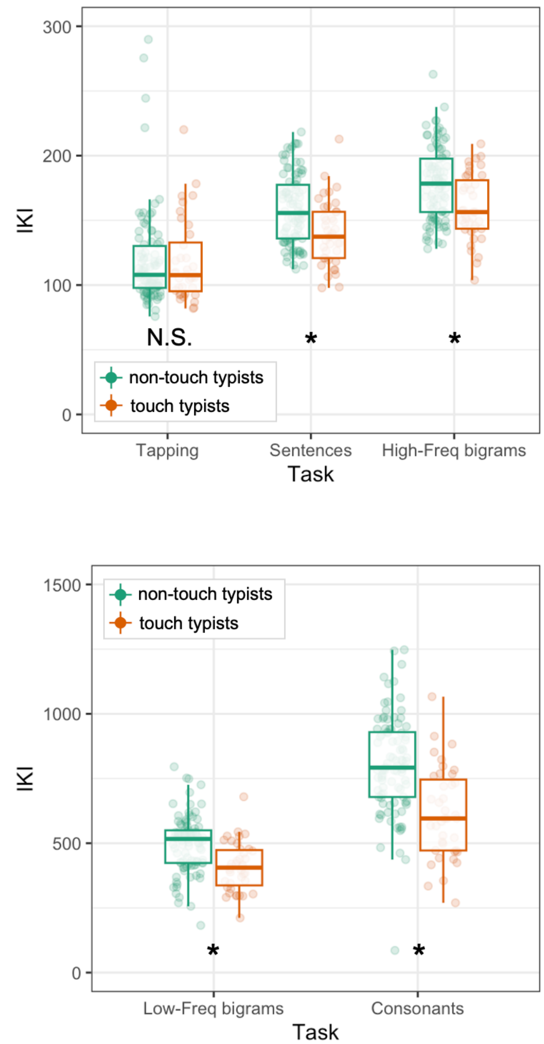

Figure 2: Boxplots showing interkeystroke intervals (in milliseconds) for each task of the typing test. Low-frequency bigrams and consonant strings copy-tasks are plotted on a separate graph to accommodate higher IKI. Touch typists are depicted in orange, non-touch typists in green.

In Experiment 1, we used performance on a blind typing task, i.e., typing with the keyboard covered, to classify everyday typists as touch vs. non-touch typists. Touch typists were defined as those with high accuracy (>60%) typing without visual guidance. In addition, touch typists were not sensitive to word length on measures of either speed or accuracy, whereas the performance of non-touch typists significantly worsened on words of increasing length.

The two groups' performance was then compared when typing in regular typing conditions (with visual guidance available). The participants classified as touch typists were faster than non-touch typists, whether copying lexical (sentences) or non-lexical material (consonant strings). However, both groups performed similarly on a motor tapping task, suggesting that the speed advantage of touch typists was specific to typing skills, rather than related to low-level motoric skills.

These results show that the typists classified as touch typists in our novel blind typing task showed superior typing skills in typical typing tasks (with visual guidance) that did not lie in low-level motoric skill but could be related to the linguistic nature of the task.

In this first experiment, the advantage of touch typists appeared specific to processing linguistic material. To further characterize the scope of the advantage conferred by the ability to type without visual guidance, in Experiment 2, we tested whether it was restricted to typing or whether touch typists would present more generalized faster linguistic processing assessed through production and perception tasks, in the written but also the oral modality.

Experiment 2

Method

Participants A subset of 39 participants from Experiment 1 participated in Experiment 2. Their age ranged from 19 to 35 years old (25±5 years old on average) and the sample comprised 32 females and 7 males. There were divided into two groups of touch (N = 16) and non-touch typists (N = 23) based on their accuracy on the blind dictation task from Experiment 1 (accuracy cut-off at 60%, M(touch) = 82.0±12%, M(non-touch) = 18.5±17%). Groups did not significantly differ in age or gender distribution (*p*s > .05).

Stimuli, Tasks, and Procedure Eighty 4- to 8-letter Spanish words and 80 matching pseudowords generated with Wuggy (default settings; Keuleers & Brysbaert, 2010) were divided into 4 lists to be used in the following four tasks: a copy task, a repetition task, an auditory lexical decision task, and a visual lexical decision task. The copy task assessed typed production and the repetition task assessed spoken production. The lexical decision tasks were used to assess language perception in auditory and visual modalities.

In the copy task, words and non-words were presented on the screen every 3500ms for participants to copy through typing. What participants typed appeared on the screen as they typed it and the keyboard was uncovered. Participants copied first all words then all non-words. In the repetition task, participants heard words and non-words every 3500ms and had to repeat them aloud while their responses were being recorded. Participants first repeated all the words before repeating non-words. In the auditory lexical decision task, participants heard auditory stimuli through headphones and had to indicate whether they were words or not by pressing keys (S and L) on the keyboard. A new word was presented every 3500ms, or 500ms after the response to the previous trial was given. The visual lexical decision task was set up in a similar way but in the visual modality, with stimuli appearing at the center of the screen. The order of tasks, the stimuli list used for each task, and the response keys mapping to words and non-words were counterbalanced between participants.

Data analysis RT was used as an index of processing speed in all tasks. Oral responses in the repetition task were transcribed by a native Spanish speaker, rated for accuracy, and RTs were measured using Praat (Boersma & Weenink, 2020). In the copy task, RT corresponded to the time between the presentation of the stimulus and the first keystroke. For tasks in the auditory modality (repetition and auditory lexical decision) RT was computed from the beginning of auditory stimulus.

Only correct trials were included in the RT analysis. For each task, RTs were analyzed through mixed-effect models that included random intercepts of stimuli and participant and contrasts were sum-coded.

Results and Discussion

We assessed language production through copy and repetition tasks (Figure 3). In copying, touch typists had lower RTs than non-touch typists, meaning they started typing their response earlier, ß = -214.8, t = -4.3, p < .001, M(touch) = 730.2 ± 125.8 ms; M(non-touch) = 940.2 ± 165.6 ms, d = 1.37. There was also a significant interaction between group and lexicality, ß = - 42.4, t = -2.7, p = .007, such that the difference between touch and non-touch typists was larger on pseudowords than on words. The main effect of lexicality did not reach significance, ß = 18.3, t = 1.2, p = .22.

In repetition, touch typists had significantly lower RTs than non-touch typists, ß = -145.0, t = -2.5, p = .017, meaning they started repeating the auditory stimulus earlier, M(touch) = 1144.0 ± 179.2 ms; M(non-touch) = 1288.7 ± 172.7 ms, d = 0.82. There was a significant effect of lexicality, ß = 28.6, t = 2.3, p = .022, with response latencies for words being shorter than for pseudowords, but no significant interaction of group and lexicality, ß = 1.4, t = 0.13, p = .90.

We assessed language perception through lexical decision tasks. In auditory lexical decision, there was no significant difference between touch and non-touch typists, ß = -57.7, t = -1.2, p = .25. Words were categorized significantly faster than pseudowords as indicated by a main effect of lexicality, ß = 85.5, t = 6.5, p < .001, but there was no significant interaction between group and lexicality, ß = 11.7, t = 0.80, p = .42. In visual lexical decision, the pattern of results was similar to auditory lexical decision. No significant difference was observed between touch and non-touch typists, ß = 6.0, t = 0.13, p = .90. A significant effect of lexicality was observed, ß = 90.0, t = 7.8, p < .001, but no significant interaction between group and lexicality, ß = 14.0, t = 0.91, p = .36.

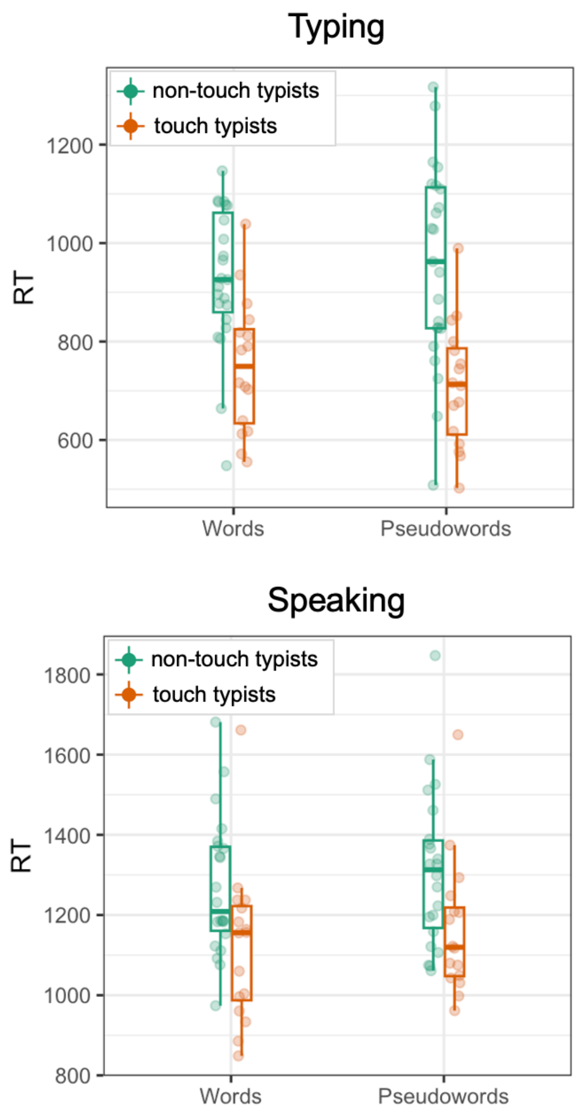

Figure 3: Boxplot of response latencies in language production tasks, top: typed copying, bottom: spoken repetition. Touch typists are depicted in orange, non-touch typists in green.

Extending results from Experiment 1 on typing speed, in Experiment 2 touch typists had faster response latencies than non-touch typists, as measured by a word/non-word copy task. Moreover, their response latencies were also faster in the oral modality when overtly repeating words and non-words. Nonetheless, touch and non-touch typists had similar response latencies in lexical decision, whether in the auditory or visual modality, arguing against a generalized improvement of linguistic processing and rather suggesting that any linguistic processing advantage may be limited to production.

General discussion

In this study, we introduced a novel way of categorizing everyday typists according to their ability to type without visual guidance from the keyboard. In two experiments, we measured participants performance on a blind typing task and tested for correlations with typing skills and general linguistic processing. Experiment 1 showed that touch typists outperformed non-touch typists in all copy typing tasks, but not in a low-level motoric task. Experiment 2 showed that performance in blind typing correlated with linguistic processing in both typed and spoken production tasks, although not perception tasks.

When measuring the distribution of skills in the blind typing task, the majority of participants fell way below 50% accuracy. We classified the upper quartile of our sample as touch typists, using a lenient cutoff of 60% accuracy. Yet, measuring the prevalence of touch typing in the general population was not the primary goal of this study, meaning our distribution shouldn't be interpreted as representative of typing skills in the general population. Rather we aimed to recruit skilled typists and so expected some sampling bias (e.g., we advertised our experiments were about typing).

The comparison of the two groups revealed significant differences in their typing performance, which were similar with or without visual guidance. Across all linguistic stimuli used (isolated words, sentences, consonant strings), touch typists outperformed non-touch typists in copying tasks, in both speed and accuracy. Moreover, without visual guidance, non-touch typists' performance was highly dependent on word length: they typed more slowly and made more errors as the number of letters in a word increased. In contrast, the performance of touch typists was unaffected. This could suggest that non-touch typists were processing words at the single letter-level, while touch typists were able to process words at a more global level.

However, non-touch typists and touch typists were equally fast at a simple motoric key-pressing task, indicating that the faster typing speed acquired by touch typists does not stem from performing simple motor actions faster. Rather, touch typists' speed advantage seems specific to processing linguistic material, whether letters or words.

Experiment 2 explicitly tested whether touch typists outperformed non-touch typists in linguistic processing that went beyond typing tasks, by using both perception and production tasks in the oral and written modalities. No difference between groups could be observed in lexical decision, in either modality (auditory or visual). Lexical decision includes perceptual as well as decision making and response selection processes. The absence of difference between groups suggests that touch typing skills do not convey any advantage for linguistic stimulus perception and identification. It also excludes a generalized improvement in processing speed.

Crucially, Experiment 2 showed that touch typists had shorter response latencies than non-touch typists in overt repetition, whether of words or non-words, with the difference between groups nearing 150 ms (a medium to large effect size). This suggests that touch typing skills may be associated with a spoken language production advantage, or tap into processes that are shared between oral and written production.

In both experiments, we found that the difference in typing performance between groups was higher with non-lexical than lexical material (pseudowords, consonant strings). Copying as well as repeating words and non-words is supported by working memory, in particular phonological working memory (Baddeley, 1983; Bonin et al., 2015). Thus, we posit that touch typing may rely on enhanced phonological working memory capacities, through the fast manipulation of linguistic material, and in particular speech sounds, in order to transcribe speech into letters. This proposal is in line with previous studies showing that literacy acquisition facilitates the retrieval of phonological representations (Araújo et al., 2019, 2023; Hervais-Adelman et al., 2022). It opens new avenues to study the link between spoken and written language processing.

The difference between groups might also lie in complex motor planning skills. Although we showed that groups did not differ in simple motoric skills, the low-level task we used did not require complex motor planning. Copying as well as repetition, in particular of non-lexical material, requires planning and assembling novel sequences of actions, which might tap into more complex motor skills. The fact that touch typists showed an advantage, in particular with non-lexical material that requires more planning than lexical material that can be retrieved from memory, would also fit with that interpretation. Whether their advantage is limited to manipulation of linguistic material or generalizes to complex motor planning of any type of actions remains to be established.

The results of the present study suggest that the acquisition of touch typing does not only rely on kinesthetic feedback but might also include an important linguistic component that has been overlooked in previous studies (Feit et al., 2016; Logan et al., 2016). This stresses the relevance of taking language processing into account when investigating typing skills, while also pointing to the importance of considering the relationships between spoken and written language.

Despite a relatively arbitrary cutoff to split our sample in two groups of touch and non-touch typists, we reported meaningful differences between groups. A larger sample size might reveal a more bimodal distribution of accuracy in the blind typing task, making it easier to categorize individuals. Characterizing the trajectory of acquisition of touch typing could also help clarify the underlying distribution. It must be noted that these data do not address the causality of the relation between faster response latencies and touch typing: in particular, it remains to be established whether acquiring touch typing skills leads to faster spoken language production, or whether better phonological skills facilitate the acquisition of touch typing skills. Direct intervention programs should be able to clarify the directionality of this effect.

In conclusion, through this novel characterization of "everyday touch typists", we demonstrate that the ability to type without looking at the hands and keyboard is a useful way to classify typing skills. In two experiments, we showed that touch typists outperformed non-touch typists in all copy typing tasks, but not in a low-level motoric task, and that performance in blind typing correlated with linguistic processing in production but not perception tasks. These results open further questions about the generalizability of typing skills and the shared processes between oral and written language, and stress the importance of considering language processing to better understand typing skills.

Acknowledgments

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