Title: QWERTY: We Like Easy Words to Type

**Authors:** Erin M. Buchanan1\*, Kathrene D. Valentine1

**Affiliations:** 1Missouri State University

\*Correspondence to: erinbuchanan@missouristate.edu

**Abstract**: Typing is a ubiquitous daily action for many individuals; yet, research on how these actions have changed our perception of language is minimal. The QWERTY effect is the supposed increase in pleasantness ratings for words typed more with the right hand on a traditional keyboard (*1*). Although this finding is intuitively appealing given both right handed dominance and the smaller number of letters typed with the right hand, the current interpretation does not appear to take account for the embodied nature of our procedural actions (*2*). The present paper reexamines the QWERTY effect within the embodied cognition framework and shows that participants rate words that are easier to type (i.e. alternating hand keypresses) as more pleasant than other typing combinations. This finding indicates that typing has influenced our perception of language due to action oriented, not spatially oriented, feedback.

**One Sentence Summary:** QWERTY keyboard typing increases likability for words that are easy to type rather than right handed words as previously reported.

**Main Text:** From its creation in 1868, to its appearance in our homes today, the QWERTY keyboard has held the interest of psychologists. The process of typing on a keyboard requires many procedures to function in tandem, which creates a wealth of actions to research (*3*). Rumelhart and Norman’s (*4*) computer model of skilled typing is still highly influential. They hypothesize that typing results from the activation of three levels of cognition: the word level, the keypress level, and the response level. They believe that after word perception, the word level is activated, causing the keypress level to initiate a schema of the letters involved in typing the word. This schema includes the optimal position on the keyboard for that specific hand-finger combination to move to at the appropriate time for individual keystrokes. Concurrently, the response system sends feedback information to initiate a keypress motion when the finger is in the appropriate space. Their theory proposes that schemata and motion activations occur simultaneously, constantly pulling or pushing the hands and fingers in the right direction.

While other studies have focused on errors in typing (*5*), Logan (*6*) argued for parallel activation of keypresses. He examined the Simon effect to show more than one letter is activated at the same time, and consequently, the second keypress motion is begun before the first keypress is done. The Simon effect occurs when congruent stimuli create faster responses than incongruent stimuli, much like the Stroop task (*7, 8*). For example, if we are asked to type the letter *f* (a left handed letter), we type it faster if the *f* is presented on the left side of the screen. Similarly, Rieger (*9*) reported a congruency effect when studying an altered Stroop task. The task consisted of centrally presented colored letters, in which participants were required to respond with left or right handed keys based on color. When the letter and color were congruent, the skilled typists’ responses were faster than when the letter and color were incongruent. These results suggest that automatic actions stimulate motor and imagery representations concurrently and may be linked together in the brain (*9, 10, 11*). The dual activation of motor and imagined items is the basis for embodied cognition, a rapidly expanding field in psychology (*2, 12*).

**Embodied Cognition.** While the mind was traditionally considered an abstract symbol processor (*13*), newer cognitive psychology theories focus on the interaction between the brain’s sensorimotor systems and mental representations of events and objects (*2, 14*). The interplay between these systems has been found in both neurological (*15, 16, 17*) and behavioral research (*18, 19, 20*). Even when not specifically asked to perform a task, the motor representation of that task is activated, and if the action is well-learned, the task is perceived as pleasant (*21, 22, 23*). For example, Beilock and Holt (*21*) asked novice and expert typists to pick which one of two letter dyads they preferred, which were either different hand combinations (*CJ*) or same finger combinations (*FV*). They found that novices have no preference in selection, while expert typists more reliably picked the combinations that were easier to type. To show that this effect was due to covert motor representation activation, and thus, expanding on findings from Van der Bergh, Vrana, and Eelen (*24*), participants also made preference selections while repeating a keypress combination. When expert motor planning was distracted by remembering the pattern presented, no preference for letter dyads was found, indicating that the simultaneous activation of the motor representation was necessary to influence their likability ratings. Similar embodied findings have also been portrayed with emotionally charged sentences and facial movements (*25*), positive-negative actions, such as head nodding or arm movements (*22, 26),* and perceptuomotor fluency (*23, 27*).

**Body Specificity Hypothesis.** Using an embodied framework, Casasanto (*28*) has proposed that handedness dictates preference because our representations of actions are grounded in our physical interactions with the environment. In several studies, he portrayed that handedness influenced preference for spatial presentation (i.e. left handed individuals associate “good” with left, while right handed individuals associate “good” with right), which in turn influenced judgments of happiness and intelligence and our decision making in hiring job candidates and shopping. In all these studies, participants reliably selected the hand-dominant side more often, which does not match cultural or neurolinguistic representations of positive-is-right and negative-is-left (*29*). These findings imply that our handedness is a motor expertise that causes ease of action on the dominant side to positively influence our perceptions of items presented on that side. Further, Casasanto (*30*) compiled a review of body specific actions and their representation in the brain using fMRIs. Handedness interacted with imagining actions, reading action, and perceiving the meanings of action verbs, such that fMRI patterns were mirrored for left and right handed participants matching their dominant side.

**The QWERTY Effect.** These effects inspired Jasmin and Casasanto (*1*) to propose the idea that typing, an action that often replaces speaking, has the ability to create semantic changes in how we perceive words. The asymmetrical arrangement of letters on the QWERTY keyboard increases fluency of typing letters on the right side because there are fewer keys, and thus, less competition for fingers. That arrangement should then cause us to perceive the letters on the right side as more positive and letters on the left side as more negative. Consequently, words that are composed of more letters from the right side (the right hand advantage) should be rated as more positive than those with more letters on the left. They found this preference for the right hand advantage over three languages (English, Spanish, and Dutch), and the effect was even stronger on words created after the invention of the QWERTY keyboard (i.e. *lol*), as well as evident in pseudowords such as *plook*. However, in contrast to the body specificity hypothesis, left and right handed participants showed the same trend in effects for positive-is-right words.

**The Current Study.** In examining the QWERTY effect, Liberman (*31*) and Dobbs and Danforth (*32*) both share concerns that these results are due to chance as they show fairly convincing arguments that the effect is very small (*r2 <* .01) and can be replicated by a random number generator. Further, while the QWERTY effect appeared to support a positive-is-right version of fluency, actual typing fluency in both expertise and physical keypress combinations was ignored. Therefore, we have examined the QWERTY effect, controlling for typing expertise, from the view point of the procedural action system wherein participants should prefer words that are easier to type to account for another form of fluency.

**Results.** Data were screened for assumptions of repeated measures ANCOVA, as well as the outlier analysis described in the supplemental methods. All assumptions were found to be satisfactory. Table 1 contains example stimuli used in the study. A 2 (real/pseudoword) X 6 (all left, all right, more left, more right, equal, perfect) repeated measures ANCOVA was analyzed with a covariate of typing speed to neutralize effects of expertise on typing preferences (*21*). Real words were rated significantly higher than pseudowords, *F*(1, 145) = 103.42, *p* < .001, *η2* = .53, and a significant main effect was found for types of words, *F*(5, 460) = 6.25, *p* < .001, *η2* = .06. The interaction between real/pseudowords and word type was also significant, *F*(5, 265) = 12.26, *p* < .001, *η2* = .12, as shown in Figure 1. To understand the pattern of interaction, real and pseudowords were analyzed with two different repeated measures ANCOVAs across word type while still controlling for typing speed. These analyses showed that real words showed significant word type differences, *F*(5, 460) = 14.27, *p* < .001, *η2* = .13. However, pseudoword ratings were not significant, *F*(5, 460) = 2.06, *p* = .07, *η2* = .02, indicating that pseudowords were rated equally pleasant regardless of typability. Next, post hoc analyses were examined using Fisher’s Least Significant Difference and a Bonferroni correction on real words only for different word types. See Table 2 for the breakdown of the 15 pairwise comparisons. Adjusted alpha was set family wise at 0.003. As shown in the Table 2, perfectly alternating words were rated significantly higher than all other word types: left, right, or equally split between hands. Next, equally split words, more left, and more right words were rated correspondingly pleasant. Below this group, all left and all right words were rated at similar levels of pleasantness.

Further, in an effort to replicate Liberman’s (*31*) criticisms and show that our results do not support the right handed preference of the QWERTY effect, we recoded words with +1 for each right handed letter and -1 for each left handed letter. This scoring ranged from all right handed words (+4) to all left handed words (-4), and where equally split and perfectly alternating words were both collapsed into 0. Figure 2 portrays the relationship between handedness of typing and pleasantness ratings, which was non-significant, *r* = .03, *p* = .66. Our scatterplot resembles the scatterplots presented in both Jasmin and Casasanto (*1*) and on Liberman’s and Dobbs and Danforth’s (*31, 32*) respective blogs, and we echo their sentiment that the correlation between right hand advantage and valence is effectively random.

**Discussion.** These results imply that the QWERTY keyboard has influenced our perceptions of words, but not as a right handed advantage touted by Jasmin and Casasanto (*1*). Rather, we find that the procedural action of typing changes our pleasantness ratings by endearing us to words that are easier to type in descending order (all alternating, some alternating, all one hand); thus supporting a strict embodied view that fluency of motor representation of an action impacts judgments. These results mirror a clever set of studies by Holt and Beilock (*19*) wherein they showed participants sentences that matched or did not match a set of pictures (i.e. *the umbrella is in the air* paired with a picture of an open umbrella). Given dual-coding theory (*33*), it was not surprising that participants were faster to indicate picture-sentence matches than non-matches (also see *34, 35*). Further, they showed these results extended to an expertise match; hockey and football players were much faster for sentence-picture combinations that matched within their sport than non-matches, while novices showed no difference in speed for matches or non-matches on sports questions. Even more compelling are results that these effects extend to fans of a sport and are consistent neurologically (i.e. motor cortex activation in experts; *36*).

Our results, however, did not support the interaction between typability and pseudowords, as all pseudowords were rated similarly with a very small effect size. Both Beilock and Holt (*21*) and Van der Bergh et al. (*24*) showed expert preferences for two and three letter combinations that were typed with different fingers. Here, our focus was on the influence of ease of typing on judgments rather than the skill of typing as a preliminary analysis, which may explain differing results. Our results could imply that our embodied actions influence preferences for procedures that are more likely in our environment. While our pseudowords were legal English phoneme combinations, they are extremely unlikely to have been previously practiced or encountered in our daily tasks. Therefore, typability preference will not extend to pseudowords (unpracticed actions) because they are not fluent (*27*). Coding typability does become extraordinarily complex with an increase in word length, but this initial reanalysis of the QWERTY effect illuminates the need to examine how skill can influence other cognitive processes. Further work should investigate these effects on other keyboard layouts, such as Dvorak, which was designed to predominately type by alternating hands to increase speed and efficiency (*37*).

References and Notes:

1. K. Jasmin, D. Casasnto, The QWERTY effect: How typing shapes the meaning of words. Psychon. Bull. Rev. **19**, 499-504 (June 2012).
2. L. Barsalou, Perceptual symbol systems. Behav. Brain Sci. **22,** 577-609 (August 1999).
3. A. W. Inhoff, A. M. Gordon, Eye movements and eye–hand coordination during typing. *Current Directions in Psychological Science* **6**, 153–157 (December 1997).
4. D. E. Rumelhart, D. A. Norman, Simulating a skilled typist: A study of skilled cognitive-motor performance. Cognit. Sci. ***6*,** 1–36 (January 1982).
5. F. A. Logan, Errors in copy typewriting. *Journal of Experimental Psychology: Human Perception and Performance* **25**, 1760-1773 (December 1999).
6. G. D. Logan, Simon-Type effects: Chronometric evidence of keypress schemata in typewriting. *Journal of Experimental Psychology: Human Perception and Performance* ***29****, 741-757* (August 2003).
7. J. R. Simon, A. M. Small Jr., Processing auditory information: Interference from an irrelevant cue. *Journal of Applied Psychology* **53,** 433–435 (October 1969).
8. J. R. Simon, in *Stimulus–response compatibility: An integrated perspective,* R. W. Proctor, T. G. Reeve, eds. (Elsevier, Amsterdam, 1990)pp. 31–86.
9. M. Rieger, Automatic keypress activation in skilled typing. *Journal of Experimental Psychology: Human Perception and Performance* ***30***, 555–565 (June 2004).
10. G. D. Logan, N. J. Zbrodoff, Stroop-type interference: Congruity effects in color naming with typewritten responses. *Journal of Experimental Psychology: Human Perception and Performance* **24**, 978-992 (June1998).
11. B. Hommel, J. Muesseler, G. Aschersleben, W. Prinz, The theory of event coding: A framework for perception and action planning. Behav. Brain Sci.***24****,* 849–878 (October 2001).
12. T. A. Salthouse, Perceptual, cognitive, and motoric aspects of transcription typing. Psychol. Bull. **99**, 303–319 (May 1986).
13. A. Newell, H. A. Simon, Computer science as empirical inquiry: Symbols and search. *Communications of the ACM* **19**, 113–126 (1976).
14. R.A. Zwaan, Embodied cognition, perceptual symbols, and situation models. *Discourse Processes* **28**, 81–88 (1999).
15. O. Hauk, I. Johnsrude, F. Pulvermuller, Somatotopic representation of action words in the human motor and premotor cortex. *Neuron* **41**, 301–307 (January 2004).
16. M. Tettamanti, G. Buccino, M. C. Saccuman, V. Gallese, M. Danna, P. Scifo, F. Fazio, G. Rizzolatti, S. F. Cappa, D. Perani, Listening to action-related sentences activates frontoparietal motor circuits. J. Cogn. Neurosci. **17**, 273–281 (February 2005).
17. I. Lyons, M. Cieslak, A. Mattarella-Micke, H. Nusbaum, S. Small, S. L. Beilock, Neural processing of action-related language. Brain Lang. **112**, 214-222 (2010).
18. R.A. Zwaan, L.J. Taylor, Seeing, acting, understanding: Motor resonance in language comprehension. *Journal of Experimental Psychology: General* **135**, 1–11 (February 2006).
19. L. E. Holt, S. L. Beilock, Expertise and its embodiment: Examining the impact of sensorimotor skill expertise on the representation of action-related text. Psychon. Bull. Rev. **13**,694-701 (August 2006).
20. E. Cartmill, S. Goldin-Meadow, S. L. Beilock, A word in the hand: Human gesture links representations to actions. Philos. Trans. R. Soc. London Ser. B (2012).
21. S. L. Beilock, L. E. Holt, Embodied preference judgments: Can likeability be driven by the motor system? Psychol. Sci. **18**, 51-57 (January 2007).
22. R. Ping, S. Dhillon, S. L. Beilock, Reach for what you like: The body’s role in shaping preferences. Emotion Review **1**, 140-150 (April 2009).
23. S. Yang, D. A. Gallo, S. L. Beilock, Embodied memory judgments: A case of motor fluency. *Journal of Experimental Psychology: Learning, Memory, and Cognition* **35**, 1359-1365 (September 2009).
24. O. Van der Bergh, S. Vrana, P. Eelen, Letters from the heart: Affective categorization of letter combinations in typists and nontypists. *Journal of Experimental Psychology: Learning, Memory, and Cognition* **16**, 1153–1161 (November 1990).
25. D. A. Havas, A. M.Glenberg, M. Rinck, Emotion simulation during language comprehension. Psychon. Bull. Rev. ***14***, 436-441 (June 2007).
26. A. M., Glenberg, B. J.Webster, E. Mouilso, D. Havas, L. M. Lindeman, Gender, emotion, and the embodiment of language comprehension. *Emotion Review* ***1,*** 151-161. (April 2009).
27. D. M. Oppenheimer, The secret life of fluency. *Trends in Cog. Sci.* ***12****, 237-241* (June 2009).
28. D. Casasanto, Embodiment of abstract concepts: Good and bad in right- and left-handers. *Journal of Experimental Psychology: General* **138**, 351-367 (August 2009).
29. R. J. Davidson, Anterior cerebral asymmetry and the nature of emotion. *Brain and Cognition* ***20****,* 125–151 (September 1992).
30. D. Casasanto, Different bodies, different minds: The body specificity of language and thought. *Current Directions in Psychological Science* **20**, 378-383 (December 2011).
31. M. Liberman, The QWERTY effect. *Language Log*. Linguistic Data Consortium. Web Blog. (March 2012).
32. P.S. Dodds, C. Danforth, Does QWERTY Affect Happiness? Computational Story Lab ++;. University of Vermont. Web Blog. (March 2012).
33. A. Paivio, *Imagery and verbal processes* (Holt, Rinehart, & Winston, Oxford England, 1971).
34. R. A. Stanfield, R. A. Zwaan, The effect of implied orientation derived from verbal context on picture recognition. *Psychological Science* **12**, 153-156 (March 2001).
35. R. A. Zwaan, R. A. Stanfield, R. H. Yaxley, Language comprehenders mentally represent the shape of objects. Psychol. Sci. **13**, 168-171 (March 2002).
36. S. L. Beilock, I. M. Lyons, in The Handbook of Imagination and Mental Simulation, K. Markman, B. Klein, and J. Suhr, eds. (Psychology Press, 2008) pp. 21-34.
37. J. Noyes, The QWERTY keyboard: a review. *International Journal of Man-Machine Studies* **18,** 265–281 (August 1988).

**Acknowledgments:** This study was originally presented at the 2012 Annual Psychonomic Society Meeting, and the data are available upon request from the authors. The authors would like to thank Brenda Burrell for her contributions to the study.

**Fig 1.** Average word pleasantness ratings for each word type by real/pseudoword combination. Error bars represent standard deviation.

**Fig 2.**The relationship between the original QWERTY effect and average pleasantness scores by word. Negative values indicate left handed words, while positive values indicate right handed words.

**Table 1.**Example Stimuli and Coding for Typability.

|  |  |  |  |
| --- | --- | --- | --- |
| **Word Type** | **Letter Coding** | **Real Words** | **Pseudowords** |
| All on Left | LLL, LLLL | Cat, Vest, Safe | Zet, Tafe, Faw |
| All on Right | RRR, RRRR | Milk, Nun, Mop | Hok, Poom, Joi |
| More Left | LLLR, LLR, RLLL, RLL | Heal, Dirt, Rude | Jeet, Tofe, Zape |
| More Right | RRRL, RRL, LRRR, LRR | Lamp, Wine, Shy | Pome, Noof, Zood |
| Equal Amount of Left and Right | LLRR, RRLL | Grin, Rain, Scum | Olra, Frol, Edop |
| Perfect Alternation | LRLR, RLRL | Burn, Cozy, Lamb | Rorp, Mepe, Spak |

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 2**. Pairwise Comparisons for Real Words*.* | | | |
| Comparison | Difference Score | *p*-value | Effect size |
| Perfect - More left | 0.228 | < 0.001 | -0.36 |
| Perfect - Equal | 0.296 | < 0.001 | -0.32 |
| Perfect - More right | 0.322 | < 0.001 | -0.41 |
| Perfect - All right | 0.546 | < 0.001 | -0.65 |
| Perfect - All left | 0.567 | < 0.001 | -0.61 |
| Equal - More right | 0.026 | 0.643 | 0.04 |
| Equal - More left | -0.068 | 0.297 | -0.09 |
| Equal - All right | 0.250 | < 0.001 | -0.34 |
| Equal - All left | 0.271 | < 0.001 | -0.34 |
| More left - More right | 0.094 | 0.087 | 0.14 |
| More left - All right | 0.318 | < 0.001 | -0.46 |
| More left - All left | 0.339 | < 0.001 | -0.46 |
| More right - All right | 0.224 | < 0.001 | -0.30 |
| More right - All left | 0.245 | < 0.001 | -0.42 |
| All left - All right | -0.021 | 0.766 | -0.03 |

*Note.* Effect size is Cohen’s *d* calculated with standard deviation of the difference scores as the denominator. These comparisons have been ordered in descending pleasantness ratings.

Supplementary Materials:

Materials and Methods:

**Participants.** Participants (*N* = 157) were recruited from the university undergraduate human subject’s pool and received course credit for their time. Data were screened for multivariate outliers, and two participants were removed for having extreme Mahalanobis distance scores (*38*). Further, nine participants were eliminated for low typing accuracy (< 80%), which left *N* = 146 in the study. Approximately 10 percent (*N* = 14) of the sample was left handed. The average typing speed was *M* = 48.55 (*SD* = 13.86; range = 22 – 98 wpm), and the average percent accuracy rate for the typing test was *M* = 93.13 (*SD* = 5.55).

**Materials.** The English ANEW (*39*) norms were used to create stimuli for this study, in an effort to replicate Jasmin and Casasanto’s (*1*) experiments. Typing manuals were consulted, and letters were coded as left (q, w, e, r, t, a, s, d, f, g, z, x, c, v, b) or right handed letters (y, u, i, o, p, h, j, k, l, n, m). The three and four letter words were selected from this database and were coded as follows. First, concepts selected were either real or pseudowords. Second, words were classified by their typability into six categories: 1. All left handed, 2. All right handed, 3. More left handed, 4. More right handed, 5. Equal left-right handed, 6. Perfect alternation between left and right handed letters. Table 1 shows examples of stimuli for each word coding. Lastly, words were coded if they repeated keypresses on the same finger (across the whole word, *kin* would repeat, but *mop* would not) as a control variable. This coding scheme created 24 possible word conditions (2-real/pseudowords X 6-typability X 2-repetition), and ten words of each type were selected (240 words total). Since the ANEW database did not have enough stimuli of each type, 76 (31.7%) new words were created so that at least ten words of each type were available.

**Procedure.** Upon consent to participate in the experiment, participants were given a typing test by using free typing test website (*40*). Each participant typed Aesop’s Fables for one minute before the website would reveal their typing speed and accuracy rate, which was recorded by the experimenter. After this test, participants indicated their dominant writing hand. Participants were then given 120 of the 240 stimuli to rate for pleasantness. Five words of each of the 24 types described above were selected from the list of 240 words, which was used to control for word effects and fatigue/boredom on participants. These stimuli were counterbalanced across participants, and the order of the stimuli was randomized. Participants were told to rate each word for how pleasant it seemed using a 9 point Likert type scale (1 – very unpleasant, 4 – neutral, 9 – very pleasant). The same self-assessment manikin from Jasmin and Casasanto (*1*) was shown to participants at the top of the computer screen to indicate the points on the Likert scale. The words appeared in the middle of the screen in 18 point Arial font. Participants then typed the number of their rating on the computer keyboard. Once they rated all stimuli, participants were debriefed and allowed to leave.

**References (38-40):**

1. B. G. Tabachnick, L. S. Fidell, *Using Multivariate Statistics* (Pearson Education, Inc., ed. 5, 2012).
2. M. M. Bradley, P. J. Lang, “Affective norms for English words (ANEW): Instruction manual and affective ratings” (Tech. Rep. C-1, the Center for Research inPsychopathology, University of Florida, 1999).
3. TypingMaster, Inc., Aesop’s Fables. TypingMaster, Inc. Web. (March 2013).