An Extension of the QWERTY Effect: Not Just the Right Hand, Expertise and Typability Predict Valence Ratings of Words

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Abstract

Typing is a ubiquitous daily action for many individuals; yet, research on how these actions have changed our perception of language is limited. The QWERTY effect is an increase in valence ratings for words typed more with the right hand on a traditional keyboard (Jasmin & Casasanto, 2012). Although this finding is intuitively appealing given both right handed dominance and the smaller number of letters typed with the right hand, extension and replication of the right side advantage is warranted. The present paper reexamined the QWERTY effect within the embodied cognition framework (Barsalou, 1999) and found that the right side advantage is replicable to new valence stimuli, as well as experimental manipulation. Further, when examining expertise, right side advantage interacted with typing speed and typability (i.e. alternating hand keypresses or finger switches) portraying that both skill and our procedural actions play a role in judgment of valence on words.

*Keywords*: keyboard, valence, QWERTY, word norms

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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 (Inhoff & Gordon, 1997). Rumelhart and Norman’s (1982) 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 many studies have focused on errors in typing to investigate response system feedback (F. A. Logan, 1999), G. D. Logan (2003) 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 (Simon, 1990; Simon & Small, 1969). 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 (2004) reported finger-congruency effects by altering a Stroop task: participants were required to respond to centrally presented letters based on color-key combinations. When the letter and color were congruent (i.e. a right-handed letter was presented in the designated color for a right response), the skilled typists’ responses were faster than incongruent combinations. Further, this effect was present when participants responded to items with their hands crossed on the responding device, suggesting the effect was expertise-based rather than experiment-response based. These results imply that automatic actions stimulate motor and imagery representations concurrently and may be linked together in the brain (Hommel, Müsseler, Aschersleben, & Prinz, 2001; G. D. Logan & Zbrodoff, 1998; Rieger, 2004). This dual activation of motor and imagined items is the basis for embodied cognition, a rapidly expanding field in psychology (Barsalou, 1999; Salthouse, 1986).

**Embodied Cognition**

While the mind was traditionally considered an abstract symbol processor (Newell & Simon, 1976), newer cognitive psychology theories focus on the interaction between the brain’s sensorimotor systems and mental representations of events and objects (Barsalou, 1999; Zwaan, 1999). The interplay between these systems has been found in both neurological (Hauk, Johnsrude, & Pulvermüller, 2004; Lyons et al., 2010; Tettamanti et al., 2005) and behavioral research (Cartmill, Goldin-Meadow, & Beilock, 2012; Holt & Beilock, 2006; Zwaan & Taylor, 2006). Motor representations of tasks are activated even when not specifically asked to perform the task, and if the action is well-learned, the task is perceived as pleasant (Beilock & Holt, 2007; Ping, Dhillon, & Beilock, 2009; Yang, Gallo, & Beilock, 2009). For example, Beilock and Holt (Beilock & Holt, 2007) 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 den Bergh, Vrana, and Eelen (1990), 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 (Havas, Glenberg, & Rinck, 2007), positive-negative actions, such as head nodding or arm movements (Glenberg, Webster, Mouilso, Havas, & Lindeman, 2009; Ping et al., 2009)*,* and perceptuomotor fluency (Oppenheimer, 2008; Yang et al., 2009).

**Body Specificity Hypothesis**

Using an embodied framework, Casasanto (2009) 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 (Davidson, 1992). 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 (2011) 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 (2012) 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 side advantage; RSA) should be rated as more positive than those with more letters on the left. They found this preference for RSA 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.

**Current Study**

The current study has two focuses: 1) examine the QWERTY effect across more stimuli norms, and 2) examine right side advantage’s interaction with traditional embodied cognition definitions (expertise, fluency). The body specificity hypothesis has previously been tested using openly available valence ratings in the ANEW (Bradley & Lang, 1999) and AFINN (Nielsen, Hansen, Arvidsson, & Colleoni, 2011) databases but only examining for RSA. We searched for other valence norms and found Ferstl, Garnham and Manouilidou’s (2011) ratings for verbs, Dodds, Harris, Kloumann, Bliss, and Danforth’s (2011) norms from Twitter, Google Books, The New York Times, and music lyrics (see also Kloumann, Danforth, Harris, Bliss, & Dodds, 2012) and a very recent publication of a large-scale valence database (Warriner, Kuperman, & Brysbaert, 2013), which examined valence across gender, age, and education. These five databases were used to analyze the different implications of the body specificity hypothesis and a more general embodied hypothesis by testing the following: 1) RSA should be a significant predictor of valence ratings, even after controlling for word length and average letter frequency, to extend the findings of Jasmin and Casasanto (2012) to three new databases. 2) To examine embodied cognition, we coded each word for number of hand alternations (akin to Beilock and Holt’s (2007) different hand preferences). Given that typing involves the procedural action system, we would also expect to find that increased hand switches are positively related to ratings of valence because words that are typed on alternating hands are easier to type. 3) Lastly, the interaction between RSA and switches was examined to determine if these hypotheses can be combined (i.e. we only like right handed words because we have to switch back and forth to type the more commonly used letters, such as *e* or *a*).

**Experiment 1**

**Method**

**Participants**

**Materials**

**Coding.** Each of the datasets used in this experiment and Experiment 2 were coded for control and experimental variables. Control variables included word length and average letter frequency. Average letter frequency was created by averaging the English letter frequency (Lewand, 2000) for each letter in a word. Words with high average letter frequencies contain more commonly used letters (*e, t, a, o*); while words with lower frequencies use more of the less common letters (*z, q, x, j*). Experimental variables included RSA, number of hand switches, and number of finger switches. 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*). Left handed letters were coded with -1 and right handed letters with +1, which created summed scores indicating the overall right side advantage for a word. Words were coded for the number of hand switches within a word using the left-right coding system described above. Finally, the number of finger switches were coded using traditional typing manuals for each finger. Finger switches was highly correlated with word length, and therefore, word length was excluded as a control variable due the interest in typing skill for experimental hypotheses. EXAMPLE HERE.

**Procedure**

**Replication with lots of words**

120 out of 2744 words

|  |  |
| --- | --- |
| **1021130.41251** | 360 |
| **1022130.4166666666666671** | 360 |
| **917130.6868055555555561** | 360 |
| **1001130.5840277777777781** | 240 |
| **1002130.6666666666666671** | 240 |
| **1003130.4798611111111111** | 240 |
| **1007130.5381944444444441** | 240 |
| **1008130.6881944444444441** | 240 |
| **1009130.4993055555555561** | 240 |
| **1014130.6479166666666671** | 240 |
| **1014130.6645833333333331** | 240 |
| **1021130.6881944444444441** | 240 |
| **1030130.651** | 240 |
| **502120.543751** | 240 |
| **502120.5826388888888891** | 240 |
| **905130.6034722222222221** | 240 |
| **909130.46251** | 240 |
| **910130.6215277777777781** | 240 |
| **910130.6465277777777781** | 240 |
| **910130.6638888888888891** | 240 |
| **916130.5423611111111111** | 240 |
| **916130.6395833333333331** | 240 |
| **916130.6458333333333331** | 240 |
| **916130.656251** | 240 |
| **916130.6645833333333331** | 240 |
| **917130.4222222222222221** | 240 |
| **917130.5381944444444441** | 240 |
| **917130.5972222222222221** | 240 |
| **917130.6423611111111111** | 240 |
| **917130.6722222222222221** | 240 |
| **918130.56111111111111155** | 240 |
| **918130.5916666666666674** | 240 |
| **918130.6694444444444441** | 240 |
| **918130.6847222222222221** | 240 |
| **919130.5201388888888891** | 240 |
| **919130.5458333333333331** | 240 |
| **920130.618751** | 240 |
| **925130.5763888888888891** | 240 |

**Experiment 2**

**Method**

**Participants**

**Materials**

**Procedure**

**Replication but they typed the words first**

**Participants**

Participants (*N* = 157) were recruited from the university undergraduate human subject pool and received course credit for their time. Rating data were screened for multivariate outliers, and two participants were found to have extreme Mahalanobis distance scores (Tabachnick & Fidell, 2012). However, these individuals did not influence the results when the data was tested with and without them, and so were left in the data set. Further, nine participants were eliminated for low typing accuracy (< 80%), which left *N* = 148 in the study. Approximately 10 percent (*N* = 14) of the sample was left-handed. The average typing speed was *M* = 48.622 (*SD* = 13.782; range = 22 – 98 wpm), and the average percent accuracy rate for the typing test was *M* = 93.074 (*SD* = 5.530). Data was not collected on participant typing styles and is discussed below as a potential limitation.

**Materials**

The English ANEW (Bradley & Lang, 1999) norms were used to create stimuli for this study, in an effort to replicate Jasmin and Casasanto’s (2012) experiments, and 240 words were selected for this experiment (120 real words, 120 pseudowords). Pseudowords were selected from Appendix E of the supplementary materials presented from the QWERTY publication. These words were coded as described in the first experiment for RSA, switches, word length, and letter frequency. These words were selected to control for equal numbers of all-right handed, all-left handed, and equally split words, as well as repeated keypresses on the same finger (across the whole word, *kin* would repeat, but *mop* would not). Stimuli were originally selected because words were coded in a categorical fashion to examine the differences in typability: all-left, all-right, mostly-left, mostly-right, equal, and perfectly alternating keypresses. 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 and Appendix E did not have enough stimuli of each type, 75 (47 pseudowords, 28 real) new words were created so that at least ten words of each type were available. After review, this categorical coding schema was recoded as number of hand switches to better capture differences in alternation.

**Materials.**

**Procedure.**

Upon consent to participate in the experiment, participants were given a typing test by using a free typing test website (TypingMaster, Inc., 2013). 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. This smaller number of stimuli was used to control 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 (2012) 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.

**Results**

Analyses were screened for assumptions of linear regression and found to be satisfactory. Because of the correlated error between participant ratings and stimuli, a mixed linear regression model was analyzed using SPSS’s mixed model function with participants as a subject variable and stimuli as a repeated random factor. Word length and average word letter frequency were added as control variables. Typing speed, right side advantage, number of hand switches, and real/pseudowords were then entered into the regression as variables of interest with all main effects and interactions to predict valence ratings. Table 3 contains estimates, standard errors, and *t*-test values for variables discussed below.

**Main effects.**Our control variables did show a significant effect on valence ratings, wherein both word length and average letter frequency were related to valence ratings. Participants appeared to rate shorter words as more pleasant, as well as words with more commonly used letters. Next, real words and pseudowords were rated differently, with pseudoword ratings approximately one point lower than real word ratings. Overall speed was not a significant predictor of word ratings, while both RSA (*b* = .086) and number of switches (*b* = .265) did significantly predict ratings. Therefore, we were able to replicate previous results by showing that right side words are more pleasant (with approximately the same strength as Experiment 1), but extend this finding to show that words that switch hands more are considered more pleasant, when controlling for participant typing speed.

**Interactions.** While several of the interactions were significant, the four-way interaction between real/pseudowords, hand switches, RSA, and typing speed was of the most interest. A second set of mixed linear regressions were analyzed separating real and pseudowords to determine if the three way interactions were significant for each word type (Table 3). In the pseudoword model, only word length, letter frequency, and RSA were significant predictors of valence ratings. Therefore, for words we’ve never seen or presumably typed, we like words better that are shorter, use more frequent letters, and are typed more on the right side. None of the other main effects or interactions were significant. For real words, a different picture emerged. Again, the main effects of word length, letter frequency, RSA, and hand switches were significant indicating that we rate words that are shorter, use more frequent letters, are typed more on the right side, but also switch hands more, as more pleasant. Speed was not a significant predictor overall, but was part of a three way interaction between switches and RSA.

This 3-way interaction was analyzed using a simple slopes analysis by separating right hand advantage into words that were more right (+1SD RSA), equally right-left (RSA = 0), and more left (-1SD RSA). Estimates that changed based on these analyses are presented in Table 4. For words that were typed more on the right hand, the speed by switch interaction was not significant nor were the main effects of speed and hand switches. Equally split words showed the same effect where the speed by switches interaction and overall speed were not significant, but the number of switches was positively related to overall valance. Words that are typed more on the left hand showed both a positive relationship with the number of switches in a word and a significant speed by switches interaction. Here, it is interesting to note that the number of hand switches changes drastically by word type. For right-handed words, the switch slope (*b* = -.119) was negative, indicating that we do not like words to switch away from the right hand. For equally split words (*b* = .273) and left-handed words (*b* = .665), the effect of hand switches was strongly positive. This finding mirrored Experiment 1 combined database findings, indicating that controlling for expertise might be the difference in understanding why analyses are inconsistent between databases.

Finally, for left-handed words only, a simple slopes analysis broken down by faster typing speed (+1SD), average typing speed (*M* = 48.622), and slower typing speed (-1SD) were analyzed. In all of these analyses, the number of switches was a significant predictor of valence ratings. For faster typists, each hand switch for predominantly left handed words increased valence ratings approximately half a point (*b* = .537) and as speed decreases from average (*b* = .665) to low (*b* = .794), the effect increases. Therefore, for left-handed words, typing speed was an important component in understanding the relationship between switches and valence ratings.

**General Discussion**

These results imply that the QWERTY keyboard has influenced our perceptions of words, in a more complex way than a simple body specificity hypothesis. In the overall normed database analyses, the original QWERTY effect was replicable across a large body of various types of stimuli (verbs, Twitter, category norms), with much the same size of effect as Jasmin and Casasanto (2012) published. Word length was often negatively related to valence ratings, which indicated that we like shorter words to type. Average letter frequency was usually a positive predictor of valence ratings wherein ratings are higher for words with more frequent letters; however, these effects were inconsistent. Our measure of fluency (switches) varied across stimulus sets but it appears, by analyzing multiple sources of ratings for words at the same time, that there might have been an interaction between RSA and number of switches. This interaction portrayed that we find words that switch off of left-handed keypresses as more pleasant, while right-handed keypresses are preferable by switching hands less often.

These effects were examined in more detail in Experiment 2, which incorporated Beilock and Holt’s (2007) study by including typing speed as a measure of expertise. Word ratings turned out to be quite complex with a four-way interaction between real/pseudowords, switches, RSA, and typing speed. All analyses showed a positive effect of right-side words, as well as if they were shorter and used more frequent letters. However, for pseudowords, no other effects were significant. Both Beilock and Holt (2007) and Van der Bergh et al. (1990) showed expert preferences for two and three letter combinations that were typed with different fingers. 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, switching preference will not extend to pseudowords (unpracticed actions) because they are not fluent (Oppenheimer, 2008).

The effect of expertise was shown on real words, where the three-way interaction between RSA, switches, and typing speed was examined by separating out right, equal, and left-handed words. For right-handed words, typing speed (or the interaction) was not a significant predictor of valence, and while not significant, number of switches was negatively related to valence ratings. For equally right-left and left-handed words, pleasantness ratings increase by switching back and forth to the right hand. Further, left-handed words showed an interaction between our two embodied cognition variables, where the number of switches increases valence ratings as the typing speed of the participant decreases. Therefore, it appears that as participants gain fluency through increased typing speed, the number of switches back and forth for left-handed words matters less for pleasantness ratings. Many of the most frequent letters on the QWERTY keyboard are on the left side, which may frustrate a slow typist because of the need to coordinate finger press schemata that involve same finger muscle movements (Rumelhart & Norman, 1982). Consequently, the number of switches becomes increasingly important to help decrease interference from the need to continue to use the same hand. The ease of action by switching back and forth is then translated as positive feelings for those fluent actions (Oppenheimer, 2008).

These embodied results mirror a clever set of studies by Holt and Beilock (2006) 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 (Paivio, 1971), it was not surprising that participants were faster to indicate picture-sentence matches than non-matches (also see Stanfield & Zwaan, 2001; Zwaan, Stanfield, & Yaxley, 2002). 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; Beilock & Lyons, 2008). These studies clearly reinforce the idea that expertise and fluency unconsciously affect our choices, even when it comes to perceived pleasantness of words.

This extension of the QWERTY effect illuminates the need to examine how skill can influence cognitive processes. Additionally, typing style, while not recorded in this experiment, could potentially illuminate differences in ratings across left-handed and right-handed words. Hunt-and-peck typists are often slower than the strict typing manual typists, which may eliminate or change the effects of RSA and switches since typists may not follow left or right hand rules and just switch hands back and forth regardless of key position. The middle of a QWERTY layout also poses interesting problems, as many typists admit to “cheating” the middle letters, such as *t,* and *y* or not even knowing which finger should actually type the *b* key. Further work could also investigate these effects on other keyboard layouts, such as Dvorak, which was designed to predominately type by alternating hands to increase speed and efficiency (Noyes, 1988).

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