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Title: 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 hand advantage is warranted. The present paper reexamined the QWERTY effect within the embodied cognition framework (Barsalou, 1999) and found that the right hand advantage is replicable to new valence stimuli, as well as experimental manipulation. Further, when examining expertise, right hand advantage interacted with typing speed and the ease of typability (i.e. alternating hand keypresses) portraying that both skill and our procedural actions play a role in judgment of valence on words.

June 27, 2013

Dr. Martin Pickering
Editor, *Journal of Memory and Language*

Dr. Pickering,

We wish to submit our article, “An Extension of the QWERTY Effect: Not Just the Right Hand, Expertise and Typability Predict Valence Ratings of Words” as a research report. Jasmin and Casasanto (2012) published research on the QWERTY effect in *Psychonomic Bulletin & Review* indicating that people like words that are predominantly typed with the right hand. This article was picked up and published widely on *Wired*, *The Atlantic*, *Scientific American*, *e! Science News*, and *The New Scientist*. Our study examines the right-handed preference effect in a new light – in line with recent publications in embodied cognition – to show fluency and expertise are important components of valence ratings. We believe this article is easily accessible to a wide audience, and that your journal is the perfect avenue for our work as a contrast to the original piece. This work has not been published and is not currently under submission elsewhere.

Sincerely,

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- The QWERTY right side advantage was replicated across new stimuli and participants.
- Shorter words with more frequently used letters were rated as more positive.
- Embodied cognition was measured through number of hand switches and expertise.
- Expertise interacted with fluency and right side advantage in predicting valence.
- Embodied cognition effects were only seen for real words.

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 hand advantage is warranted. The present paper reexamined the QWERTY effect within the embodied cognition framework (Barsalou, 1999) and found that the right hand advantage is replicable to new valence stimuli, as well as experimental manipulation. Further, when examining expertise, right hand advantage interacted with typing speed and the ease of typability (i.e. alternating hand keypresses) portraying that both skill and our procedural actions play a role in judgment of valence on words.

Keywords: keyboard, valence, QWERTY, word norms

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

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), 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 & Small, 1969; Simon, 1990). 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 (Rieger, 2004; Logan & Zbrodoff, 1998; Hommel, Muesseler, Aschersleben, & Prinz, 2001). 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, & Pulvermuller, 2004; Tettamanti et al., 2005; Lyons et al., 2010) and behavioral research (Zwaan & Taylor, 2006; Holt & Beilock, 2006; Cartmill, Goldin-Meadow, & Beilock, 2012). 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 (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 der 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, Dhillon, & Beilock, 2009), and perceptuomotor fluency (Yang, Gallo, & Beilock, 2009; Oppenheimer, 2008).

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

Materials.

Coding. Each of the datasets used in this experiment and Experiment 2 were coded for word length, average letter frequency, RSA, and number of switches. 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*). 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. Lastly, words were coded for the number of hand switches within a word using the left-right coding system described above. Database entries with more than one word (i.e. *some kind, yelled at*) or symbols (i.e. *#fb, c-net*) were excluded for all analyses.

ANEW (Bradley & Lang, 1999). The ANEW database ($N = 1,034$) is a popular large-scale database containing valence, dominance, and arousal ratings across male and female subjects. These ratings were made on paper-and-pencil forms using a self-assessment manikin (SAM: Lang, 1980) that was described as happy to unhappy feelings for the concept presented. The scores are scaled from 1-9 with high scores indicating pleasant valence ratings. This database contains words varying in length from 3 to 13 characters, that have an average letter frequency of $M = 6.179$ ($SD = 1.214$), a range in RSA from -9 to 7, and a range in number of switches from 0 to 7.

AFINN (Nielsen et al. 2011). The AFINN database ($N = 2,452$) is a collection of English words tagged from Twitter and other microblogs and coded valence ratings. Words were coded by the researcher and were scaled from -5 to 1 and 1 to 5 with low scores indicating unpleasant words. For our purposes these scores were rescaled from 1-9 with high scores indicating pleasant valence ratings. This database contains words varying in length from 2 to 18 characters, that have an average letter frequency of $M = 6.279$ ($SD = 1.067$), a range in RSA from -11 to 8, and a range in number of switches from 0 to 10.

Verb Valence (Ferstl et al., 2011). The verb database ($N = 288$) was designed to examine the effects of gender and word valence on causality bias for various types of verbs. Participants made valence ratings ranging from -3 to +3 originally, but were then scaled from 1-9 with high scores indicating pleasant valence ratings. This database contains words varying in length from 3 to 13 characters, that have an average letter frequency of $M = 6.648$ ($SD = .832$), range in RSA from -11 to 3, and show from 0 to 6 hand switches.

Warriner et al. ANEW extension (2013). This database ($N = 13,808$) is an extension of the Bradley and Lang (1999) ANEW database for many new words and category norms. The study also included analyses of valence differences for age, gender, and educational levels. These norms were collected via Amazon's Mechanical Turk (Buhrmester, Kwang, & Gosling, 2011) using a similar happy to unhappy scale from Bradley and Lang. These scores were scaled from 1 to 9 with low scores indicating low valence and high scores indicating positive valence. This database contains words varying in length from 2 to 17 characters, that have an average letter frequency of $M = 6.196$ ($SD = 1.151$), a range in RSA from -12 to 8, and a range in number of switches from 0 to 11.

Social Network Data (Dodds et al., 2011). The social network database ($N = 9,912$) was constructed by selecting the most frequent words from Twitter, Google Books, music lyrics, and the New York Times. These words were then rated for valence using Amazon's Mechanical Turk for data collection. Ratings were scaled from low pleasantness (1) to high pleasantness (9), which matched our scaling system. This database contains words varying in length from 1 to 18 characters, that have an average letter frequency of $M = 6.200$ ($SD = 1.274$), a range in RSA from -10 to 8, and a range in number of switches from 0 to 10. This database does contain many entries that would not traditionally be described as real words (i.e. *grr*, *smh*, *biz*). Jasmin and

Casasanto's (2012) study found that RSA was present for new words (including *LOL*) and pseudowords, so we would therefore expect RSA to extend to these short-hand speak (acronyms, abbreviations or text slang) words.

Results and Discussion

Separate databases. Each database was examined using a hierarchical regression analysis controlling for word length and average letter frequency in the first step, the main effects of RSA and switches in the second step, and finally the interaction between RSA and switches in the third step. Since databases are quite large, we have included pr^2 values for each predictor as a measure of effect size, and the unstandardized b values for easier interpretation of slopes. These values can be found in Table 1 for the step in which they were entered into the equation.

The ANEW database valence norms were not significantly predicted by either of our control variables, word length or average frequency, or number of switches in the second step. RSA was marginally significant ($p = .061$) at predicting valence indicating that words with more right hand letters were rated more positively, albeit with a small effect size ($pr^2 = .003$). The addition of the interaction in the final step was not significant. For the AFINN database, the control variables and number of switches were not significant predictors of valence, while RSA was a significant predictor of valence ratings. This slope value ($b = .059$) and the ANEW slope value ($b = .054$) are roughly the same, indicating that sample size may have contributed to the statistical significance of the effect. However, they both match previous results when words were compared across languages and for new words finding that RSA predicted valence approximately $b = .044$ and $b = .060$ (when controlling for word length and letter frequency,

Jasmin & Casasanto, 2012 Experiment 1 & 2). The interaction of hand switches and RSA was not a significant addition to the equation for the AFINN database.

The three new databases showed slightly different results. First, the verb database analysis indicated no significant predictors of valence. However, the RSA slope was $b = .064$ replicated with a smaller sample, supporting Casasanto's analysis that the correlation between RSA is small but consistent (Casasanto & Jasmin, 2012). Further, the slope for switch values was marginally significant ($p = .087$), but unexpectedly negative ($b = -.199$) indicating that each hand switch had a negative effect on valence ratings. The addition of the interaction was not significant. Next, the Warriner et al. (2013) database showed significant effects of all variables, again likely due to very large sample size. Word length was negatively related to valence rating indicating that shorter words are considered more pleasant. Words with more frequently used letters were rated more positively. Both of these effects support an embodied view, as shorter words are easier to type than longer words and frequently used letters are typed more (and are therefore, more fluent) than those pesky *q*, *z*, and *x* letters. In this dataset, RSA slope was smaller than normal ($b = .013$), and switches were positively related to valence ($b = .022$) portraying that right handed words are rated more positively, as well as words that switch more frequently. The interaction was not a significant addition to the regression equation. Lastly, the social network database showed the opposite effect of word length ($b = .054$) wherein longer words were rated more pleasantly and no effect of average letter frequency. RSA was a marginally significant predictor ($p = .088$) of valence with a very small b value for this dataset ($b = .009$). Switches were positively related to valence with approximately the same size as the previous data, ($b = .016$) but this main effect was not significant. Again, the interaction was not significant.

Combined databases. In a second analysis, we combined these five databases into one dataset for words that appeared in at least two sets of norms. We then used a mixed model linear regression with database as the subject variable and word as a repeated random factor to examine the same variables relationship with valence ratings. This analysis allowed us to determine if effects are consistent across the common words (which may explain varying results across Table 1), while controlling for correlated error terms of using the same words multiple times. All estimates, standard errors, t , and p values are in Table 2. First, word length was not a significant predictor of valence ratings. However, letter frequency does appear to be a positive predictor of ratings, wherein words with letters that are used more frequently receive more positive ratings. RSA was positively related to valence with the same sized estimate ($b = .051$) as previously seen. Number of hand switches was not a significant predictor of valence. However, the interaction between switches and RSA was significant. To examine this effect, we coded words as more right-handed (+1SD RSA), equally right-left (RSA = 0) or more left-handed (-1SD RSA) in a simple slopes analysis. Left-handed words showed a non-significant positive effect of switches on valence ($b = .014$), while right-handed words showed a significant negative effect of switches on valence ($b = -.048$). This finding indicated that if words are being typed on the right hand, generally, we like words that do not switch back and forth, while words typed on the left hand are more pleasant if they switch back to the right hand.

These analyses supported the body specificity hypothesis in showing consistent right-side advantage for word valence ratings. The results for an embodied view are mixed: word length and letter frequency inconsistently predict valence ratings, and hand switch slope values were often negative, the opposite direction of what was expected. However, these databases contain average ratings for word valence across many different types of raters (college students, Amazon

Mechanical Turk participants). Beilock and Holt (2007) showed an embodied effect on typing only for the expert typists, so the results from hand switches might be muddled by averaging word values across participants whose expertise levels are unknown. Therefore, we designed a second experiment to investigate the relationship between expertise, RSA, and the number of switches on pleasantness ratings. This experiment examines the following: 1) Taking into account the procedural effort of typing under the embodied cognition hypothesis, we would believe that increased switches would relate to increase valence ratings as typing on alternating hands is generally perceived as easier. Additionally, we examined RSA to determine if the body specificity hypothesis was replicable after controlling for the switches and expertise. 2) However, as previously shown in Beilock and Holt (2007), we expected to find an interaction between the expertise of the participant (typing speed), the number of switches between hands, and RSA. This effect was examined for real and pseudowords to assess not only if the RSA effect replicates, but also the effects of expertise and hand switches on pseudoword ratings.

Experiment 2

Method

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.

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 valence. 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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Table 1.

Estimates of Effects for Each Database

Database	Step	Effect	Estimate (SE)	df	t	p	pr ²
ANEW	Step 1	Word Length	-0.052 (0.035)	1031	-1.507	0.132	0.002
		Letter Frequency	0.014 (0.052)	1031	0.264	0.792	<0.001
	Step 2	RHA	0.054 (0.029)	1029	1.876	0.061	0.003
		Switches	-0.021 (0.056)	1029	-0.372	0.710	<0.001
	Step 3	RHA * Switches	-0.018 (0.017)	1028	-1.038	0.299	0.001
AFINN	Step 1	Word Length	-0.019 (0.015)	2449	-1.231	0.218	0.001
		Letter Frequency	0.049 (0.033)	2449	1.488	0.137	0.001
	Step 2	RHA	0.059 (0.015)	2447	3.855	< 0.001	0.006
		Switches	-0.006 (0.029)	2447	-0.192	0.847	<0.001
	Step 3	RHA * Switches	0.004 (0.007)	2446	0.537	0.591	<0.001
Verb Valence	Step 1	Word Length	0.046 (0.070)	285	0.655	0.513	0.002
		Letter Frequency	-0.053 (0.152)	285	-0.346	0.730	<0.001
	Step 2	RHA	0.064 (0.064)	283	0.990	0.323	0.003
		Switches	-0.199 (0.116)	283	-1.719	0.087	0.010
	Step 3	RHA * Switches	-0.020 (0.039)	282	-0.514	0.608	0.001
Warriner et al. ANEW Expansion	Step 1	Word Length	-0.019 (0.005)	13805	-4.109	<0.001	0.001
		Letter Frequency	0.043 (0.010)	13805	4.511	<0.001	0.001
	Step 2	RHA	0.013 (0.005)	13803	2.627	0.009	<0.001
		Switches	0.022 (0.009)	13803	2.465	0.014	<0.001
	Step 3	RHA * Switches	-0.004 (0.002)	13802	-1.667	0.095	<0.001
Social Network Data	Step 1	Word Length	0.054 (0.005)	9909	11.421	<0.001	0.013
		Letter Frequency	0.005 (0.009)	9909	0.537	0.591	<0.001
	Step 2	RHA	0.009 (0.005)	9907	1.707	0.088	<0.001
		Switches	0.016 (0.010)	9907	1.593	0.111	<0.001
	Step 3	RHA * Switches	-0.003 (0.003)	9906	-1.063	0.288	<0.001

Table 2.

Estimates of Effects for the Combined Database Analysis

Model	Effect		Estimate (SE)	df	<i>t</i>	<i>p</i>	<i>pr</i> ²
Real Words	Word Length		0.014 (0.008)	13007.112	1.739	0.082	<0.001
	Letter Frequency		0.065 (0.013)	13005.118	5.077	<0.001	0.002
	Switches		-0.014 (0.012)	13005.777	-1.118	0.263	<0.001
	RHA		0.051 (0.010)	13005.600	5.313	<0.001	0.002
	Switches * RHA		-0.007 (0.003)	13005.015	-2.129	0.033	<0.001
	Right Handed Words	Switches	-0.048 (0.023)	13005.327	-2.052	0.040	<0.001
	Equally Right-Left	Switches	-0.014 (0.012)	13005.777	-1.118	0.263	<0.001
	Left Handed Words	Switches	0.020 (0.016)	13005.259	1.237	0.216	<0.001

Table 3.

Estimates of Effects for Experiment 2

Model	Effect	Estimate (SE)	<i>df</i>	<i>t</i>	<i>p</i>
Overall	Word Length	-0.155 (0.036)	17413.913	-4.275	< 0.001
	Letter Frequency	0.140 (0.013)	17410.093	10.611	< 0.001
	Real/Pseudo Words	-0.936 (0.159)	17411.371	-5.893	< 0.001
	Speed	< -0.001 (0.004)	223.959	-0.031	0.975
	Switches	0.265 (0.076)	17410.142	3.467	0.001
	RHA	0.086 (0.038)	17410.156	2.265	0.024
	Real/Pseudo * Speed	-0.009 (0.003)	17411.201	-2.890	0.004
	Real/Pseudo * Switches	-0.374 (0.106)	17410.517	-3.539	< 0.001
	Real/Pseudo * RHA	-0.004 (0.052)	17410.039	-0.079	0.937
	Speed * Switches	-0.002 (0.002)	17410.152	-1.264	0.206
	Speed * RHA	-0.001 (0.001)	17410.178	-0.922	0.356
	Switches * RHA	-0.170 (0.064)	17415.009	-2.684	0.007
	Real/Pseudo * Speed * Switches	0.003 (0.002)	17410.546	1.460	0.144
	Real/Pseudo * Speed * RHA	0.001 (0.001)	17410.000	0.491	0.623
	Real/Pseudo * Switches * RHA	0.218 (0.090)	17421.185	2.413	0.016
	Speed * Switches * RHA	0.003 (0.001)	17414.873	2.611	0.009
	Real/Pseudo * Speed * Switches * RHA	-0.004 (0.002)	17420.682	-2.070	0.038
Pseudowords	Word Length	-0.152 (0.038)	8590.989	-3.966	< 0.001
	Letter Frequency	0.049 (0.015)	8591.146	3.391	0.001
	Speed	-0.009 (0.007)	156.596	-1.352	0.178
	Switches	-0.096 (0.052)	8591.158	-1.845	0.065
	RHA	0.060 (0.026)	8591.028	2.284	0.022
	Speed * Switches	0.001 (0.001)	8591.152	1.040	0.298
	Speed * RHA	< -0.001 (0.001)	8591.019	-0.397	0.691
	Switches * RHA	0.026 (0.046)	8593.315	0.558	0.577
	Speed * Switches * RHA	< -0.001 (0.001)	8593.251	-0.145	0.885
Real Words	Word Length	-0.118 (0.056)	8686.960	-2.114	0.035
	Letter Frequency	0.212 (0.020)	8674.744	10.774	< 0.001
	Speed	< -0.001 (0.005)	194.059	-0.007	0.995

Switches	0.273 (0.086)	8672.338	3.190	0.001
RHA	0.113 (0.043)	8672.381	2.653	0.008
Speed * Switches	-0.002 (0.002)	8672.304	-1.151	0.250
Speed * RHA	-0.001 (0.001)	8672.350	-0.822	0.411
Switches * RHA	-0.179 (0.071)	8680.893	-2.521	0.012
Speed * Switches * RHA	0.003 (0.001)	8680.660	2.452	0.014

Table 4.

Simple Slopes Analyses for Experiment 2

Model	Effect	Estimate (SE)	df	<i>t</i>	<i>p</i>	
Real Words	Right Handed	Speed	-0.002 (0.005)	253.124	-0.284	0.777
		Switches	-0.119 (0.183)	8677.534	-0.649	0.517
		Speed * Switches	0.006 (0.004)	8677.101	1.551	0.121
	Equally Right-Left	Speed	<-0.001 (0.005)	194.059	-0.007	0.995
		Switches	0.273 (0.086)	8672.338	3.190	0.001
		Speed * Switches	-0.002 (0.002)	8672.304	-1.151	0.250
	Left Handed	Speed	0.001 (0.005)	242.125	0.275	0.784
		Switches	0.665 (0.172)	8680.481	3.867	< 0.001
		Speed * Switches	-0.009 (0.003)	8680.624	-2.793	0.005
	Faster Typists	Switches	0.537 (0.128)	8680.277	4.177	< 0.001
	Average Typists	Switches	0.665 (0.172)	8680.481	3.867	< 0.001
	Slower Typists	Switches	0.794 (0.217)	8680.565	3.664	< 0.001

Note. This table only includes estimates that changed during the analyses of the interaction between RHA, speed, and number of hand switches. The other estimates did not change and are included in Table 3.