# The QWERTY Effect: How stereo-typing shapes the mental lexicon.

**Kyle Jasmin**[1,2,3] **(kyle.jasmin@mpi.nl)**

**Daniel Casasanto**[1,4,5] **(casasanto@alum.mit.edu)**

[1]Neurobiology of Language Department, Max Planck Institute for Psycholinguistics, Nijmegen, NL
[2]Institute of Cognitive Neuroscience, University College London, UK
[3]Laboratory of Brain and Cognition, National Institute of Mental Health, Bethesda, USA
[4]Donders Center for Brain, Cognition, and Behaviour, Nijmegen, NL
[5]Department of Psychology, The New School for Social Research, New York, USA

**Abstract**

The QWERTY keyboard mediates communication for millions of language users. Here we investigated whether differences in the way words are typed correspond to differences in their meanings. Some words are spelled with more letters on the right side of the keyboard and others with more letters on the left. We tested whether asymmetries in the way people interact with keys on the right and left of the keyboard influence their evaluations of the emotional valence of the words. In Experiment 1, we found a relationship between emotional valence and QWERTY key position, across three languages (English, Spanish, and Dutch). Words with more right-hand letters were rated as more positive in meaning on average than words with more left-hand letters. In Experiment 2 we replicated this pattern in nonce words. Although these data are correlational, the fact that a similar pattern was found across languages suggests that the QWERTY keyboard is shaping the meanings of words, as people filter language through their fingers. Widespread typing introduces a new mechanism by which semantic changes in language can arise.

**Keywords:** body-specificity hypothesis; motor action; meaning; orthography; typing; valence.

## Introduction

For many people, language may be typed and read almost as much as it is spoken and heard. Today the phrase "talk to you later" (abbreviated "*ttyl*") often means that conversational partners will continue "talking" with their fingers. When they do, they are likely to use the QWERTY keyboard. The QWERTY layout was invented in 1878, as a remedy for mechanical problems with the original Remington typewriters, the keys of which were arranged alphabetically. During fast typing, neighboring keys would jam when used in succession. QWERTY was designed to separate frequently-used letter pairs to opposite sides of the keyboard, avoiding mechanical clashes. The final arrangement was constrained by the inner workings of the Remington machine, and by the need to place the letters in "t-y-p-e-w-r-i-t-e-r" conveniently on the top row of keys, to help salesmen tap out what was, at the time, a brand name (David, 1985).

The QWERTY keyboard, which originated as a tool for journalists, is now everywhere in our culture. Increasingly, coffee shop chatter is being replaced by the sound of clicking keystrokes. Conversations and even courtships can take place entirely through text. Smart phones and laptops let people type messages from virtually anywhere. Routinely, language is produced without speech. When linguists and psychologists talk about the *articulators* used in language production, they are ordinarily referring to parts of the mouth. But increasingly, the articulators that mediate our day-to-day language production are the fingers.

The way words are articulated with the mouth is related to their meaning. Although many sound-meaning mappings are arbitrary (de Saussure, 1966), there are aspects of meaning that appear non-arbitrarily linked to the configuration of the vocal-tract articulators used to produce them (Ohala, 1984). Here we propose a link between the meanings of words and the action of the manual articulators used for typing them. Because patterns of articulation are not independent of meaning, typing introduces a new mechanism by which semantic changes in language can arise.

We propose that typing words on the keyboard may influence their emotional valence (i.e., the positivity or negativity of their meanings). Typing is a special kind of motor action. Performing motor actions fluently generally leads to positive feelings and evaluations (Oppenheimer, 2008; Ping, Dhillon, & Beilock, 2009). Therefore, motor fluency could mediate relationships between the location of letters on the QWERTY keyboard and the valence of the words they compose, either directly or indirectly.

A direct link between motor fluency and valence could result from the distribution of letters on the right and left sides of the keyboard. In standard QWERTY typing, the left hand is responsible for typing more letters than the right hand (15 letters vs. 11). For skilled and unskilled typists alike, fingers on the left hand are responsible for more keys than fingers on the right. This should make planning and executing keystrokes more difficult with the left hand than with the right, because the amount of cognitive control required to strike one key among its neighbors should increase with the number of keys, due to increased response

competition (Ridderinkhof, van den Wildenberg, Segalowitz & Carter, 2004). This proposal is supported by reaction time data showing that, when participants are presented with letters in isolation and asked to press the corresponding keys, they are faster to type letters from the right side of the keyboard than the left (Logan, 2003).

If right-hand letters are easier to type, this should lead to more positive feelings when people type words composed of more right-hand letters, and more negative feeling when they type words with more left-hand letters. Over time, associations between typing fluency and emotion could cause "right-hand words" to acquire more positive meanings and "left-hand words" more negative meanings. Skilled typists implicitly prefer easy-to-type letter strings, even when they were not typing, supporting the possibility that typing fluency could influence the emotional valence of the things people type (Beilock & Holt, 2007; Van den Bergh, et al. 1990). To summarize this first proposal, on the basis of *keyboard kinematics*, words with more right-hand letters should be easier to type, and should therefore acquire more positive meanings on average than words with more left-hand letters.

Alternatively, motor fluency might interact with QWERTY to influence the valence of words more indirectly. The hands are not created equal. Most people have a dominant hand, and therefore interact with the environment more fluently on one side of space than the other. As a consequence, people implicitly associate positive things with their dominant side and negative things with their nondominant side. When asked to decide which of two products to buy, which of two job applicants to hire, or which of two alien creatures looks more trustworthy, right- and left-handers respond differently. Right-handers tend to prefer the product, person, or creature presented on their right side, but left-handers tend to prefer the one on their left (Casasanto, 2009). Children as young as 5 years old already make evaluations according to their handedness, judging animals shown on their dominant side to be nicer and smarter than animals on their nondominant side (Casasanto & Henetz, 2011). Beyond the laboratory, people's association of "good" with their dominant side can be observed in their spontaneous gestures during positive and negative speech (Casasanto & Jasmin, 2010).

Overall, these results cannot be predicted or explained by metaphors or idioms in language, which consistently associate "good" with "right" and "bad" with "left" (e.g., my right-hand man; two left feet). Rather, these results reveal implicit *mental metaphors* linking left-right space and emotional valence, which are body-specific (Casasanto, 2009): Right- and left-handers, who have different patterns of motor fluency, implicitly associate "good" and "bad" with opposite sides of space.

These mental metaphors influence people's judgments even when they are not using their hands, indicating that immediate motor experience is not necessary to activate body-specific associations between space and valence: Mentally representing locations on one's "good" or "bad" side of space is sufficient (Casasanto & Brookshire, 2011; Casasanto & Chrysikou, 2011). People who know how to type automatically activate the positions of keys when they read words (Rieger, 2004). Consequently, words spelled with more letters on one side of the keyboard than the other could activate mental metaphors linking space with valence whether or not people are typing, and whether or not typing is actually more fluent with one hand than with the other.

Although Keyboard Kinematics and Mental Metaphors both predict relationships between QWERTY key position and word valence, they predict different effects of handedness. According to the Keyboard Kinematics proposal, right- and left-handers should both show a Good Is Right pattern, rating words with more right-hand letters to be more positive in meaning, since there should be less response competition for typing letters on the right side than on the left, regardless of the typer's handedness. Alternatively, the Mental Metaphors proposal predicts that right-handers should rate words with more right-hand letters to be more positive, since these words should activate their implicit Good Is Right association more strongly; by contrast, left-handers should rate words with more left-hand letters to be more positive, since these words should activate their implicit Good Is Left association.

Here we explored the relationship between QWERTY key position and word meaning, in two experiments. In Experiment 1 we tested for associations between left-right key position and emotional valence in words from three QWERTY-using languages (English, Spanish and Dutch). In Experiment 2 we tested whether effects of QWERTY key position are restricted to existing words, or whether key position also affects the valence of nonce words that have never been seen or typed. In both experiments we compared word ratings between left- and right-handers, to evaluate Keyboard Kinematics and Mental Metaphors as potential causes of the hypothesized relationship between QWERTY and word meaning.

## Experiment 1: Does QWERTY predict valence ratings for words across languages?

Experiment 1 tested whether associations between side of keyboard and emotional valence are detectable in participants' judgments about words in three languages.

### Methods

**Participants** Native Dutch speakers (N=132; 14 left-handers, 118 right-handers by self-report) participated online, for payment.

**Materials and Procedure** We analyzed words from 3 corpora. The Affective Norms for English Words corpus (ANEW; Bradley and Lang, 1999) consists of 1034 words. Participants used a pencil to rate valence on a 9-point scale composed of five Self-Assessment Manikins (SAMs), which ranged from a smiling figure at the positive end of the scale to a frowning figure at the negative end.

Participants were told to mark one of the manikins, or a space between two adjacent manikins.

The second corpus was a Spanish version of ANEW (SPANEW; Redondo, et al. 2007), in which translations of the ANEW words were rated by native Spanish speakers using a procedure.

The third corpus was a Dutch version of ANEW (DANEW), which we created. The 1034 ANEW words were translated into Dutch by a native speaker. Three of the English words translated to the same Dutch word. Removing these duplicates left 1031 words in the sample.

Each participant saw 85 of the translated ANEW words intermixed with 74 words from an unrelated experiment, which served as fillers. Participants saw words one at a time, and rated them for emotional valence on 9-point SAM scales. Whereas ANEW and SPANEW participants used pencil and paper, DANEW participants responded by clicking one of 9 radio buttons located beside the 5 manikins, or in between two manikins. In ANEW and SPANEW the manikins were arranged from left to right. In DANEW, the manikins were arranged vertically on the screen, to avoid any unintended interactions between a left-right rating scale and the left-right positions of the letters that composed stimulus words.

## Results and Discussion

For each word in the corpus, we computed the difference of the number of left-hand letters (q,w,e,r,t,a,s,d,f,g,z,x,c,y,b) and right-hand letters (y,u,i,o,p,h,j,k,l,n,m), a measure we call the Right Hand Advantage [RHA=(# right-hand letters)-(# left-hand letters)]. Overall, there was a significant positive relationship between RHA and Valence in ANEW, SPANEW, and DANEW combined, according to a linear regression with items (ANEW words and their translation equivalents) as a repeated random factor (Wald $\chi^2$=5.34, df=1, p=.02; Figure 1). Words with more right-hand letters were rated to be more positive on average than words with more left-hand letters. We will call this relationship *the QWERTY effect*.[1]

To determine whether the QWERTY effect differed across languages, Language was added to the regression model as a fixed factor. The mean valence ratings differed between languages, producing a main effect of Language (Mean Valence Ratings: Dutch=5.07 (SD=2.27); English=5.15 (SD=1.99); Spanish=4.74 (SD=2.14); Wald $\chi^2$=101.09, df=2, p=.0001). Importantly, however, Language did not interact with RHA to predict Valence (Wald $\chi^2$=0.23, df=2, p=.89), and the effect of RHA on Valence remained significant when the effect of Language and the interaction of Language with RHA were controlled (Wald $\chi^2$=5.19, df=1, p=.02).

Since there was no significant difference in the strength of the QWERTY effect across languages, an analysis of each separate language is neither required nor licensed. With that caveat, we note that the predicted relationship between RHA and Valence was significant in English (Wald $\chi^2$=4.61, df=1, p=.03) and in Dutch (Wald $\chi^2$=5.81, df=1, p=.02), and a trend in the same positive direction was found in Spanish (Wald $\chi^2$=1.04, df=1, p=.31). It would be inappropriate to interpret these patterns as differing between languages, given the lack of any statistical difference (Wald $\chi^2$<1), which cannot be attributed to a lack of power (minimum N=1031 items).

A further analysis was conducted to control for possible effects of Word Length and for the frequency with which individual letters are used in each language (Letter Frequency).[2] RHA remained a significant predictor of Valence when Word Length, Letter Frequency, Language, and their interactions were controlled (Wald $\chi^2$=6.95, df=1, p=.008).

A final set of analyses tested for effects of handedness in the DANEW raters (no information is available about the handedness of the raters for ANEW and SPANEW). According to a mixed regression model with subjects and items as repeated random factors, RHA predicted Valence in right- and left-handers, combined (F(1,1022)=4.92, p=.03). When Handedness was added to the model, it did not interact with RHA to predict Valence (F(1,6077)=0.16, p=.69). The association between RHA and Valence remained significant when the effect of Handedness and the interaction of Handedness and RHA were controlled (F(1,1224)=4.00, p=.05).

Although the QWERTY effect did not differ significantly between right- and left-handers, we conducted an exploratory analysis to determine whether handedness influenced the direction of the correlation between RHA and Valence, since this information is critical to deciding between different possible causes of the QWERTY effect. Right-handers showed a positive association of RHA with Valence (F(1,1020)=4.84, p=.03). Left-handers showed a trend in the same positive direction, which did not approach significance, likely due to the small number of left-handers (F(1,416)=0.27, p=.61).

Overall, words with more right-hand letters were rated to be more positive than words with more left-hand letters. Since this pattern did not differ between right- and left-handers (not even qualitatively, in terms of direction), the results of Experiment 1 support Keyboard Kinematics as the cause of the QWERTY effect.

[1] The phrase "QWERTY effect" is sometimes used informally in Economics, to describe a product that is highly successful despite being inferior to its competitors. The semantic QWERTY effect we report here is unrelated.

[2] Information about frequency of letter use across languages was obtained from http://en.wikipedia.org/wiki/Letter_frequency, accessed April 10, 2011.

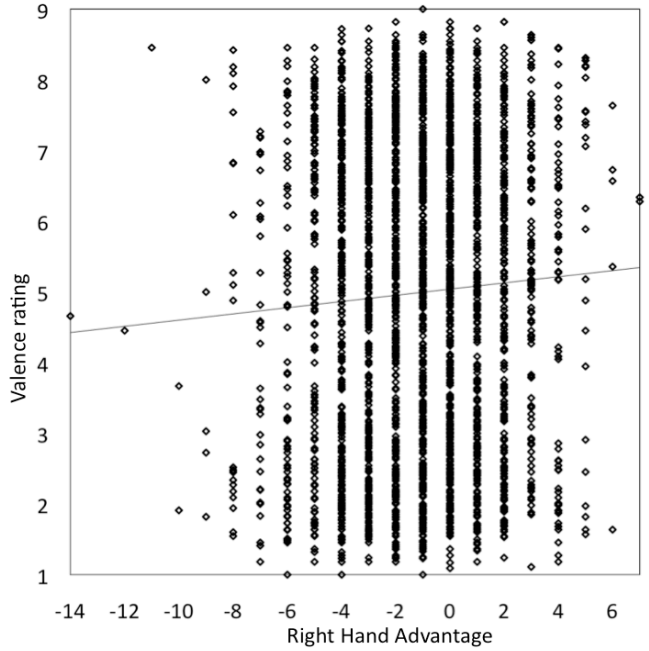


**Figure 1:** Results of Experiment 1. The difference between the number of right-hand letters and left-hand letters (RHA) predicted valence ratings for English, Dutch and Spanish words.

## Experiment 2: Does QWERTY predict valence judgments for nonce words?

Experiment 2 tested whether the QWERTY effect would be found for nonce words, with no pre-experimental meaning. This experiment addressed three questions raised by Experiment 1. First, would an effect of handedness emerge in a larger sample of participants, including more left-handers? Second, does the QWERTY effect arise at the level of the word, or at a sub-lexical level (i.e., letters or clusters of letters)? Third, could the QWERTY effect be an artifact of lexical frequency? In principle, if words with higher RHAs also had higher frequencies, this could result in a spurious correlation between RHA and Valence. Information about lexical frequency was not available for all of the words form Experiment 1, complicating an analysis to rule out possible frequency effects. In the present experiment, however, all items were novel, and therefore had frequencies of zero.

### Methods

**Participants** English speakers (N=800; 36 left-handers, 751 right-handers, 13 ambidextrous by self-report) were recruited via the Amazon Mechanical Turk website and participated online, for payment.

**Materials and Procedure** A corpus of pronounceable, single-syllable English nonce words was generated by crossing a set of 46 consonant (or cluster) onsets and 18 consonant codas, for a total of 828 onset-coda combinations (Consonant Frames; CFs). These CFs were crossed with 4 vowels (/i/, /u/, /eɪ/, /oʊ/) to generate 3,312 nonce words. The vowels /i/ and /u/ were spelled with double-e (*pleek*), and double-o (*plook*). The vowels /eɪ/ and /oʊ/ were spelled with an *a* and final *e* (*plake*) and with *o* and final *e* (*ploke*). CFs containing words that were spelled or pronounced like existing English words were excluded. Spellings were adjusted so that all nonce words had legal English spellings. This left 404 CFs which, crossed with 4 vowels, yielded 1616 words. Four CFs were randomly excluded to leave 1600 nonce words, which were presented in a Latin square design. Participants were instructed to read words in "an alien language" and indicate how positive the meaning seemed on a 9-point scale by clicking on a radio button with the mouse. Each participant rated 20 words.

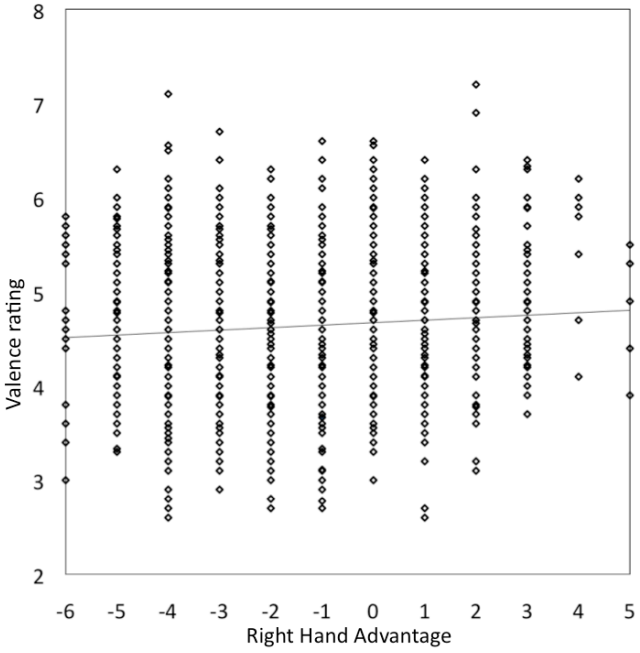


**Figure 2:** Results of Experiment 2. The difference between the number of right-hand letters and left-hand letters (RHA) predicted valence ratings for English nonce words.

### Results and Discussion

RHA was calculated as in Experiment 1. There was a significant positive relationship between RHA and Valence, according to a mixed linear regression with subjects and items as repeated random factors ($F(1,1584)=10.85$ $p=.001$; Figure 2), replicating the main result of Experiment 1. When Handedness (for left- and right-handers) was added to the model, it did not interact with RHA to predict Valence ($F(1,15053)=.03$, $p=.86$). In further exploratory analyses, right-handers showed a positive association of RHA with Valence ($F(1,1574)=11.76$, $p=.001$). Left-handers showed a trend in the same positive direction, which did not approach significance ($F(1,600)=0.68$, $p=.41$). As in Experiment 1, there was no effect of handedness on the association

between RHA and Valence, which trended in the same direction for right- and left-handers.

Nonce words with more right hand letters were judged to have more positive meanings in an alien language, suggesting that Good Is Right associations are stored or activated at the level of letters or combinations of letters. Importantly, the QWERTY effect in Experiment 2 cannot be explained by an unexpected relationship between lexical frequency and key position, since all items were novel, and had frequencies of zero.[3]

## General Discussion

In two experiments, we demonstrate a previously undocumented relationship between the meanings of words and the way they are typed: the QWERTY effect. On average, words spelled with more right-hand letters (on the right of the keyboard) were rated to be more positive in emotional valence than words spelled with more left-hand letters (on the left of the keyboard). This was true even though raters were not typing when they responded: In some cases they were using pencil and paper. A similar relationship between key position and word meaning was found across three languages (English, Spanish, and Dutch), and was also extended to nonce words with no pre-experimental meaning.

We proposed two possible causes of the QWERTY effect, which made contrasting predictions. According to the Keyboard Kinematics account, people should tend to rate words with more right-hand letters than left-hand letters as more positive, regardless of their handedness. According to the Mental Metaphors account, right-handers should tend to rate words with more right-hand letters as more positive, but left-handers should favor words with more left-hand letters. Results of both experiments showed similar patterns in right- and left-handers, supporting the Keyboard Kinematics account. Right-hand letters are less numerous, therefore words with more right-hand letters may acquire more positive meanings because they are easier to type, due to an asymmetry built into the QWERTY keyboard.

Although there was no significant difference between right- and left-handers, we note that the association between RHA and Valence was numerically weaker in left-handers in both experiments, as would be expected if there were additive effects of Keyboard Kinematics and Mental Metaphors, strengthening the Good Is Right effect in right-handers, but weakening it in left-handers.

### Alternative accounts of the QWERTY effect?

The fact that we found no differences in the strength of the QWERTY effect across English, Spanish, and Dutch argues against two alternatives explanations for this effect. First, if the effect had been found in only one language, it would be amenable to explanations based on accidents of sound symbolism (Ohala, 1984). In any single language, it could happen by chance that words with higher RHAs are more positive due to sound-valence associations. But despite some commonalities, the English, Dutch, and Spanish languages have different phonological systems, and different letter-to-sound mappings. To maintain this skeptical alternative, it would be necessary to posit that RHA correlated with *different* letter-sound-valence mappings in each of these three languages (with strengths that did not differ across languages).

Second, if we had found the QWERTY effect in English alone, it would seem plausible that space-valence mappings had shaped the QWERTY layout, but not the other way around. QWERTY was designed by an English speaker. Since there is about a 90% chance he was a right-hander, implicit space-valence associations could have biased him to place letters that carried positive associations on the right and letters with negative associations on the left of the keyboard. Presumably, however, such implicit associations would be based on the peculiar roles these letters play in English words or sounds. The finding of similar QWERTY effects across languages suggests that, even if English-based letter-space-valence associations influenced QWERTY's design, QWERTY has now "infected" typers of other languages with similar associations. Since the present data are correlational, establishing the causal relationships underlying the QWERTY effect will require further research.

## Conclusions

Although the relationship between words' forms and meanings is largely arbitrary, aspects of how words are produced can shape their meanings. In the past, language was only spoken, and was therefore only subject to constraints on hearing and speaking. Now language is frequently produced by the fingers, and for millions of people, it is filtered through QWERTY. As people develop new technologies for producing language, these technologies shape the language they were designed to produce.

The meanings of words in English, Dutch, and Spanish are related to the way people type them on the QWERTY keyboard. Words with more right-hand letters are rated as more positive in emotional valence than words with more left-hand letters. The fact that nonce words also show the QWERTY effect suggests that new coinages in language will show effects of how they are typed immediately. People responsible for naming new products, companies, and brands might do well to consider the potential advantages of consulting their keyboards and choosing the "right" name.

[3] It is possible that when judging the valence of nonce words, participants activated real English words that were phonologically or orthographically similar. However, this is merely as source of noise, and is unlikely to account for the observed RHA effect, since letters that are phonological or orthographic neighbors are unlikely to be *typographic* neighbors on the QWERTY keyboard.

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