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The QWERTY Effect:
How typing shapes word meanings and baby names

Daniel Casasanto[1] **Kyle Jasmin[2,3]** **Geoffrey Brookshire[1]** **Tom Gijssels[1,4]**
(casasanto@uchicago.edu) (kyle.jasmin.11@ucl.ac.uk) (brookshire@uchicago.edu) (tomgijssels@uchicago.edu)

[1] Department of Psychology, University of Chicago, IL
[2] Institute of Cognitive Neuroscience, University College London, London, UK
[3] Laboratory of Brain and Cognition, National Institute of Mental Health, Bethesda, MD
[4] Free University of Brussels, Belgium

Abstract

Filtering words through our fingers as we type appears to be changing their meanings. On average, words typed with more letters from the right side of the QWERTY keyboard are more positive in meaning than words typed with more letters from the left: This is the QWERTY effect (Jasmin & Casasanto, 2012), which was shown previously across three languages. In five experiments, here we replicate the QWERTY effect in a large corpus of English words, extend it to two new languages (Portuguese and German), and show that the effect is mediated by space-valence associations encoded at the level of individual letters. Finally, we show that QWERTY appears to be influencing the names American parents give their children. Together, these experiments demonstrate the generality of the QWERTY effect, and inform our theories of how people's bodily interactions with a cultural artifact can change the way they use language.

Keywords: QWERTY effect; Space; Typing; Valence

Introduction

Although some form-meaning relationships in language may be arbitrary (de Saussure, 1966), words' meanings are constrained by the way they are produced. For example, across languages there appears to be a systematic relationship between the forms and meanings of words denoting "small" vs. "large": *chico* vs. *gordo* (Spanish); *petit* vs. *grand* (French); /mikros/ vs. /makros/ (Greek); *teeny* vs. *humongous* (English), etc. (Ohala, 1984). In each case, a vowel in the "small" word requires the speaker to shorten the vocal tract, and a vowel in the "large" word requires the speaker to lengthen it, by comparison (see also Jakobson & Waugh, 1979; Sapir, 1929).

Until recent years, words in spoken languages were produced mainly with the mouth, so form-meaning relationships like the one described above were mediated by the way speakers articulate words with the vocal tract. Increasingly, however, "spoken" words are produced with the hands as we type, and for millions of language users word production is mediated by the QWERTY keyboard. Widespread typing creates an opportunity for new kinds of form-meaning relationships in language to arise. In addition to being shaped by the vocal tract articulators, words' meanings can potentially be shaped by the way we articulate their orthographic forms with our fingers.

One such form-meaning relationship has been documented. On average, words typed with more letters from the right side of the QWERTY keyboard are more positive in meaning than words typed with more letters from the left: This is the QWERTY effect, which has been shown in three languages (English, Spanish, and Dutch), in a large corpus of phonotactically legal English pseudowords, and in a collection of keyboard-based neologisms (e.g., LOL; Jasmin & Casasanto, 2012; hence J&C).

This effect was predicted on the basis of a more general relationship between left-right space and emotional valence. Implicitly, people tend to associate "positive" with their dominant side of space, and "negative" with their non-dominant side (Casasanto, 2009; 2011). This means that for right-handers, "right" is "good" and "left" is "bad." This implicit association is enshrined in idioms like "my right hand man" and "two left feet," found across many languages, presumably because the overwhelming majority of language users are right-handers. For this same reason J&C predicted that, overall, the lexicons of QWERTY-using language communities should show a "right-side advantage": a tendency for words typed with more right-side letters to be more positive in meaning, both because QWERTY use should influence the meanings of existing words, and because it should serve as a filter for the creation or adoption of new words.

Although these predictions were supported by a series of experiments (Jasmin & Casasanto, 2012), many questions remained regarding the generality of the QWERTY effect and the mechanisms by which interacting with the QWERTY keyboard shapes people's lexicons. Here in Experiments 1-2 we replicated the QWERTY effect in a large English corpus, and extended it to a fourth language (Portuguese). In Experiment 3 we extended the effect to a fifth language (German), and ruled out one of the possible origins of the QWERTY effect J&C had proposed. In Experiment 4 we showed that the relationship between keyboard position and valence extends to individual letters. Furthermore, we confirmed that left-handers show a similar QWERTY effect to right-handers, further constraining theorizing about the origins of the QWERTY effect. Finally, in Experiment 5 we showed a strong relationship between QWERTY key position and the names that American parents choose for their babies, providing one demonstration of the QWERTY effect's real-world impact.

Experiment 1: QWERTY in a larger corpus

The goal of Experiment 1 was to replicate J&C's main result in a larger corpus of English words. We predicted that words with more right-side letters would be, on average, more positive in valence than words with more left-side letters.

Method and Results

We analyzed words from the NewANEW corpus (Warriner, et al. 2013), which consists of 13,915 words normed for Valence, Arousal, and Dominance, with Amazon Mechanical Turk. Subjects rated words on these dimensions using a 9-point scale.

Following J&C, we calculated the Right Side Advantage for each word by taking the difference of the number of letters on the right side of the keyboard (y, u, i, o, p, h, j, k, l, m n) and subtracting the number from the left side (q, w, e, r, t, a, s, d, f, g, z, x, c, v, b; [RSA=(# right-side letters) - (# left-side letters)]). Only the Valence scores were of interest, so Arousal and Dominance scores were not analyzed.

For each of the corpora analyzed in Experiments 1-3 here, we report three analyses. For the sake of completeness, we first report the relationship between Valence and RSA in a simple linear regression model including random intercepts for items (i.e., words), as in J&C. This model does not control for word length and letter frequency. Length and (word) frequency are controlled in the majority of psycholinguistic studies, and are known to influence numerous dependent variables. Since longer words with lower frequency letters may be read less fluently than shorter words with higher frequency letters, controlling for these factors was particularly well motivated in the present study. Therefore, we conducted a second analysis, regressing Valence on RSA, controlling for Word Length, Letter Frequency, and their interaction, as in J&C.[1] Finally, we added a third analysis to confirm the relationship between Valence and RSA using a nonparametric randomization test, which makes no assumptions about the distribution of the data (e.g., that the distribution is normal), and provides an intuitive way to assess whether the observed relationship is likely to have occurred by chance. Valence ratings were residualized in a linear regression with word length, mean letter frequency, and their interaction. These valence residuals were then correlated with 20,000 random permutations of the observed RSA values. The *p*-value (one tailed) represents the proportion of random permutations with a higher correlation coefficient than the actual observed value.

In our first simple regression analysis, Valence was positively related to RSA in the NewANEW words, as predicted, but the relationship was not significant (b=.003, Wald χ^2=.67, df=1, p=.41). When we controlled for Word Length, mean Letter Frequency, and their interaction, however, RSA was a significant predictor of Valence (b=.013, Wald χ^2=7.06, df=1, p=.008; fig. 1a). We confirmed this result with a 20,000-iteration permutation test (p = .0095, one-tailed; fig 1b). This p-value indicates that there was less than a 1-in-100 chance of obtaining a relationship between RSA and Valence that was greater than the observed relationship by chance.

In summary, when irrelevant factors known to influence processing fluency were controlled, parametric and nonparametric tests showed a significant QWERTY effect in NewANEW: English words with more right-side letters were, on average, more positive in valence than words with more left-side letters. This analysis extends the original English QWERTY effect to a corpus containing an order of magnitude more words. The majority of the words in NewANEW were distinct from those in original ANEW, but even for the minority of overlapping words, the authors of NewANEW obtained new ratings; thus, these data represent a fully independent replication of the QWERTY effect, in a sixth corpus.

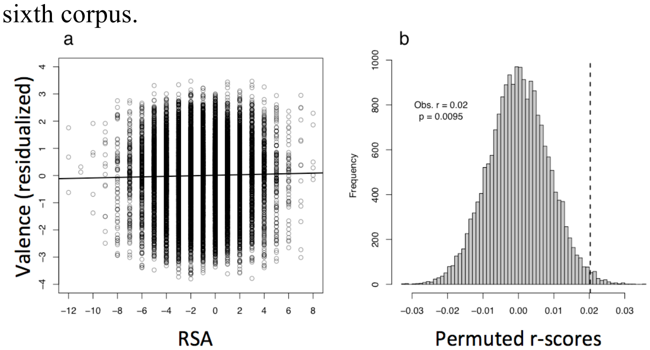


Figure 1. Results of Experiment 1. Relationship between Valence and RSA (controlling for word length, letter frequency, and their interactions) in NewANEW, analyzed parametically (1a, left) and nonparametrically (1b, right). The histogram in 1b shows the frequency with which each r-value was obtained in the permutation test.

Experiment 2: QWERTY Effect in Portuguese

Experiment 2 tested for the QWERTY effect in Portuguese version of the original ANEW corpus.

Method and Results

We analyzed valence-normed words from the European Portuguese adaptation of the Affective Norms for English Words corpus (EP-ANEW; Soares, et al. 2011). EP-ANEW consists of 1034 words, which were rated by 958 native Portuguese speakers for Valence, Arousal and Dominance, using 9-point scales and Self-Assessment Manikins (SAM) scale (see Soares, et al. for detailed methods and Bradley & Lang, 1999 for details on SAMs).

As in Experiment 1, we computed the RSA for each word in the corpus: [Left-hand letters: (q, w, e, r, t, a, s, d, f, g, z, x, c, v, b); Right-hand letters: (y, u, i, o, p, h, j, k, l, ç, n, m, -)]. Diacritics were stripped from the letters because, on the

[1] It was not possible to control for word frequency because frequency counts were not available for all words. We note, however, that the QWERTY effect has been shown in a large pseudoword corpus, for which all "words" had a frequency of zero (Jasmin & Casasanto, 2012, Experiment 3).

Portuguese keyboard, accented letters do not have their own keys. Nineteen of the words had hyphens, which were treated as right-side letters due to the hyphen's placement on the Portuguese keyboard.

In a simple regression, RSA was a highly significant predictor of Valence (*b*=.06, Wald χ^2=7.06, df=1, *p*=.008). A second analysis controlling for Word Length, mean Letter Frequency, and their interaction showed the predicted positive relationship between Valence and RSA, though the effect in the controlled analysis was marginally significant (*b*=.038, Wald χ^2=2.80, df=1, *p*=.09; fig 2a). We confirmed this result with a 20,000-iteration permutation test (*p* = .0714; fig 2b).

In summary, Experiment 2 extends the QWERTY effect to a seventh corpus and a fourth language: European Portuguese. In the controlled analyses, the relationship between Valence and RSA was of marginal statistical significance, likely due to the relatively small number of words in the original ANEW corpus. To determine whether the Portuguese QWERTY effect differed in magnitude from the effects found in English, Spanish, and Dutch versions of ANEW (see J&C), we conducted a regression analysis combining the data from all four languages, with words (i.e., translation equivalents) as a repeated random factor. The magnitude of the QWERTY effect did not differ between languages, as indicated by the absence of any RSA by Language interaction (Wald χ^2=1.26, df=1, *p*=.73), and the relationship between RSA and Valence remained highly significant when the effect of Language was controlled (Wald χ^2=7.34, df=1, *p*=.007).

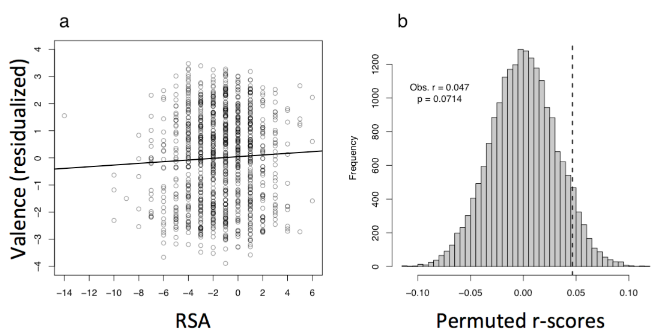


Figure 2. Results of Experiment 2. Relationship between Valence and RSA (controlling for word length, letter frequency, and their interactions) in EP-ANEW, analyzed parametically (2a, left) and nonparametrically (2b, right). The histogram in 2b shows the number of times each r-value was obtained in the permutation test.

Experiment 3: QWERTZ Effect in German

Experiment 3 tested whether key position predicted valence for German words, in order to extend the QWERTY (or QWERTY-like) effect to another language, and to test one of the possible origins of the QWERTY effect proposed by J&C. J&C initially predicted the QWERTY effect on the basis of manual motor asymmetries in right-handers: righties should prefer right-hand letters because they are easier to type with their dominant hand. However, there is an asymmetry built into QWERTY keyboards, *per se*: There are more left-hand letters than right-hand letter, creating more response competition for letters typed with the left hand than the right. The QWERTZ keyboard, however, has an equal number of right- and left-hand letters. Therefore, testing for a QWERTZ effect allowed us to determine whether the left-right asymmetry that gives rise to the QWERTY effect is located in the keyboard, *per se*, or in the bodies of its right-handed users.

Method and Results

We analyzed valence-normed words from the BAWL-R corpus (Võ, et al., 2009). BAWL-R consists of 2902 words rated for valence, arousal and imageability. Valence ratings were made on a 7-point scale from -3 (very negative) through 0 to +3 (very positive; see Vo, et al. 2006 and Vo, et al. 2009) for detailed methods). Only valence ratings were analyzed in this experiment.

We calculated the RSA for each German word, using QWERTZ key position: [Left-hand letters: (ß, z, u, i, o, p, ü, h, j, k, l, ö, ä, n, m); Right-hand letters: (q, w, e, r, t, a, s, d, f, g, y, x, c, v, b)]. In a simple linear regression, RSA was a significant predictor of Valence (*b*=.023, Wald χ^2=5.37, df=1, *p*=.02). In a second analysis controlling for Word Length, mean Letter Frequency, and their interaction, the effect of RSA on Valence was highly significant (*b*=.029, Wald χ^2=7.54, df=1, *p*=.006; fig 3a). We confirmed this result with a 20,000-iteration permutation test (*p* = .0062; fig. 3b).

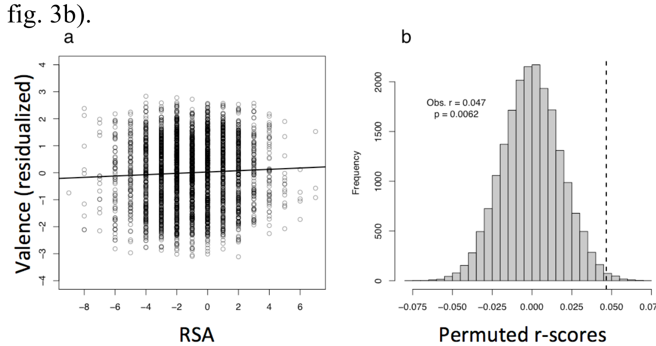


Figure 3. Results of Experiment 3. Relationship between Valence and RSA (controlling for word length, letter frequency, and their interactions) in BAWL-R, analyzed parametically (3a, left) and nonparametrically (3b, right). The histogram in 3b shows the number of times each r-value was obtained in the permutation test.

In summary, the QWERTZ effect was highly significant, in both the "raw" and controlled analyses, extending the effect of RSA on word meaning to an eighth corpus and a fifth language: German. Moreover, this finding argues strongly against one of the two possible explanations for the QWERTY effect proposed by J&C, locating the origin of the effect in the bodies of typers, not in the keyboard, *per se*.

Experiment 4: QWERTY Effect in Letters

In Experiment 4, we tested for an effect of QWERTY key position on English speakers' valence ratings for individual letters, and compared this effect between right- and left-handers.

Method and Results

Native English speakers were recruited via Amazon Mechanical Turk and participated for online payment (N = 209). Of these participants, 7 were excluded for not following instructions and 4 were excluded for having a non-Qwerty keyboard. Data from the remaining 198 participants were analyzed.

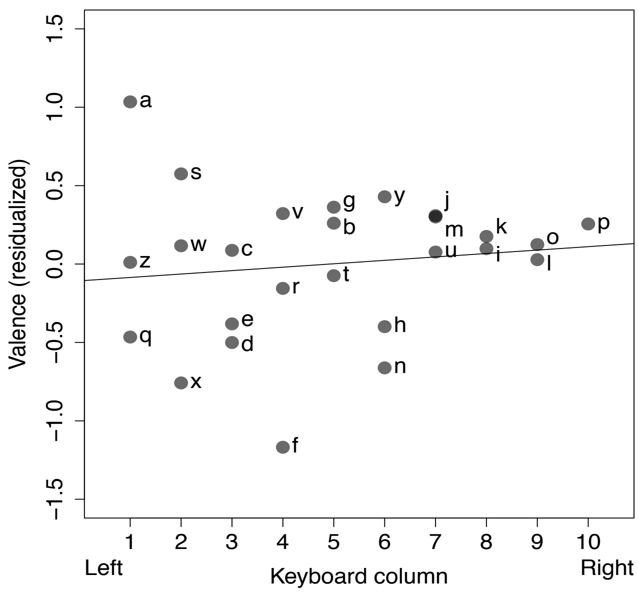
Each letter from the alphabet was presented in lower case on an individual page, with the order of presentation randomized. Participants indicated how positive the letter seemed on a vertical 9-point SAM scale (5 manikins were used as well as two labels: 'Very Positive' at the top; 'Very Negative' at the bottom). For the analysis, each letter was assigned a value corresponding to its left-to-right column position on the keyboard (Column 1 = [q, a, z]; Column 2 = [w, s, x], etc.)

In a simple regression including random intercepts for subjects, Keyboard Column was a significant predictor of Valence (b=.029, Wald χ^2=7.37, df=1, p=.007). We found the same positive relationship when controlling for a letter's frequency, its ordinal position in the alphabet, and their interaction (b=.026, Wald χ^2=5.80, df=1, p=.016; fig. 4a), and confirmed this relationship in a 20,000-iteration permutation test (p = .01135; fig 4b).

In a further analysis, we tested whether the relationship between Keyboard Column and Valence was categorical or continuous. On one possibility, this relationship could be categorical: letters typed with the left hand could be treated as more negative and those typed with the right hand as more positive. Alternatively, this relationship could be continuous: On average, the valence of letters could increase gradually, column-by-column, from left to right. According to a non-parametric rank-order test of the relationship between keyboard position and valence the relation appears to be continuous (Kendall Tau = .02, p = .056).

Finally, to test whether the effect of Keyboard Column varied with handedness, we added Handedness and its interaction with Keyboard Column to the model. Handedness was measured using the Edinburgh Handedness Inventory (EHI; Oldfield, 1971). Consistent with common practice, right-handedness was operationalized as having an EHI greater than 40 (n = 168 right-handers) and left-handedness as having an EHI less than -40 (n = 10 left-handers; 20 ambidextrous participants were excluded from this analysis). Importantly, the effect of horizontal position did not differ between right- and left-handers (Wald χ^2=.843, df=1, p=.36). Right- and left-handers showed similar QWERTY effects in tests of the effect of Keyboard Column on Valence, controlling for the letters' Ordinal Position in the alphabet, their Frequency, and the interaction of Ordinal Position and Frequency (Left-handers: b=.097, Wald χ^2=4.11, df=1, p=.04; Right-handers: b=.022, Wald χ^2=3.53, df=1, p=.06). Overall, the effect of Keyboard Column on Valence remained significant when Handedness, the interaction of Handedness with Keyboard Column, the letters' Ordinal Position in the alphabet, their Frequency and the interaction of Ordinal Position and Frequency were all controlled (b=.024, Wald χ^2=3.86, df=1, p=.05).

a.



b.

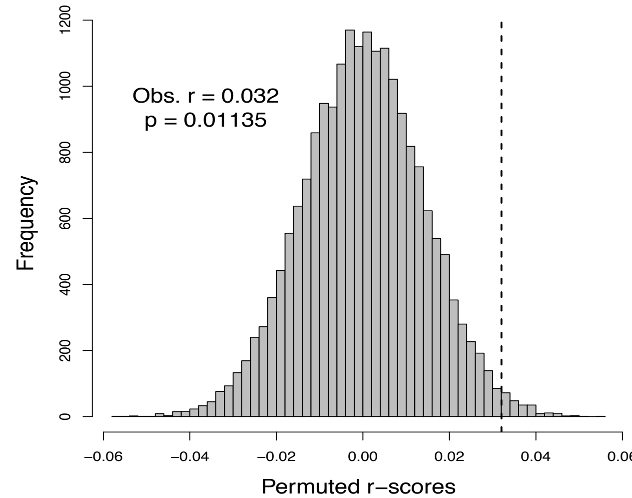


Figure 4. Results of Experiment 4. Relationship between Valence and Keyboard Column for individual letters (controlling for letters' frequency, ordinal positions in the alphabet, and their interactions), analyzed parametrically (4a, top) and nonparametrically (4b, bottom). The histogram in 4b shows the number of times each r-value was obtained in the permutation test.

In summary, the relationship between keyboard position and valence shown previously at the level of words was found here in individual letters: on average, letters farther to the right were rated as more positive in valence than letters on the left. This pattern was found in spite of the fact that letter "a," located in the left-most column, was the most positively rated letter by far (controlling for its frequency and ordinal position), presumably because "a" signifies the top rating in American school grades and other evaluation schemes. The meaningfulness of this letter, and its status as an outlier in our data, both work *against* the "right-is-good" relationship that we hypothesized, which we found in both right- and left-handers.

Experiment 5: QWERTY and Baby Names

Does the QWERY effect influence people's behavior beyond the laboratory? Although the effect is subtle, it is pervasive: It may be shading the meanings of words, according to Experiment 4, with every letter we type, read, and perhaps imagine. One domain of language use in which people have a great degree of autonomous choice, and therefore where a QWERTY effect is likely to be found, is in naming new places, products, or people. In Experiment 5, we tested whether the first names that Americans give their children have changed over time, as QWERTY has become ubiquitous in people's homes, and whether new names coined after the popularization of QWERTY are spelled using more right-side letters (i.e., have a greater RSA) than names coined earlier.

Method and Results

We obtained naming statistics from the US Social Security Administration website (http://www.ssa.gov/oact/babynames/limits.html). This database reports the frequency of each name that was given to 5 or more children in the United States that year. RSA was computed as in Experiment 1.

Longitudinal analysis of names' popularity. We first analyzed the mean RSA of all names from 1960–2012 that had been given to at least 100 children every year (n = 788 distinct names). Results showed that the mean RSA has increased since the popularization of the QWERTY keyboard, as indicated by a correlation between the year and average RSA in that year (1960–2012, r = .78, df = 51, p = 8.6×10^{-12}; fig. 5a). This correlation remained highly significant when word length was controlled by dividing RSA by the number of letters in a name (r = .77, df = 51, p = 1.7×10^{-11}).

Comparison of pre- versus post-QWERTY era names. QWERTY may also influence how new names are coined. We compared the RSA of names coined before and after the massive popularization of QWERTY. It is difficult to pinpoint the moment in history at which QWERTY became ubiquitous in Americans' homes, and a part of people's daily lives across a wide variety of demographics. Apple Macintosh and Windows home computers became available, though not yet widely used, in 1984 and 1985, respectively (http://en.wikipedia.org/wiki/Timeline_of_operating_systems; accessed February 8, 2013). America Online made the Internet widely available in people's homes starting in 1991 (http://en.wikipedia.org/wiki/AOL; accessed February 8, 2013). We chose the year 1990 as the beginning of the "QWERTY era" based on a survey of technological landmarks like those listed above, and on the inflection point observed in figure 5a, rounded to the nearest decade.

Names invented after 1990 (n = 38,746) use more letters from the right side of the keyboard than names in use before 1990 (n = 43,429; 1960–1990 mean RSA = -0.79; 1991–2012 mean RSA = -0.27, $t(81277.66) = 33.3$, $p < 2.2 \times 10^{-16}$; fig. 5b). This difference remained significant when length was controlled by dividing each name's RSA by the number of letters in the name ($t(81648.1) = 32.0$, $p < 2.2 \times 10^{-16}$).

We note that the second result, reported in figure 5b, is statistically independent from the result reported in figure 5a. The longitudinal analysis (see fig. 5a) only included names that were given to at least 100 children for every year from 1960–2012; none of the names invented after 1990 (see fig. 5b) were included in that analysis.

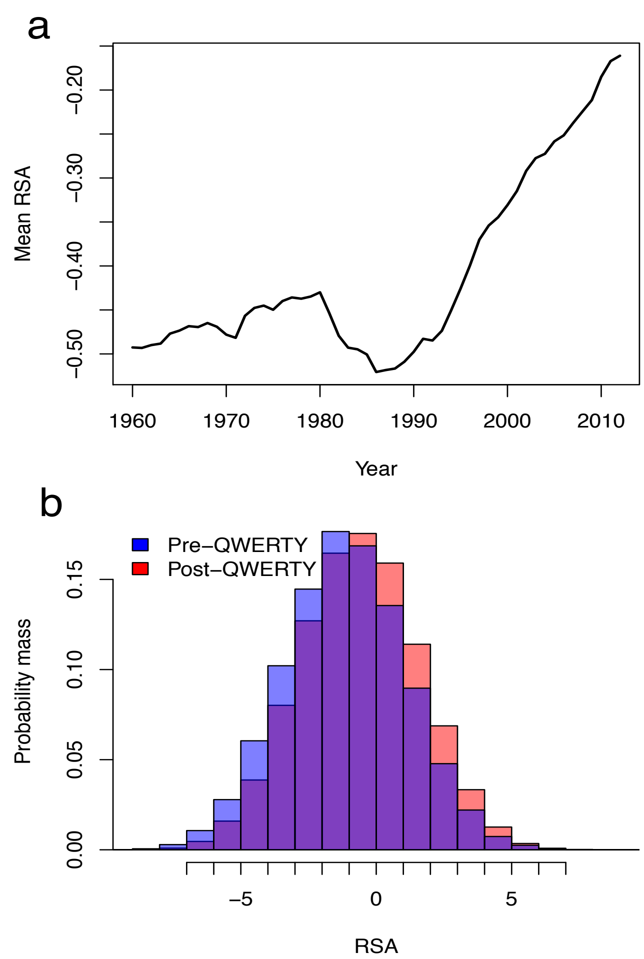


Figure 5. Results of Experiment 5. 5a (top): Mean RSA of names given to at least 100 children per year from 1960–2012. 5b (bottom): Overlaid histograms of the RSAs for all names in use before the mass popularization of QWERTY (1960–1990) and after its popularization (1991–2012).

In summary, we find very strong relationships between the names Americans have decided to give their children and the QWERTY key positions of the letters in those names. In a longitudinal analysis, we found that the mean RSA of names that were already in use as of 1960 increased dramatically starting at the dawn of the "QWERTY era," indicating that higher-RSA names were increasing in popularity and lower-RSA names declining in popularity. In a second analysis, we found that names coined after 1990 have significantly higher RSAs than names used during the previous three decades.

General Discussion

In five experiments, we replicate and extend the QWERTY effect, showing the predicted relationship between keyboard position and valence in two new languages, single letters, and in the names US parents choose for their babies. These data underscore the robustness and generality of this effect, and also constrain theorizing about its origins.

J&C proposed that the left-right asymmetry that gives rise to the QWERTY effect could either be inherent in the bodies of the keyboard's right-handed users or in the keyboard, *per se.* Finding a QWERTY-like effect in German argues strongly against the second possibility. Whereas the QWERTY keyboard has more left-hand letters than right-hand letters, the German QWERTZ keyboard does not. Since the QWERTZ effect cannot be explained by asymmetries built into the keyboard, it would be unparsimonious to invoke this explanation for the QWERTY effect found in other languages. The relationship between keyboard position and word meanings in all of the languages tested, therefore, is best explained in terms of manual motor asymmetries inherent in the keyboards' users, the great majority of whom are right-handers (Casasanto, 2009; 2011; Logan, 2003).

The QWERTY effect in single letters rules out two other possible explanations for the effect. Typing letter combinations that use (i.) distinct fingers or (ii.) alternating hands is easier than typing combinations that reuse the same fingers or the same hand (Beilock & Holt, 2007). Could the QWERTY effect be driven by some unexpected relationship between the right-left position of keys and finger repetitions (FRs) or hand alternations (HAs)? Previously, J&C ruled out effects of FRs and HAs statistically, showing that the effect of RSA on valence remained significant when these variables were controlled. Here we rule out the effects of FRs and HAs definitively: The relationship between valence the left-right positions of single letters cannot be explained in terms of typing easy vs. hard key combinations.

Finally, theorizing about the QWERTY effect's origins is strongly constrained by the finding of a significant QWERTY effect in left-handers, which did not differ quantitatively or qualitatively from the effect found in right-handers. This replicates previous findings by J&C, who showed a trend toward the standard right-biased QWERTY effect in left-handers. On the simplest prediction about the effects of typing on word meanings, right-handers should show a right-side advantage (preferring words with more right-hand letters), but left-handers should show a *left-side advantage*, giving higher valence ratings to words with more left-side letters. This prediction follows from studies showing that lefties manifest a "good-is-left" bias in numerous ways, which is rooted in their greater left-hand motor fluency (Casasanto, 2009; 2011).

The finding that both left- and right-handers prefer words with more right-side letters suggests that the QWERTY effect arises both from typing experience and from the experience of using typed words in speech. Variation in the way words are used is constrained by communities of language users, which are composed mostly of right-handers. English speakers, for example, must all agree that the "correct answer" is the "*right* answer," even if they are lefties. Perhaps "good" is associated with "right" on the keyboard because "good" is associated with "right," more generally, in a social world dominated by right-handers.

References

Beilock, S. L. & Holt, L. E. (2007). Embodied preference judgments: Can likeability be driven by the motor system? *Psychological Science*, 18, 51-57.

Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings* (pp. 1-45). Technical Report C-1, The Center for Research in Psychophysiology, University of Florida.

Casasanto, D. (2009). Embodiment of abstract concepts: good and bad in right- and left-handers. *Journal of Experimental Psychology: General,* 138(3), 351-367.

Casasanto, D. (2011). Different Bodies, Different Minds: The body-specificity of language and thought. *Current Directions in Psychological Science*, *20(6)*, 378–383.

de Saussure, F. (1966). *Course in General Linguistics*. Charles Bally and Albert Sechehaye (Eds.), Translated by Wade Baskin. New York: McGraw-Hill Book Company.

Jakobson, R. & Waugh, L. R. (1979). The sound shape of language. Bloomington, IN: Indiana University Press.

Jasmin, K. & Casasanto, D. (2012). The QWERTY Effect: How typing shapes the meanings of words. *Psychonomic Bulletin and Review, 19(3),* 499-504.

Logan, G. D. (2003). Simon-type effects: Chronometric evidence for keypress schemata in typewriting. *Journal of Experimental Psychology: Human Perception and Performance*, 29, 741-757.

Logan, G. D., & Crump, M. J. C. (2011). Hierarchical control of cognition and action: The case for skilled typewriting. In Brian Ross (ed.). *Psychology of Learning and Motivation*, Vol. 54, Burlington: Academic Press, 1-27.

Ohala, J. J. (1984). An ethological perspective on common cross-language utilization of F0 of voice. *Phonetica*, *41*(1), 1-16.

Oldfield, R.C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9,* 97–113.

Sapir, E. (1929). The status of linguistics as a science. *Language,* 207-214.

Soares, A. P., Comesaña, M., Pinheiro, A. P., Simões, A., & Frade, C. S. (2012). The adaptation of the Affective Norms for English Words (ANEW) for European Portuguese. *Behavior research methods*, *44*(1), 256-269.

Võ, M. L., Conrad, M., Kuchinke, L., Urton, K., Hofmann, M. J., & Jacobs, A. M. (2009). The Berlin affective word list reloaded (BAWL-R). *Behavior research methods*, *41*(2), 534-538.

Warriner, A. B., Kuperman, V., & Brysbaert, M. (2013). Norms of valence, arousal, and dominance for 13,915 English lemmas. *Behavior Research Methods*, 45, 1191-1207.