Psychonomic Bulletin & Review (2022) 29:1938–1945
https://doi.org/10.3758/s13423-022-02093-1

BRIEF REPORT

Do first and last letters carry more weight in the mechanism behind word familiarity?

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Accepted: 22 March 2022 / Published online: 5 April 2022

Abstract
Previous research has suggested a role of letter location information in familiarity-detection that occurs with word stimuli, but no studies have yet investigated whether certain letter positions are weighted more heavily in the feature-based mechanism behind word familiarity-detection. Based on psycholinguistic research suggesting that first and last letters are weighted more heavily than interior letters when it comes to reading words, we investigated whether first and last letters carry more weight in the mechanism behind word familiarity that results from feature familiarization in a list-learning paradigm. In two experiments, participants studied word fragments (e.g., RA_ _ _ _OP) and later rated the familiarity of complete words (e.g., RAINDROP). We varied whether the first and last or only interior letters were present at study. Participants consistently rated test words whose fragments went unidentified at study as more familiar when the first and last letters had been studied than when only interior letters had been studied. This suggests that first and last letters contribute more strongly to the word familiarity signal than interior letters.

Keywords Psycholinguistics · Reading · Recognition · Word recognition

Introduction

Familiarity is a sensation of memory whereby one feels that something or someone has been encountered before without recalling specifics (Mandler, 2008; Yonelinas, 2002). Computational models assume that familiarity emerges from the match between the features of all studied items in memory and the current stimulus (e.g., Clark & Gronlund, 1996), and data generally support this assertion (Cleary et al., 2016; McNeely-White et al., 2021; Ryals & Cleary, 2012). As long as there is some feature overlap between studied items and a test cue, there should be some degree of perceived familiarity with the test cue even in the face of recall failure, and the greater the feature overlap, the stronger the perceived familiarity intensity.

One type of feature shown to potentially be involved in word familiarity is letter location information (Cleary & Greene, 2000, 2001; Peynircioglu, 1990). For example, in the Recognition Without Identification (RWI) paradigm (Cleary & Greene, 2000, 2001; Peynircioglu, 1990), participants study words such as RAINDROP, and are later tested on word fragments, some of which correspond to studied words (e.g., R_ _ND_ _P). Among unidentified test fragments, participants rate fragments corresponding to studied words as more familiar-seeming than fragments not corresponding to studied words (the RWI phenomenon). Presumably, this familiarity-detection in the absence of word identification occurs because fragments corresponding to studied items contain enough features of studied items (in this case letters in particular positions) that they create a sense of familiarity through the feature-matching process assumed to underlie the computation of the familiarity signal (Clark & Gronlund, 1996; McNeely-White et al., 2021).

Prior work suggests that the amount of letter overlap between a test probe and words stored in recent memory matters to the strength of the familiarity signal (or to the perceived familiarity with a test stimulus during recall failure). For example, Cleary and Greene (2000) showed that using only two letters in a fragment resulted in a smaller RWI effect than using four letters. Similarly, Ryals and Cleary (2012) found that increasing the amount of letter overlap between a test cue and studied words in memory led to a corresponding increase in familiarity. For example,

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if a participant studied ADRIFT, ADEPT, ADOPT, and ADAPT, the test cue ADEIFT would later feel more familiar when none of the study words resembling the cue could be recalled than if only ADRIFT had been studied and failed to be recalled. These studies are broadly consistent with global matching approaches to the computation of the familiarity signal (Clark & Gronlund, 1996) in that *the amount of* feature overlap (such as letters) matters to the strength of the perceived familiarity signal. However, no studies have yet examined whether particular letter positions matter more than others in the mechanism behind familiarity. That is, are all letter *positions* weighted equally in the familiarity signal mechanism?

From the psycholinguistic literature, there is reason to suspect that letter locations are not all weighted equally in the mind's representations of word characteristics (e.g., Grainger & Whitney, 2004). In particular, when it comes to reading words, the first and last letters, which we will call *exterior letters*, appear to have greater importance than interior letters. For example, McCusker et al. (1981) primed participants with either the exterior or interior two letters in a four-letter word-naming task. The authors found that priming with the exterior letters produced faster word naming than priming with interior letters. Mason (1982) presented word arrays briefly followed by single letters that were present or not in the array from a few seconds earlier. Mason found that when the probe came from the first or last letter of the array, accuracy was higher and reaction times faster than when the probe came from the interior letters (also see Hammond & Green, 1982; Mason, 1975; Mason & Katz, 1976; Pitchford et al., 2008).

Similarly, Humphreys et al. (1990) primed participants with either the first and last letters or middle letters before quickly flashing the full word. Participants had to identify the full word. The authors found that priming with exterior letters was more helpful than priming with interior letters. Furthermore, when trying to recall briefly flashed letter strings without any priming, participants tend to more accurately report the exterior letters than the interior letters (Averbach & Coriell, 1961; Butler & Merikle, 1973; Estes et al., 1976; Haber & Standing, 1969; Merikle, 1974; Merikle & Coltheart, 1972; Merikle et al., 1971; Mewhort & Campbell, 1978). More accurate recall of exterior letters also occurs with actual words as opposed to just letter strings (Carr et al., 1976; Jordan & Bevan, 1996; Jordan et al., 2000; Jordan et al., 2003a; Jordan et al., 2003b).

Lastly, swapping exterior letters in a word has more detrimental effects on reading than swapping interior letters (Chambers, 1979; Holmes & Ng, 1993; Perea & Lupker, 2003; Schoonbaert & Grainger, 2004). For example, Johnson and Eisler (2012) examined the effect of different letter transpositions (swapping) on sentence processing. Sentences were presented and participants tried to read them as quickly as possible. Several words within a sentence had two letters swapped. Whether those two letters were the first two, last two, or interior letters was manipulated. Johnson and Eisler found that transposing the first two letters or the last two letters slowed down reading more than transposing interior letters.

If exterior letters carry more weight in the various psycholinguistic tasks discussed above, do they also carry more weight in the mechanism behind word familiarity from letter location information? If indeed letter locations within words involves stronger weightings of exterior than interior letter locations, then one might expect this representational difference to manifest in other ways besides word reading. If so, it would provide converging evidence from a different paradigm for the existence of differential representational emphasis for outer versus inner letters within words. Toward this end, the present study examined whether exterior letters would carry more weight in the feature-matching-based mechanism behind familiarity signal intensity than interior letters. Specifically, do exterior letters carry more weight than interior letters?

Experiment 1

In Experiment 1, we used the reverse RWI paradigm in which participants study and attempt to identify word fragments in an encoding phase then later judge the familiarity of whole words in which those and non-studied fragments are embedded (Cleary & Greene, 2000, Experiments 3A and 3B). RWI in this method is shown by higher recognition ratings among test words containing studied fragments that went unidentified at study than among words containing unstudied fragments. In the study phase of Experiment 1, we varied whether the exterior letters (e.g., RA_ _ _ _OP) or interior letters were presented (e.g., _Q_IR_E_) within a given study fragment (the second and second last letters were always present). Participants were tested on complete words that corresponded to studied exterior letter fragments, interior letter fragments, or neither (e.g., RAINDROP, SQUIRREL, VOLCANIC, respectively). In replication of previous work, RAINDROP and SQUIRREL should feel more familiar than VOLCANIC due to having more letter overlap with studied words. The key question in Experiment 1 was whether RAINDROP and SQUIRREL would show approximately equal levels of perceived familiarity given that they have the same number of overlapping letters with an unidentified studied item, or if RAINDROP would be perceived as more familiar than SQUIRREL due to the fact that the exterior, rather than interior, letters were familiarized in the encoding phase. The latter finding would constitute converging evidence for differential letter location representation from a novel paradigm examining a different cognitive process (familiarity-detection) than that typically investigated in past research on letter location representation.

Method

Participants

Forty-eight Colorado State University undergraduates participated in exchange for course credit. We chose this number based on previous RWI experiments (Cleary & Greene, 2000). Cleary and Greene ran one experiment while not including the first letter in the word fragments. For RWI, Cleary and Greene found a Cohen's *d* of 1.63 with the first letter, and 1.15 without the first letter in another experiment. We based our sample size on the difference in these effects (0.48). G power (Faul et al., 2007) recommended a sample size of 48 to achieve 90% power, which is what we aimed to run in both experiments. One participant was removed for providing the same answer for every trial. Another three participants were lost due to computer crashes, leaving 44 participants.

Design

Experiment 1 used a one-way repeated-measures three-level design. The independent variable was the fragment type corresponding to each test word (exterior, interior, unstudied), which was manipulated within subjects. The dependent variables were familiarity ratings for the test words whose fragments either went unidentified at study or were unstudied, and identification rates at study. Our reason for focusing on words whose fragments were unidentified at study is that an identified word at study would involve all letters of the word as well as other features (e.g., semantic information) to be matched with the test word and not just the intended letters. Our hypotheses are centered on how letter position information contributes to perceived word familiarity.

Materials

We used a total of 120 eight-letter words from Cleary and Greene (2000) to create four study-test blocks. Each of the four study blocks contained 20 fragments followed by 30 test words. Ten of the 20 fragments appeared in each of the two fragment conditions at study (exterior and interior fragments). Study fragments always contained the second and second last letter. This was done to distinguish each because many fragments for different words would have been identical due to different words having the same first and last letter (e.g., SQUIRREL and SHRAPNEL would both be shown as S_ _ _ _ _ _L). Therefore, 10 of the 20 fragments were exterior fragments that contained the first and last letter as well as the second and second last letter (e.g., RA_ _ _ _OP), while 10 of the 20 fragments were interior fragments that contained the middle two letters as well as the second and second last letters (e.g., _Q_IR_E_). As can be seen in these two examples, the missing letters were replaced with underscores. Consecutive underscores also had spaces between them to help participants see the number of letters missing, as in Cleary and Greene (2000, 2001). The full materials and results from both experiments can be found using the Open Science Framework (OSF), (n.d.) link found in the references.

Among the 30 words in a given test block, 10 corresponded to studied exterior fragments (e.g., RAINDROP), 10 corresponded to studied interior fragments (e.g., SQUIRREL), and 10 did not correspond to any study fragments. The order of items in each study and test block was randomized. We created three versions of the experiment so that each word appeared equally often in each of the three conditions across participants. For example, the test word SQUIRREL would have the studied fragment SQ_ _ _ _EL, _Q_IR_E_, or no studied fragment counterbalanced across participants by version. By mistake, despite attempting to ensure that each fragment corresponded to only one test word, three of the 240 total fragments mapped to more than one test word. These were as follows: CO_ _ _ _TS and CO_ _ _ _TS mapped to CONTEXTS and COMFORTS, CO_ _ _ _VE and CO_ _ _ _VE mapped to COERCIVE and CONTRIVE, and DI_ _ _ _VE and DI_ _ _ _VE mapped to DIVISIVE and DISSOLVE. However, we still included them in the analyses.

It is important to note that any lexical factors such as word frequency or orthographic neighborhood size are held constant in our method; for example, though the study fragment type for VOLCANIC would change across participants, any lexical characteristics of the test word VOLCANIC would be present regardless of what fragment type was studied. The same is also true for identification rates; the lexical characteristics of the sought-after word are the same regardless of the fragment type. That said, the orthographic neighborhood size and word frequency of our words are available on the OSF.

Though we counterbalanced the fragments corresponding to the target words, it is not possible to counterbalance the individual letters across fragment types, as this would result in different words for the test phase. For example, changing RA_ _ _ _OP to _R_AO_P_ would make it a fragment of different word than RAINDROP. Thus, it is important to establish that any effects that we observed would be due to letter position instead of some quality of the letters such as frequency. We therefore compared the average overall letter frequency and average positional frequency of the first and last letters to the middle letters. We did not include the frequency of the second and second last letters since those were held constant across both conditions. For example, RA_ _ _ _OP and _A_ND_O_ both contained A and O in the same positions. The frequencies were taken from Norvig (2012). There was no significant difference in the overall letter frequency of exterior ($M = 5.69\%$, $SD = 2.62\%$) and interior fragments ($M = 5.85\%$, $SD = 2.17\%$), $t(119) = -0.59$, $SE = 0.28$, $p = 0.57$, Cohen's $d = -0.07$. There was a significant difference in the positional frequency between exterior ($M = 7.21\%$, $SD = 3.74\%$) and interior fragments ($M = 6.16\%$, $SD = 3.03\%$), $t(119) = 2.51$, $SE = 0.42$, $p = 0.013$, Cohen's $d = 0.31$. To our knowledge it has not been established that positional letter frequency affects familiarity. However, this potential issue will be addressed in Experiment 2.

Procedure

We tested participants individually in separate rooms on individual computers. We programmed the experiment into E prime software. The instructions told participants that they would see a list of fragments and try to complete them and that later they would take a memory test that would be explained when they got to it. For each of the study blocks, the fragments appeared one at a time in the top and center of the screen in black on a white background in an 18-pt font. The study fragments were presented in a random order. So that participants would not go through the fragments too quickly without making any attempt to solve them, each fragment appeared for 2 s before participants tried to complete it by typing in the word. After the 2-s presentation, the instructions "type the whole word if you can" appeared below the fragment. Participants pressed Enter when they had typed their answer or gave up on attempting to complete the fragment. Beyond the initial 2 s, participants completed the fragments at their own pace. After going through the 20 fragments of the first study block, participants began the first test block. The instructions informed participants that they would see whole words and rate their familiarity as to how strongly they believed they studied a fragment of the whole word being shown. Zero meant unfamiliar/definitely not studied; 10 meant familiar/definitely studied. The test block consisted of 30 full words. The test words were presented in a random order. On each trial, the prompt displayed "How familiar is this word to you (0–10)? Type your answer and press Enter" below each word. Participants typed a number from 0 to 10 and pressed Enter to advance to the next trial. Upon completing all 30 test words in a test block, the next study block of fragments began. This procedure repeated for three more study-test blocks.

Results

One difference between our first experiment and previous RWI experiments (Cleary & Greene, 2000, Experiments 3A and 3B) was that some of the fragments could be completed by multiple words. However, we separately analyzed the familiarity ratings while not including identification of a different word than would appear in the test phase, and it did not change our findings. The analysis shown does include those cases as we sought to focus on test items whose studied fragments were clearly unidentified at study, but the aforementioned analysis is available on the OSF found in the references, along with our data.

We first analyzed the identification rates.[1] We included instances of completion with the intended word and alternatives that fit the fragment, and compared the rate of completion of exterior and interior fragments for each participant with a paired-samples t-test. Participants completed exterior fragments ($M = 0.24$, $SD = 0.10$) more often than interior fragments ($M = 0.08$, $SD = 0.06$), $t(43) = 11.55$, $SE = 0.01$, $p < 0.001$, Cohen's $d = 1.81$.

For our analysis of familiarity ratings, we took the average familiarity rating for each of the three conditions (words corresponding to unidentified exterior studied fragments, to unidentified interior studied fragments, and to unstudied fragments) for each participant. We then used these means from each participant as the dependent measure in a repeated-measures ANOVA and paired-sample t-tests. Fragment type had a significant effect on familiarity ratings, $F(2, 86) = 11.64$, $MSE = 0.40$, $p < 0.001$, $\eta_p^2 = 0.21$. For the paired-sample t-tests, we applied a Bonferroni correction, with a significance level of 0.05 divided by three from the three comparisons made for a needed significance level of 0.016. Participants gave higher familiarity ratings to words corresponding to unidentified exterior letter fragments ($M = 5.17$, $SD = 2.19$) than to words whose unidentified fragments contained interior letters ($M = 4.72$, $SD = 2.23$), $t(43) = 3.44$, $SE = 0.13$, $p = 0.001$, Cohen's $d = 0.21$. The higher familiarity ratings to words whose unidentified interior letter fragments were studied than to words whose fragments had not been studied approached but did not reach significance ($M = 4.54$, $SD = 2.30$), $t(43) = 1.96$, $SE = 0.09$, $p = 0.056$, Cohen's $d = 0.08$. Lastly, participants gave higher familiarity ratings to words corresponding to unidentified exterior letter fragments than to words whose fragments had

[1] Familiarity ratings and identification rates would ideally be analyzed within the same multivariate model; however, this approach cannot be taken for the full data set because there are no identification rates for unstudied fragments. That said, we did carry out a MANOVA with only familiarity ratings for words corresponding to unidentified exterior and interior fragments along with identification rates for exterior and interior fragments. This did not change our results and can be found in the Online Supplementary Materials.

not been studied, $t(43) = 3.71$, $SE = 0.17$, $p = 0.001$, Cohen's $d = 0.28$.[2,3,4]

Experiment 2

The results of Experiment 1 suggest that exterior letters are weighted more heavily in the mechanism behind word familiarity than interior letters. Just as exterior letters seem to be especially important in word processing (e.g., Jordan et al., 2003a; Jordan et al., 2003b), they also seem to be more important in the mechanism behind word familiarity. The special status of exterior letters has not been considered in investigations of the feature-matching mechanisms underlying word familiarity in list-learning paradigms.

Experiment 2 sought to address some potential issues with Experiment 1. In manipulating whether exterior or interior letters appeared in a fragment in Experiment 1, our process also varied the adjacency of letters. For example, in the fragment for RAINDROP (RA_ _ _ _OP) there are two letters next to other letters (R is next to A and O is next to P). In contrast, the fragment for SQUIRREL (_Q_IR_E_) only has one pair of adjacent letters (IR). It is possible that adjacency between letters could alter the strength of the familiarity signal in some way. To prevent this possible confound of adjacency, we used a similar procedure in Experiment 2, but this time both fragment types had two pairs of adjacent letters such as SW_ _ _OW and _AC_IN_ for the test words SWALLOW and VACCINE, respectively.

We also made another modification in Experiment 2. This was to create fragments that could only be completed with one word as has been done in previous RWI experiments (Cleary & Greene, 2000). Lastly, we used words that did not have a significant difference in their fragments' positional frequency.

Method

Participants

Forty-eight Colorado State University undergraduates completed the experiment online in exchange for course credit. This number was based on the same power analysis as in Experiment 1.

Design

Experiment 2 used the same one-way, three-level (fragment type: exterior, interior, unstudied) within-subjects design. Familiarity ratings for words whose fragments went unidentified at study or were unstudied and identification rates were the dependent variables.

Materials

Experiment 2 used 120 seven-letter words instead of eight-letter words. We used letter locations so that adjacency would not act as a possible confound. For example, CIRCUIT would have been studied as CI_ _ _IT in the exterior condition, or _IR_UI_ in the interior condition. With this method, any possible effect of adjacency should be equal in both conditions since both fragments have two pairs of adjacent letters. These words were generated using the English Lexicon Project Web Site (Balota et al., 2007). Additionally, we ran the words through a crossword solver by Young (2020). This allowed us to create unique fragments that could only be completed with one solution. Only words that could appear as exterior and interior fragments with only one solution were used in the experiment. However, we did include words whose fragments could be completed by an alternative word that we judged to be extremely obscure. For example, the fragment of OVERALL (OV_ _ _ _LL) can be completed by the word OVICELL, which is a biology term. We randomly picked words from a pool of seven-letter words until 120 useable words were found that met our criteria for inclusion. The selected words had a HAL frequency ($M = 10{,}746.43$, $SD = 19{,}425.28$) range of 432–139,009, and a log HAL frequency ($M = 8.35$, $SD = 1.34$) range of 6.07–11.84.

[2] As another means of considering whether identification effects were related to familiarity effects, we took the difference in identification rates between exterior and interior fragments for each participant and correlated it with the difference in familiarity ratings for words that were unidentified from their exterior and interior fragments during study. This correlation was not significant in Experiment 1, $r = -.15$, $p = .34$. Also, there was no significant correlation between the rate of identified exterior fragments and exterior familiarity ratings for each participant, $r = -.20$, $p = .21$, nor between identification rates in the interior condition and interior familiarity ratings for each participant, $r = .04$, $p = .79$. Taken together these results suggest that the exterior letter position significance for familiarity ratings was not related to more exterior fragments being solved.

[3] It is worth noting that the means for each participant were usually based on more words in the interior condition. This is because participants typically identified more words in the exterior condition than in the interior condition, leaving fewer words whose exterior fragment was studied and unidentified to be used in the analysis. As a means of addressing this, we randomly selected an equal number of trials from each condition.

This analysis can be found in the Online Supplementary Materials. It did not change our results.

[4] We also analyzed identification rates and familiarity ratings by block in both experiments. There was no significant block x fragment type interaction for familiarity ratings in either experiment. There was also no main effect of block on familiarity ratings in either experiment. Identification rates did change across blocks, as did the difference in exterior and interior identification rates in both experiments. These analyses can be found in the Online Supplementary Materials.

We split the words and their associated fragments into four study test blocks as was done in Experiment 1. However, we organized the blocks so that a single bigram was not repeated in the same location in the same block. For example, the fragments for the test words ANTIQUE and ANARCHY were placed in different study test blocks so the bigram AN would not be shown twice in the same block. This was done for all four bigram positions within the seven-letter words. The full materials can be found using the OSF link in the references.

We also verified that the effects were due to position as opposed to letter frequency. Thus, we compared the overall frequency and positional frequency of the first and last letters to the third and third last letters. As in Experiment 1 we did not include the second and second last letters as these were held constant in both fragment types. There was no significant difference in overall letter frequency between exterior ($M = 6.08\%$, $SD = 2.92\%$) and interior ($M = 6.26\%$, $SD = 2.29\%$) fragments, $t(119) = -0.51$, $SE = 0.34$, $p = 0.612$, Cohen's $d = -0.07$. Unlike Experiment 1, there was not a significant difference between exterior ($M = 7.54\%$, $SD = 3.75\%$) and interior fragments ($M = 6.70\%$, SD = 3.33%) in the positional frequency of letters, $t(119) = 1.85$, $SE = 0.45$, $p = 0.067$, Cohen's $d = 0.24$. Since the letter fragments in both conditions each contained two bigrams, we also compared the average bigram frequency between the two fragments for each test word. Exterior fragments ($M = 0.56\%$, $SD = 0.62\%$) did not have a higher bigram frequency on average than interior fragments ($M = 0.54\%$, $SD = 0.39\%$), $t(119) = 0.26$, $SE = 0.06$, $p = 0.796$, Cohen's $d = 0.03$.

Procedure

The procedure was identical to that used in Experiment 1 with the following exceptions. First, the data were collected online using Qualtrics because of the COVID-19 pandemic. Second, the instructions informed participants that the fragments could not be completed by names or proper nouns. Third, the fragments and test words appeared in black in a 36-pt font at the center of the screen. Lastly, participants clicked on a response between 0 and 10 to give their familiarity rating instead of typing it in.

Results

Participants identified exterior letter fragments ($M = 0.35$, $SD = 0.21$) more often than interior letter fragments ($M = 0.17$, $SD = 0.17$), $t(47) = 9.20$, $SE = 0.02$, $p < 0.001$, Cohen's $d = 0.85$.

Fragment type had a significant effect on familiarity ratings, $F(2, 98) = 39.66$, $MSE = 0.48$, $p < 0.001$, $\eta_p^2 = 0.46$. We applied the same Bonferroni correction as in Experiment 1 (for a needed significance level of 0.016). Participants gave higher familiarity ratings to words corresponding to unidentified exterior fragments ($M = 5.18$, $SD = 2.41$) than to words corresponding to unidentified interior letter fragments ($M = 4.51$, $SD = 2.45$), $t(47) = 5.40$, $SE = 0.12$, $p < 0.001$, Cohen's $d = 0.28$. Participants gave higher familiarity ratings to words whose studied fragment contained interior letters than to words whose fragment was not studied ($M = 3.92$, $SD = 2.46$), $t(47) = 5.40$, $SE = 0.11$, $p < 0.001$, Cohen's $d = 0.24$. Additionally, participants gave higher familiarity ratings to words corresponding to unidentified exterior fragments than to words whose fragments had not been studied, $t(47) = 6.96$, $SE = 0.18$, $p < 0.001$, $d = 1.00$.[5]

General discussion

In two experiments, we found evidence that exterior letters carry more weight than interior letters in the mechanism behind word familiarity from encoded letter information. These results suggest that letters' involvement in the feature-matching process that is thought to generate familiarity signal intensity for word stimuli involves more than a matter of the amount of letter overlap between a test word and letter information stored in memory (e.g., Cleary & Greene, 2000; Ryals & Cleary, 2012); the specific *positions* of the letters that do overlap also matter in the mechanism behind familiarity, with overlap between exterior letters playing a larger role in increasing familiarity intensity than equivalent letter overlap between interior letters. Similarly, mathematical models of familiarity (e.g., Clark & Gronlund, 1996) also only focus on the amount of feature overlap, such as letters. Our study suggests that the *location* of letter overlap also matters.

Our results also build upon a substantial psycholinguistic literature and provide converging evidence from a novel methodological and theoretical approach for the differential weighting of exterior and interior letters of words in the human mind. Prior work has suggested that the mind places

[5] We also examined the relationship between identification rates and mean familiarity ratings in each condition for each participant in Experiment 2. We first took the difference in identification rates between exterior and interior fragments for each participant and correlated it with the difference in familiarity ratings for words whose exterior versus interior fragments were unidentified during study. This correlation was not significant, $r = .04$, $p = .81$. There was also not a significant correlation between identification rates in the interior condition and familiarity ratings for words corresponding to unidentified fragments in the interior condition, $r = -.09$, $p = .53$. There was a significant negative correlation between identification rates in the exterior condition and familiarity ratings for words corresponding to unidentified fragments in the exterior condition, $r = -.31$, $p = .03$. Thus, the familiarity effect does not seem to be a product of higher identification in the exterior condition.

increased importance in its representations of exterior letters of words relative to interior letters (e.g., Jordan et al., 2003a; Jordan et al., 2003b). However, most of the tasks demonstrating exterior position significance relate to speed of processing in word-reading types of tasks, and from these, researchers have argued (e.g., Forster, 1976) that first and last letters are the first to be accessed in word identification. Our results demonstrate that the increased importance of exterior letters extends beyond the speed of perception and into the mechanisms responsible for feature-matching-based familiarity-detection in list-learning paradigms. This pattern suggests that there may be something inherently different about the way that the mind represents exterior and interior letters of words, and/or the processes that act upon them. Although not the focus of our experiments, identification of words was also higher for exterior letter fragments than for interior letter fragments, in line with the psycholinguistics literature. The effect of location on identification is yet further evidence that exterior letters have special significance over and above the speed of perception.

A direction for future research is to investigate the relative importance of first versus last letters in the mechanisms behind familiarity. Often, both the first and the last letters are investigated in studies of word reading (e.g., Jordan et al., 2003a; Jordan et al., 2003b; McCusker et al., 1981). However, some of the studies discussed earlier did show that the first letter is even more important than the last letter (e.g., Johnson & Eisler, 2012); thus, comparing first versus last letter positions is an important direction for future research aiming to understand how letter positions are differentially weighted in the mechanisms behind word familiarity.

Another direction for future research is to investigate why exterior letter positions are especially important in word familiarity. One possibility might relate to a point by Johnson and Eisler (2012), who argued that first and last letters only have one adjacent letter, while interior letters have two adjacent letters. This difference in lateral interference could mean that exterior letters are processed more efficiently than interior letters. Something similar could be happening in familiarity-detection. Perhaps exterior letter positions receive less interference in memory, because they have fewer adjacent letters, than interior letter positions.

We did equate the number of adjacent letters in Experiment 2. However, this interference could still be present. One possibility is that the underscores in our experiments still cause the same interference that a letter would: An exterior fragment could receive interference from one letter, while an interior fragment receives interference from one letter and one underscore. It could also be the case that in trying to complete the fragments, self-generated letters cause interference. As a person would not be trying to generate letters in front of the first letter position, or after the last letter position, these positions might not receive as much interference in memory. Future research should investigate the potential effect of adjacent interference and any other potential reasons why exterior letters seem to be more important than interior letters in word familiarity.

Though we found that the identification effects seemed to be independent, or possibly even in the opposite direction of familiarity effects, future research should investigate how non-fitting words might affect familiarity ratings. It is possible that participants could think of letters without typing them in that do not actually fit the fragment, which could affect their later familiarity ratings given to words. One could pilot fragments in future work to determine if non-fitting words more readily come to mind in any condition.

In summary, our results suggest that the specific positions of overlapping letters between a test cue and memory representations matters to the level of perceived familiarity intensity with a word stimulus. There could be other types of letter information that carry more weight than others in word familiarity, and previous research has suggested ways of incorporating differential weightings of different feature types in global matching model computations of familiarity signal intensity (McNeely-White et al., 2021). The present experiments help to increase understanding of how the curious feeling of word familiarity is generated from letter location features.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.3758/s13423-022-02093-1.

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