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The Curious Case of Orthographic Distinctiveness: Disruption of Categorical Processing

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How does orthographic distinctiveness affect recall of structured (categorized) word lists? On one theory, enhanced item-specific information (e.g., more distinct encoding) in concert with robust relational information (e.g., categorical information) optimally supports free recall. This predicts that for categorically structured lists, orthographically distinct (OD) word lists should be recalled better than orthographically common (OC) word lists. Another possibility is that OD items produce a far-reaching impairment in relational processing, including that of categorical information. This view anticipates an advantage in recall for OC items relative to OD lists. In Experiment 1 categorically structured OC lists produced better recall performance and higher clustering than did categorically structured OD lists. When words were presented in capital letters, thereby minimizing orthographic distinctiveness, OC and OD lists showed equivalent recall and category clustering (Experiment 2). When recall was cued with category labels, OC items were still better recalled than OD items (Experiment 3). These patterns, along with category access and items-per-category recalled, are consistent with the interpretation that orthographic distinctiveness creates a disruption in encoding of inter-item associations within a category. This interpretation expands previous work indicating that orthographic distinctiveness disrupts encoding of serial order information, another kind of inter-item association.

Keywords: orthographic distinctiveness, mnemonic effects, recall of categorized lists, disruption of categorical processing, relational processing

Distinctiveness is a central concept in memory research, with countless demonstrations of distinct stimuli and encoding conditions producing superior memory performance (for reviews, see Hunt & Worthen, 2006; McDaniel & Bugg, 2008; Schmidt, 1991). The bizarreness effect (e.g., McDaniel & Einstein, 1986), the orthographic distinctiveness effect (e.g., Hunt & Elliot, 1980), and the von Restorff effect (1933; also Hunt, 1995) are all well-documented examples of distinctiveness producing advantages in memory. Recent work and accompanying theoretical developments, however, have illuminated conditions under which some aspects of memory may be compromised for distinctive stimuli. In this article, we explore the extent to which certain distinctive stimuli, orthographically distinct words, might exert an even more profound disruption of memory than has been thus far documented or appreciated. In free recall, one clear boundary condition of distinctiveness effects is list composition (see McDaniel & Bugg, 2008; Schmidt, 1991, for reviews). In mixed-list designs, in which manipulations (of stimuli characteristics or encoding conditions) occur within a given list, the classic benefits of distinctiveness (e.g., bizarreness, orthographic distinctiveness) emerge on free recall measures. However, in pure-list designs, in which manipulations occur across lists (and between-subjects), the distinctive stimuli are recalled no better than more typical stimuli (e.g., orthographically common words). This pattern clearly dovetails with the results reported for the effects of orthographic distinctiveness on free recall (Hunt & Elliot, 1980; McDaniel, Cahill, Bugg, & Meadow, 2011).

There are a number of theoretical accounts of this free recall pattern, both for the effects of orthographic distinctiveness per se (e.g., Hunt & Elliot, 1980; McDaniel, Cahill, Bugg, & Meadow, 2011), as well as for a range of effects related to distinctiveness (bizarreness, Geraci, McDaniel, Miller, & Hughes, 2013; see McDaniel & Bugg, 2008, and Schmidt, 1991, for broader reviews). Here we focus on one account, the item-order account, because the current experiments were motivated by that framework. First proposed by Nairne, Riegler, and Serra (1991) to explain the free recall advantage for generated versus read items in mixed lists but not pure lists, the framework has since been generalized to explain a range of free-recall advantages for distinct items, enacted items, and masked items relative to common items with mixed lists but not pure lists (McDaniel & Bugg, 2008; see also Jonker, Levene, & MacLeod, 2014, for related evidence with the production effect). This account emphasizes the importance of two types of information that contribute to free recall: item-specific information and

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relational information (Hunt & McDaniel, 1993, provide a detailed treatment of this assumption). Item-specific information includes the features encoded with the individual item, and relational information includes any information that can be used to connect the items in the list (e.g., categorical relations). In the absence of a salient organizational scheme, list order information (or temporal context; see Howard & Kahana, 1999) is the primary relational information available (Kintsch, 1970; Mandler, 1969; Mandler & Dean, 1969).

Crucially for present purposes, the item-order account posits that distinctiveness has opposing effects on these two types of information: an enhancement of item-specific information but an impairment of the temporal order relational information among list items. Pure distinct lists, then, produce more item-specific information but less relational information than pure common lists, with these two differences essentially offsetting and producing equivalent recall. The recall advantage for distinct items in mixed lists results because mixed lists as a whole (both the common and distinct items) produce an intermediate level of encoding of temporal order (less temporal-order encoding than pure common but more than pure distinct lists). In this case, common and distinct items benefit from the same amount of relational information, but the distinct items garner advantaged individual-item processing and thus are better recalled. McDaniel et al. (2011) supported the item-order account with respect to orthographic distinctiveness by demonstrating that the equivalent recall for pure common and pure distinct lists was accompanied by better recognition (item-specific processing) for distinct lists but better input–output correspondence at recall (relational encoding) for common lists. In mixed lists, as expected, input–output correspondence was intermediate, and both recognition and recall were superior for distinct items.

The focus of the item-order framework has been to integrate findings from paradigms using unstructured word lists, and this framework has incorporated the idea that for these kinds of lists, learners will use temporal-order information to help guide free recall (see also Howard & Kahana, 1999, for a related view). However, even with pure lists of common items, the recall patterns suggest a somewhat modest relation between temporal input order and recall, as well as incidental memory for order per se (e.g., Mulligan & Lozito, 2007). Presumably such temporal-order information is not necessarily robustly encoded, and consequently distinct items may easily disrupt the encoding and use of temporal-order information for recall of unstructured lists.

The key question motivating the current experiments concerns the consequences of orthographic distinctiveness on encoding and recall of lists that have a more robust relational structure. Following a venerable theme in the memory literature, here we focus on lists of items that are categorically related and therefore allow a compelling organizational structure for encoding and recall of list items (Einstein & Hunt, 1980; Hunt & Einstein, 1981; Mandler, Pearlstone & Koopmans, 1969). At present, the dynamics of orthographic distinctiveness on free recall are unknown when categorical structure is available. Further, this issue is of theoretical import, as several possible frameworks anticipate divergent patterns.

Distinctiveness and Organization: Theoretical Frameworks

As noted above, the item-order account (McDaniel & Bugg, 2008) rests in part on a general theory of recall that assumes that free recall is dependent on two types of information: information that relates the items in the event (e.g., categorical information) and item-specific information, that is, information about unique features of each item (e.g., distinctive information; see Guynn, McDaniel, Strosser, Ramirez, Castleberry, & Arnett, 2014; Hunt & McDaniel, 1993). A further extension of this more general theory is the assumption that generally a categorically structured word list prompts encoding of the shared features of the list items (relational information among the words) and de-emphasizes the unique (distinct) features of each item (see Einstein & Hunt, 1980; Hunt & McDaniel, 1993). Accordingly, free recall for structured word lists is advantaged by increasing the distinctiveness of the individual items (words) in the list because doing so stimulates the encoding of item-specific information (reflected in the distinctive aspects of each word) that ordinarily would be relatively modestly encoded in a categorically structured list. This expectation has been widely confirmed with experiments that have implemented orienting tasks to promote more extensive individual item processing of target words (presumably increasing their distinctiveness; Einstein & Hunt, 1980; Hunt & Einstein, 1981; McDaniel, Einstein, & Lollis, 1988).

Most pertinent for present purposes are similar findings with structured word lists for manipulations like generation/read and low/high frequency, for which free recall effects observed in pure unstructured lists diverge from those with mixed lists. Specifically, in contrast to effects with pure unstructured lists, with pure categorically structured lists, generation of words produces better free recall than reading words (McDaniel, Waddill, & Einstein, 1988; Nairne et al., 1991). The interpretation is that more extensive individual-item encoding enjoyed by generated items (relative to read items) enhances recall when combined with the salient relational information (categorical relations among the words) of the structured word list (see Hunt & McDaniel, 1993, and Guynn et al., 2014, for theoretical accounts of how individual item and relational information jointly support high levels of recall).

In a similar vein, consider free recall of low- and high-frequency words. In unstructured pure lists, the common finding is that high frequency words are recalled better than low-frequency words (e.g., Gregg, Montgomery, & Castaño, 1980). Merritt, Delosh, and McDaniel (2006) replicated this typical pattern with unstructured lists, but using categorically structured pure lists found a reversed pattern. With the structured lists, the novel finding emerged that low-frequency items were better recalled than high-frequency items. Again, the interpretation is that greater item-specific processing stimulated by low-frequency words (relative to high-frequency words) improved free recall when the list also afforded robust relational processing (e.g., categorical information). Based on these past findings and the accompanying theoretical framework that enhanced item-specific information (e.g., more distinct encoding; Hunt & McDaniel, 1993) in concert with robust relational information (e.g., categorical information) optimally supports free recall, a clear expectation is that orthographically distinct items should produce superior recall to orthographically common items in categorically structured lists.

Other interesting theoretical possibilities exist, however, with these possibilities generating predictions that oppose those just developed. One possibility is that orthographically distinct items produce a far-reaching impairment in relational processing. The idea here (which we label the *relational disruption hypothesis*) is that the unusual orthography captures attention toward those features, thereby disrupting full and complete encoding of the categorical (or other relational) links among the items. Essentially, this is a stronger formulation than that proposed by the item-order framework. The item-order framework suggests that distinct items will disrupt temporal order encoding, but not necessarily disrupt encoding of more salient relational information such as categorical relations. A precedent for disrupting encoding of salient categorical information can be found, however, in the negative repetition effect (Mulligan & Peterson, 2013; Peterson & Mulligan, 2012). In this paradigm, participants were presented with a list of cue–target pairs, blocked by category, and completed a free recall test of the targets after a 5-min interval. The manipulation was whether participants studied the same list of cue-target pairs in an uncategorized fashion prior to studying the categorized lists. Surprisingly, the repetition condition (participants who had seen the list in uncategorized then categorized fashion) had lower levels of recall, relative to the group that had only seen the words once (in structured format). The interpretation was that the encoding of the unstructured presentation during the first list presentation interfered with using the categorical information to guide encoding during the second list presentation. The relational disruption hypothesis is that orthographic distinctiveness also might impair encoding of categorical information in structured lists. This formulation generates the novel prediction that for structured pure lists, there will be a robust advantage in free recall for orthographically common items because common but not distinct items will benefit from the categorical list structure.

Another theoretical possibility is that distinct items will not necessarily impair processing of the categorical structure, but participants (given pure distinct lists) will rely on distinct information to the exclusion of categorical information in guiding their free recall. This possibility (which we label the *distinctiveness retrieval priority hypothesis*) is consistent with frameworks that claim that distinctive information provides privileged or preferred routes to recall (e.g., Knoedler, Hellwig, & Neath, 1999; see also Geraci et al., 2013). Also lending support to this possibility is the finding that when relational information is well encoded (i.e., participants are instructed to attend to and remember the serial order of the list items) that relational information is not exploited to guide recall of bizarre (distinct) items even though the relational information is evident in recall of common items (McDaniel, DeLosh, & Merritt, 2000). This distinctiveness retrieval priority hypothesis, like the relational disruption hypothesis, implies that for well-structured word lists, orthographically distinct lists may reduce recall to levels significantly below that of orthographically common lists.

Experiments 1A and 1B

Experiments 1A and 1B were conducted to examine the competing predictions outlined above. To do so, we assembled a new set of orthographically distinct and common words that allowed construction of categorized word lists. We also imposed a delay between the end of the presentation phase and the recall test (unlike McDaniel et al., 2011), so that participants would find value in relying on the categorical information to guide recall (cf. McDaniel & Masson, 1977). We retained short word lists (eight items) to parallel the pure-list conditions in McDaniel et al. (2011) under which OD words were found to disrupt temporal order information (another type of relational information). Our objective in Experiment 1A was to confirm that when the new set of words was presented in unstructured lists (one item from each of the several categories), the recall patterns would replicate previous reports: orthographically common and orthographically distinct lists would be recalled equivalently (Hunt & Elliot, 1980; McDaniel et al., 2011). Having done so, we conducted a companion Experiment 1b using the same materials and procedure as Experiment 1A, but with the critical addition of the lists being constructed to reflect a salient category structure. Another key feature of Experiment 1B was that during encoding participants performed an orienting task that directed attention to the category membership of the list items to further emphasize the categorical list structure.

Method

Materials. In a pilot study (also reported in McDaniel et al., 2011), following Hunt and Elliot (1980; see also Rajaram, 1998) participants were instructed to rate the "visual weirdness" of 321 words on a scale from 1 to 5, and these ratings were used to classify words as *orthographically distinct* (OD) or *orthographically common* (OC). For the current experiments, words with ratings above 2.6 were classified as OD words and words with ratings below 2.4 were classified as OC words. From this pool of words, 32 OD words (range = 2.61 to 3.85, $M = 3.01$) and 32 OC words (range = 1.42 to 2.31, $M = 1.98$) were selected for use in the current set of experiments. The number of orthographic neighbors (Coltheart's *N*; Coltheart, Davelaar, Jonasson, & Besner, 1977) for words in each set was tabulated. OD words averaged far fewer neighbors ($M = .69$, $SE = .26$) than did OC words ($M = 5.63$, $SE = 1.03$), $t(62) = 4.65$, $p < .001$). This index thus converges with the subjective ratings to indicate that the OD items have distinctive nonsemantic features, as defined by Hunt and Elliot (1980): "distinctive features of words are those shared by few other words" (p. 55). Both sets of words contained four exemplars from each of the following eight categories: Egypt, Colors, Animals, Nautical, Fruit, Respiratory, Musical Instruments, and Spices. Orthographically distinct and orthographically common words were matched on frequency, which is based on log-transformed Hyperspace Analogue to Language (HAL; Lund & Burgess, 1996) frequency norms ($M = 6.98$ for common words and $M = 6.57$ for distinct words), $t(62) = 1.35$, $p > .15$. Coltheart's *N* and HAL for each word were extracted from the English Lexicon Project database (Balota et al., 2007).

For Experiment 1A, four uncategorized OC lists and four uncategorized OD lists were constructed from these words. Each of these lists contained only a single exemplar from each of the eight categories. List order was counterbalanced such that all lists appeared in every possible serial position (1 through 4) an approximately equal number of times. Serial order of words within each list was randomized across participants.

For Experiment 1B, four categorized OC lists and four categorized OD lists were constructed. Each list contained words from two semantic categories (four words per category), and four category combinations were used (*Ancient Egypt* and *Colors*, *Fruits* and *Respiratory, Musical Instruments* and *Spices,* and *Animals* and *Nautical*). As with Experiment 1A, list order was counterbalanced and serial order of words within each list was randomized across participants.

Participants and design. For Experiments 1A and 1B, participants were randomly assigned to the conditions of a two-group between-subjects experimental design, with orthographic distinctiveness as the independent variable. Experiments 1A and 1B both included 46 Washington University students ($n = 24$ for the orthographically distinct condition and $n = 22$ for the orthographically common condition in both experiments). The experiments lasted approximately 30 min, and participants were compensated with either $5 or course credit.

Procedure. In Experiment 1A, participants were instructed to view word lists and remember them for a later memory test. During list presentation, words were presented in black font in the center of a white background for 2,000 ms with a 200-ms interstimulus interval. Each eight-word list was followed by a 30-s delay period during which participants counted backward by three's using pen and paper, starting from a number presented on the monitor. After the fourth list (and 30-s delay period), participants completed 10 min of filler tasks before completing free recall. For the first filler task participants were provided with a list of the 50 states and spent 5 min writing down as many state capitals as they could. The second filler task required participants to work on a set of two-digit multiplication problems; this task also lasted 5 min. After the filler tasks, participants were instructed to write down all of the words they could remember from the four lists viewed earlier. Participants were given 4 min to complete this free recall, and they were instructed to try to use all of the allotted time.

The procedure for Experiment 1B was identical to Experiment 1A, except for the addition of a category decision task during list presentation. Participants were instructed that they would be placing words into categories and then recalling them at a later time. Before each list, an information screen provided participants with the categories for the upcoming list and instruction on how to categorize (e.g., "please press *5* if you see an *animal* word and *6* if you see a *nautical* word"). The *5* and *6* keys always corresponded to the two categories in the list. Additionally, participants were told that words would always remain on the screen for 2 s, and that they should try to make their responses within that timeframe. Participants were given one block of practice to familiarize themselves with the category decision task before presentation of the critical lists. During this practice block, participants were presented with words related to *medicine* and *geometry*.

Results

As expected, in Experiment 1a recall proportions for the OC ($M = .20$, $SE = .02$) and OD ($M = .21$, $SE = .02$) conditions were equivalent, $t(44) = .40$, $p > .65$. To provide further statistical evidence that recall did not differ for OD versus OC conditions, we used the Bayes information criterion (BIC) value to generate the posterior probability of the null hypothesis (following Wagenmakers, 2007; see also Masson, 2011). The probability of the null, $P_{BIC}(H_0|D)$, was .86, indicating positive support for the null (using Raftery's, 1995, guidelines). In contrast, in Experiment 1B, the OC condition ($M = .42$, $SE = .03$) demonstrated a robust advantage in recall levels, relative to the OD condition ($M = .28$, $SE = .03$), $t(44) = 3.68$, $p < .001$, $d = 1.09$.

Category clustering in recall (Experiment 1B) was measured using the adjusted ratio of clustering (ARC; Roenker, Thompson, & Brown, 1971) score, which ranges from 1.0 to −1.0, with 1.0 indicating perfect clustering and 0.0 indicating chance clustering. ARC scores were also significantly higher for the OC ($M = .66$, $SE = .06$) than for the OD conditions ($M = .29$, $SE = .11$), $t(42) = 3.13$, $p < .01$, $d = 1.09$, suggesting that the recall advantage for OC words was driven by better utilization of the categorical structure of the lists. The ARC score was significantly higher than zero (i.e., chance) for both the OC condition, $t(21) = 11.78$, $p < .001$, and the OD condition, $t(21) = 2.70$, $p < .005$.[1]

Combined analysis. To directly demonstrate that the orthographic distinctiveness patterns were significantly altered by the salience of the categorical information, we analyzed free recall with an analysis of variance in which orthographic distinctiveness (OC vs. OD) and category structure (unstructured lists—Experiment 1A vs. structured lists—Experiment 1B) were between-subjects factors. In general, OC words were better recalled than OD words, $F(1, 88) = 6.25$, $p < .05$, $MSE = .014$, $\eta_p^2 = .15$, and categorically structured lists produced better recall than unstructured lists, $F(1, 88) = 33.65$, $p < .001$, $MSE = .014$, $\eta_p^2 = .30$. The interaction was significant, $F(1, 88) = 9.20$, $p < .01$, $MSE = .014$, $\eta_p^2 = .09$, indicating that the OC recall advantage was limited to the categorized list (Experiment 1B; see Figure 1). Simple effects tests also revealed that the benefit of category structure for recall was significant in the OD condition, $F(1, 88) = 4.01$, $p < .05$, $d = .59$, as well as the OC condition, $F(1, 88) = 37.39$, $p < .001$, $d = 1.81$.

Orienting responses. We examined the accuracy and latencies to the category orienting questions (Experiment 1B). OC words displayed a slightly higher proportion of correct responses than OD words ($M = .94$ and .92, respectively), $t(44) = 2.12$, $p < .05$, $d = .63$, and were responded to more quickly than OD words ($M = 755$ and 864 ms, respectively), $t(44) = 3.54$, $p < .001$, $d = 1.04$.

Discussion

Experiment 1B represents the first evidence reported in the literature of which we are aware of distinctiveness-related decrements in free recall. No differences emerged in free recall when the OC and OD word were presented in categorically unstructured lists (Experiment 1A), replicating previous results with pure OC and OD lists (Hunt & Elliot, 1980; McDaniel et al., 2011. However, when salient category information was available (Experiment 1B), the OC condition appeared to use this information well (as indicated by ARC scores), driving OC free recall scores higher (relative to the nonsalient category condition in Experiment 1A). In fact, imposing a salient category structure doubled the free recall performance for OC lists. The addition of a salient category

[1] ARC could not be computed for 2 participants in the OD group because they did not recall multiple members of any categories.

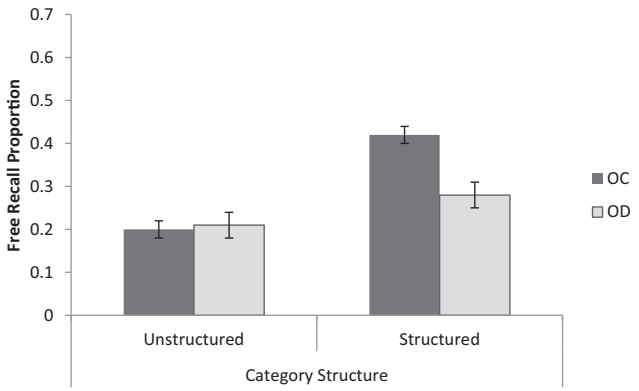

Figure 1. Mean proportion correctly recalled in unstructured (Experiment 1A) and structured (categorically structured; Experiment 1B) lists of orthographically common or distinct items. Error bars represent the standard error of the mean. OC = orthographically common word lists; OD = orthographically distinct word lists.

structure had a significant but much smaller impact on OD recall, and consequently, under conditions of a salient category structure, recall for OD lists was significantly impaired, relative to OC lists. One possible explanation for this impairment may hinge on the slower orienting-task response latencies to the OD words. For OD words, perhaps there was insufficient time remaining after the orienting response to appreciate the category information embedded in the list. We reexamine this possibility following Experiment 2.

However, a note of caution must be presented at this point. The OC and OD lists potentially differed on aspects other than their orthography. The OC and OD words did not differ significantly on word frequency, but the OC words still had nominally higher frequency than OD items (and a Bayesian analyses showed only weak support for the null hypothesis that OC and OD words had equivalent frequency, P_{BIC} (H_0|D) = .64). Moreover, it is possible that other nonorthographic differences exist between the OC and OD words, and these could have contributed to the pattern of results in Experiment 1B. For example, the OC words might be better category representatives than the OD words. Perhaps favoring this possibility, the category-orienting decisions for the OC words were faster than for the OD words. Accordingly, distinctiveness per se might not have been the reason for better use of category information in the OC condition. Rather, the category structure may have disproportionately benefitted the OC words simply because the words in the OC condition were better tied, semantically, to the imposed category structure. The posited superior linkages of OC items to the category structure could be because of prior knowledge, because of slightly more time to rehearse these links (after entering the category decision), or both. Experiment 2 was designed to rule out these alternative, and less interesting, interpretations of the Experiment 1 results.

Experiment 2

In Experiment 2, we set out to verify that the recall (and clustering) differences in Experiment 1B were driven by orthography rather than differences on semantic dimensions. We replicated Experiment 1B, using the same procedure and words, with the only change being that we presented all of the words in capital letters, following Hunt and Elliot (1980, Experiment 2). Crucially, this shift from lower-case to capital letters has no impact on semantic factors such as word frequency or category representativeness; orthography was the only dimension that was altered. If this manipulation, which muted the orthographic differences between the OC and OD lists, were to eliminate the recall differences seen in Experiment 1B, support would be provided for the interpretation that Experiment 1B results were driven by orthographic distinctiveness. Conversely, if this change in orthography did not alter the pattern of results from Experiment 1B, this result would indicate that nonorthographic characteristics, such as frequency or category representativeness, may have produced the recall advantage for the OC lists in Experiment 1B.

Method

Participants and design. Participants were randomly assigned to the conditions of a two-group between-subjects experimental design, with orthographic distinctiveness as the independent variable. Experiment 2 included 48 Washington University students (n = 23 for the orthographically distinct condition and n = 25 for the orthographically common condition). The experiment lasted approximately 30 minutes, and participants were compensated with either $5 or course credit.

Materials and procedure. Materials and procedure for Experiment 2 were identical to those in Experiment 1B, except that all words were presented in capital letters during list presentation.

Results

In contrast to Experiment 1B, the OC (M = .39, SE = .02) and OD (M = .36, SE = .02) conditions did not differ significantly on free recall, $t(46)$ = .87, $p > .35$. Also, category clustering (ARC) scores did not differ between the OC (M = .51, SE = .05) and OD (M = .45, SE = .06) conditions, $t(46)$ = .69, $p > .45$, and these scores were significantly higher than zero for both the OC condition, $t(24)$ = 9.70, $p < .001$, and the OD condition, $t(22)$ = 7.75, $p < .001$. Bayesian analyses indicated positive support for the null for both the free recall and ARC outcomes, P_{BIC} (H_0|D) = .82 and P_{BIC} (H_0|D) = .84, respectively.

Orienting responses. The proportion of correct responses was nearly identical to that found in Experiment 1B, with slightly higher accuracy displayed for the OC words than for the OD words (M = .93 vs. .91, respectively, $t(46)$ = 1.31, $p > .10$). Also, as in Experiment 1B, OC words were responded to more quickly than OD words (M = 824 and 904 ms, respectively), $t(46)$ = 2.61, p = .01, d = .75.

Discussion

Changing orthography by capitalizing all words altered the pattern of results from that found in Experiment 1B. If the Experiment 1B results were driven by semantic characteristics such as word frequency or category representativeness, muting differences in orthographic distinctiveness between lists (by presenting words in capitalized letters) should not have led to a different pattern of results from that found in Experiment 1B. However, capitalizing

the words in the OC and OD lists completely eliminated the recall and clustering differences shown in Experiment 1B, supporting the idea that the distinctive orthography was the critical feature that impaired the use of category information and free recall performance of the OD lists in Experiment 1B.

Although Experiment 2 pinpoints orthography as the cause of the pattern (in Experiment 1B), the mechanism by which distinctive orthography disrupts the use of category information remains unclear. One tentative idea suggested in the previous discussion was that the increased response latencies to the category orienting questions for OD relative to OC words disadvantaged OD words in terms of allowing extra time (within the 2 s presentation interval) to consider category information. This idea is also disconfirmed by the present pattern. When the words were presented in capital letters, OD words still showed significantly slower response times, yet the levels of recall and clustering for OD words were not compromised relative to OC words.

Experiment 3

The findings thus far are consistent with the theoretical possibility outlined earlier that distinctiveness can disrupt the use of relational information, even salient relational information such as categorical information, during free recall. This disruption has typically been assumed to be limited to order information (e.g., lower input-output correspondences in recall or flatter conditional response probability curves, which assess the probability that adjacent items will be recalled; McDaniel et al., 2011), but the current results are novel in demonstrating that the disruption can extend to category information (e.g., ARC; Experiment 1B). However, the preceding experiments could not distinguish between the two views developed in the introduction. From the relational disruption view, the distinctiveness of items enhances encoding of item-specific information at the expense of relational (e.g., categorical) information. Encoding of relational information is thus disrupted, thereby providing only impoverished relational features for use at retrieval. But the Experiment 1B results could also be interpreted from a distinctiveness retrieval priority account: OC and OD lists may afford the same encoding of relational information (especially when the encoding tasks orient participants to the categorical information), but the two types of lists may encourage different retrieval strategies. With OC lists, which have no other salient cues, individuals may rely on the category structure to guide retrieval, and the use of this category structure boosts recall. With OD lists, in contrast, the visually distinct features of the items may be so salient that individuals utilize these features at retrieval and rely less on the category structure. This priority on distinctiveness during retrieval, rather than an encoding deficit for the categorical information, could potentially explain the relatively poor recall (and clustering) for OD lists.

In Experiment 3, we kept the encoding conditions exactly the same as used in Experiment 1B, but we slightly altered the recall procedure. At the top of the free recall sheets, we provided a list of all the categories that participants had seen during list presentation. Participants were not explicitly told to recall the words clustered by category, but it was expected that the salient category information present throughout retrieval would strongly encourage all participants to use a category-based retrieval strategy. We reasoned that if the poor use of category information for OD lists was the result of an inefficient, distinctiveness-based retrieval strategy, then the provision of this salient category information at retrieval would shift OD participants to a category-based retrieval strategy and boost recall, perhaps even above that of OC participants (because of the enhanced item-specific encoding in the OD condition). Thus, elimination or reversal of the OC recall advantage found in Experiment 1B in this new retrieval context would support a retrieval account of the OD effects reported in Experiment 1B.

By contrast, if OD lists result in poorer encoding of category information (i.e., weaker links between item and category or weaker links between categorically related items), then the salient category information at retrieval should have little impact on recall for OD lists even if it does encourage OD participants to use a category-based retrieval strategy. Thus, replication of the Experiment 1B pattern in this new retrieval context would imply that the negative effects of OD on recall of pure, categorically structured lists rest on an encoding deficit.

Method

Participants and design. Participants were randomly assigned to the conditions of a two-group between-subjects experimental design, with orthographic distinctiveness as the independent variable. Experiment 3 included 48 Washington University students ($n = 24$ for the orthographically distinct condition, and $n = 24$ for the orthographically common condition). The experiment lasted approximately 30 min, and participants were compensated with either $5 or course credit.

Materials and procedure. Materials and procedure for Experiment 3 were identical to those in Experiment 1B, except that the names of the eight categories were listed at the top of the recall sheet.

Results and Discussion

The levels of recall were significantly lower for the OD condition ($M = .37$, $SE = .03$) than for the OC condition ($M = .50$, $SE = .04$), $t(46) = 2.59$, $p < .05$, $d = .75$. In contrast to Experiment 1b, however, ARC scores were equivalent between OC ($M = .46$, $SE = .09$) and OD ($M = .54$, $SE = .09$) lists, $t(46) = .84$, $p > .50$. A Bayesian analysis indicated positive support for the null, $P_{BIC}(H_0|D) = .84$. ARC scores were significantly above zero for the OC condition, $t(23) = 6.21$, $p < .001$, and the OD condition, $t(23) = 5.12$, $p < .001$.

As demonstrated by the ARC scores, our modified recall procedure (providing category labels during recall) successfully pushed the OD group toward a category-based retrieval strategy. Unlike in Experiment 1B, the OC and OD groups showed nonsignificantly different clustering, indicating that the retrieval strategy of the two groups was similar in terms of relying on the categorical information to guide recall. If differences in retrieval strategy (distinctiveness priority at retrieval) were the only factor underlying the recall differences between OC and OD lists in Experiment 1B, then the reliance on the category information to guide recall in Experiment 3 should have resulted in recall for OD lists that was at least equivalent, if not superior, to recall for OC lists.

Contrary to the distinctiveness retrieval priority view, however, even in the face of equated clustering, the OC recall advantage in

the present Experiment 3 was almost identical to that found in Experiment 1B. This pattern strongly suggests that the OC recall advantage in categorized lists was not a function of retrieval strategy differences between OC and OD lists. Instead, OD lists may impair the encoding of relational information, rather than its use at retrieval. To further illuminate this impairment in relational encoding, we tabulated two additional measures of recall: the proportion of categories for which at least one word was recalled (labeled *category access*) and the average number of words (out of four possible) recalled from each category (for categories from which at least one word was recalled). The category access score can be taken as an index of category—item relations (vertical organization, cf. Roediger, 1973; Rundus, 1973), and the number of items per category likely reflects, at least in part, relations among the particular items within a category (horizontal organization; Rundus, 1973). Category access did not significantly differ across the OD and OC conditions ($M = 6.33$ and 6.96, respectively, $t(46) = 1.66$, $p > .10$). However, the Bayesian analysis showed only weak support for the null, $P_{BIC}(H_0|D) = .63$. Fewer words per category were recalled in the OD ($M = 1.87$) than the OC condition ($M = 2.22$), $t(46) = 2.37$, $p < .05$. These patterns suggest that orthographic distinctiveness may impair encoding of linkages between items within a category (for at least some items, as the items per category index has also been interpreted as reflecting item-specific processing).[2] We expand on this conclusion in the General Discussion.

Orienting responses. The proportion of correct responses was significantly higher for OC words than for the OD words ($M = .94$ vs. .88, respectively, $t(46) = 2.67$, $p = .01$, $d = .77$). Also, as in the previous experiments, OC words were responded to more quickly than OD words ($M = 774$ and 879 ms, respectively), $t(46) = 3.10$, $p < .01$, $d = .89$.

General Discussion

The benefits of orthographic distinctiveness for improving memory, especially with regard to free recall, have been well documented in the literature (Geraci & Rajaram, 2002; Hunt & Elliot, 1980; Hunt & Mitchell, 1978, 1982; Hunt & Toth, 1990; McDaniel et al., 2011). It has also been established that the orthographic distinctiveness effect in free recall is eliminated in pure lists of OD and OC words (Hunt & Elliott, 1980; Hunt & Mitchell, 1982; McDaniel et al., 2011). The present experiments demonstrated for the first time that orthographic distinctiveness impairs recall (Experiments 1B and 3) under conditions in which the word lists are categorically structured. Moreover, the impairment is robust, reflecting a large effect size. Not only is this a novel finding, but from several theoretical perspectives this negative orthographic distinctiveness effect is quite curious.

One perspective hinges on the established principle that optimal free recall is supported by both relational and item-specific information (Einstein & Hunt, 1980; Hunt & Einstein, 1981; Hunt & McDaniel, 1993). Given that categorically structured lists provide robust relational information (Einstein & Hunt, 1980; Hunt & Einstein, 1981; Masson & McDaniel, 1980; McDaniel & Masson, 1977) and orthographically distinct words stimulate rich item-specific encodings (Hunt & Elliot, 1980; McDaniel et al., 2011), categorized lists of OD words would seem to reflect an optimal condition for producing high levels of free recall. Instead, however, categorized OD word lists were recalled significantly less well than categorized OC word lists. It is important to note this pattern cannot be discounted because of potential artifacts. The particular word stimuli in the current experiments produced the standard finding of equivalent recall for OD and OC pure lists when the categorical relations among the words were not salient (Experiment 1A). Another potential artifact could be that the orthographically distinct items were substantially less representative of the categories than were the orthographically common items, thereby putting the orthographically distinct items at a disadvantage in the categorized lists. This was not the case, however, because when the words were presented in capital letters (eliminating differences in orthographic distinctiveness) there was no significant difference in free recall or in category clustering across the two types of word lists (Experiment 2; see Hunt & Elliot [1980], Experiment 2, for a similar free recall pattern with mixed lists).

Another extant theoretical account of orthographic distinctiveness is that orthographically unusual items are processed as distinct only when set against the background of common items (Hunt & Elliot, 1980). According to this view, orthographically distinct items lose functional distinctiveness when all of the items in the list share this distinctiveness. Thus, pure distinct lists and pure common lists are processed similarly, resulting in equivalent recall. In line with this account, Hunt and Elliott (1980) reported no significant difference in "weirdness" when OD and OC words were rated in pure lists. On this view, pure categorized lists would also be expected to demonstrate equivalent recall of OD lists and OC lists, again because each would be processed similarly. Therefore, the impaired recall performance for distinctive items relative to common items in the categorized lists (for lower case presentations) is also surprising from this perspective. This finding in conjunction with Hunt and Elliot's reported ratings may suggest that though OD and OC pure-list items become more subjectively similar, the objective lexical distinctiveness (nonsemantic features) of OD items—as indicated by orthographic-neighborhood sparseness—creates some disruption of category (semantic) processing.

The current negative effect of orthographic distinctiveness on recall of categorized lists may at first blush appear consistent with the negative generation (Burns, 1990) and negative testing effects (Mulligan & Peterson, 2015). In this general paradigm, target words from several categories are preceded by rhyming words. In the generation paradigms, the targets must either be generated (the initial letter of the word is usually provided) or are read. In the testing-effect paradigms, after an initial study session (all items are presented, along with the rhyme cue words), the list is presented for restudy or the rhyme words are presented and the participants must recall the associated target item. In both cases, generation or retrieval of the target item produces impaired free recall relative to the read or restudy conditions, and this recall impairment is accompanied by reduced category clustering in recall. Thus, not unlike the present negative effects of orthographic distinctiveness, focusing on a nonsemantic dimension of the word during generation or retrieval interferes with processing categorical information that would help support good free recall.

[2] We thank Reed Hunt for this observation.

Noteworthy, however, is that in the generation and testing paradigms, the read and restudy conditions demonstrate significant category clustering, suggesting that in these ordinary study conditions the rhyme cue does not obscure processing of the categorical relations among the words. In the present paradigm, the orthographically distinctive items were studied in a standard manner (i.e., not generated or retrieved); moreover, the orienting task, rather than emphasizing nonsemantic features (i.e., rhyme features in the negative generation and testing paradigms), focused directly on categorical features of the words. Yet even under these optimal study conditions, conditions that ordinarily would encourage encoding the categorical structure of the list items, orthographic distinctiveness resulted in impairments in use of category information to support free recall and concomitant reduction in overall free recall levels.

Orthographic Distinctiveness Disrupts Encoding of Relational Information

As developed in the introduction, the impairment in category processing produced by orthographic distinctiveness could relate to either the initial encoding of the categorical information or the use of categorical information at retrieval. Given that the orienting task focused attention on the categorical information, thereby presumably prompting encoding of that information, the free recall and clustering decrements for orthographically distinct lists (Experiment 1B) seemed to suggest that distinctiveness disrupted reliance on category information at retrieval. Experiment 3 indicated, however, that when category cues were provided during recall, participants were equally likely to rely on categorical information for orthographically distinct as for orthographically common lists (as indicated by comparable and significant category clustering). Critically, though, even when participants relied on categorical information during retrieval, there was a significant decline in recall for orthographically distinct lists, relative to common lists. This pattern implies that categorical information was not as robustly encoded for the distinct items as for the common items, and therefore was less available (than for common items) for supporting recall.

Theoretically, two kinds of disruption to categorical encoding could occur. Orthographic distinctiveness might have disrupted encoding of the inter-item associations for instances from the same category (horizontal organization; Rundus, 1973), the category label-instance associations (vertical organization), or both. Our analyses in Experiment 3 provided initial insights into these possibilities. The number of categories for which at least one word was recalled did not significantly differ for orthographically distinct and common lists suggesting that category-label instance associations may not have been disrupted for orthographically distinct items.[3] This conclusion must be considered tentative, however, given only weak support for the null finding from the Bayesian analysis. The average number of words per category was reduced for orthographically distinct relative to common lists, implying a disruption in the inter-item associations for words within a category.

Another question is why, even with a category orienting task, orthographically distinctive items impair categorical encoding. One idea might be that unusual items that draw attention to item-specific information generally attenuate the processing of category structure. Extant findings are not consistent with this general disruption view. Encoding and use of categorical information are not disrupted when low frequency words (i.e., atypical words) are presented in categorized pure lists or when words are presented as word fragments (an unusual presentation). And for both low frequency words and generated items, significant benefits to free recall are observed when these items are presented in categorized pure lists, relative to high frequency and read words, respectively (Merritt et al., 2006; McDaniel et al., 1988; Nairne et al., 1991), A more specific disruption hypothesis may be more accurate: Orthographic distinctiveness reflects information related to a nonsemantic dimension, whereas categorical information relates to a semantic dimension. Perhaps the processing of the nonsemantic distinctive information (orthography) disfavors or interferes with full extraction of the information on semantic dimensions, such as the features reflected in categorical information. If so, it remains possible that with sufficient encoding time, learners could completely process the categorical information in structured lists of orthographically distinct words.

However, our tentative conclusion that orthographically distinct items create a disruption in encoding of inter-item associations within a category is in line with previous findings that orthographic distinctiveness disrupts encoding of serial order information (McDaniel et al., 2011), another kind of inter-item association (temporally rather than categorically based). The present findings thus converge with the conclusion that orthographic distinctiveness broadly disrupts encodings of inter-item associations within a list, perhaps because orthographic distinctiveness stimulates focus on individual-item information. Though enhanced individual-item encoding (distinctiveness) may promote a range of memory benefits (see Hunt & McDaniel, 1993), it now appears that orthographically distinct items may exact a cost to memory of functionally important inter-item relations.

[3] The number of categories accessed was only examined in Experiment 3 because the interpretation would have been ambiguous in Experiments 1B and 2. In Experiments 1B and 2 categories were not presented during free recall so non-accessed categories could indicate either that the category itself was accessed but none of the items could be retrieved or that the category itself was never accessed. In Experiment 3, categories were provided, so a non-accessed category unambiguously indicates a failure to retrieve any items from an available category (i.e., a disruption of vertical organization).

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