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How does knowledge promote memory? The distinctiveness theory of skilled memory ☆

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Abstract

The robust effects of knowledge on memory for domain-relevant information reported in previous research have largely been attributed to improved organizational processing. The present research proposes the distinctiveness theory of skilled memory, which states that knowledge improves memory not only through improved organizational processing but also through more effective processing of differences between items in the context of the similarity defined by organization. Individuals with either high or low knowledge about NFL football were presented with lists containing items from the target domain (NFL football) or a control domain (cooking). Individuals either performed a category sorting task, a pleasantness rating task, or both. Results on a surprise free recall test later showed knowledge effects on memory (high knowledge individuals had greater recall than low knowledge individuals for football items but not for cooking items). Secondary measures established that the knowledge effect on memory was due not only to better organizational processing but also to more effective item-specific processing.

Keywords: Skilled memory; Organizational processing; Distinctive processing; Distinctiveness theory; Knowledge; Expertise

Introduction

Individuals who have high knowledge (HK) within a domain can show remarkable levels of memory for domain-relevant information. For example, chess grandmasters correctly recalled the location of 25 pieces after a five-second presentation of an in-progress chess game (de Groot, 1966; Chase & Simon, 1973). The memory advantage of HK individuals over low knowledge (LK) individuals has also been shown for domain-relevant information as wide-ranging as dinner or drink orders (Ericsson & Polson, 1988; Huet & Mariné, 2005), architectural drawings (Akin, 1982), sporting events (Spilich, Vesonder, Chiesi, & Voss, 1979), city street names (Kalakoski & Saariluoma, 2001), and computer program code (McKeithen, Reitman, Rueter, & Hirtle, 1981).

The most common assumption of contemporary theories of skilled memory is that knowledge improves

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memory by supporting more effective organizational processing (e.g., Ericsson & Kintsch, 1995, 2000; Gobet, 2000; Gobet & Simon, 1996). For example, according to long-term working memory (LTWM) theory (Ericsson & Kintsch, 1995), individuals with high knowledge are able to use organized knowledge structures (referred to as retrieval structures) to quickly and reliably encode information into long-term memory and subsequently to quickly and reliably access that information from long-term memory. Template theory (Gobet & Simon, 1996), formulated primarily to account for skilled memory within the domain of chess, also assumes that skilled memory depends on the use of organized knowledge structures. According to template theory, these knowledge structures can range from clusters (containing the location of several chess pieces in a commonly occurring pattern) to templates (containing information about fixed locations of around 10–12 pieces, with slots that may be filled with other pieces or clusters in variable locations on the board) to retrieval structures (to organize templates when more than one board configuration must be remembered).

However, Hunt and McDaniel (1993) have noted "a weak link in the chain of organizational theory ... How is organization unpacked at retrieval to provide access to the elements?" (p. 423). Although theories of skilled memory focus heavily on the contribution of domain knowledge to organizational processing, organization alone will seldom be sufficient to support skilled memory. Thus, although we agree that organizational processing plays a key role in skilled memory, we argue that theories of skilled memory that focus only on organizational processing are incomplete.

In the current work, we propose and test the *distinctiveness theory* of skilled memory. According to distinctiveness theory, knowledge promotes memory by supporting more effective *distinctive processing* of domain-relevant information. Distinctive processing is "the processing of differences among elements that are similar on some dimension ... That is, distinctive processing is not the absolute processing of differences but is processing that marks something as different from other things that are related on some dimension" (Hunt, 2003, p. 812). Distinctive processing thus involves two basic mechanisms. First, distinctive processing involves *organizational processing* of higher-order feature dimensions or category superordinates that define similarities among items, which can later be used to effectively guide memory search at retrieval. Second, distinctive processing involves *item-specific processing* of the properties that uniquely specify a particular item within a category and distinguish it from otherwise similar or related items (Einstein & Hunt, 1980; Hunt, 2003; Hunt & Einstein, 1981). Together, the two processes yield a potent combination—distinctiveness—that supports memory (a) by increasing the likelihood of accessing an appropriate memory search set and (b) by increasing the discrimination of target items within the set from one another and from related, non-target items.

In sum, whereas previous theories of skilled memory have primarily assumed that knowledge leads to better memory by supporting more effective organizational processing, we propose that knowledge leads to better memory by supporting more effective distinctive processing. Note that these two theoretical approaches share a part–whole relationship: according to distinctiveness theory, organizational processing is a necessary part of skilled memory, but the whole arises when differences in the context of that similarity are also effectively encoded. Thus, distinctiveness theory is not a rejection of organization-based theories of skilled memory. Rather, it represents an important extension of these earlier theories by claiming that the potency of organizational processing in skilled memory depends on effective item-specific processing in the context of that organization.

Basic research on distinctive processing

The distinctiveness theory of skilled memory is motivated by a wealth of research in the basic memory literature that has firmly established the effects of distinctive processing on memory (e.g., Begg, 1978; Einstein & Hunt, 1980; Epstein, Phillips, & Johnson, 1975; Hunt, 2003; Hunt, Ausley, & Schultz, 1986; Hunt & Einstein, 1981; Hunt & McDaniel, 1993; Hunt & Smith, 1996). For example, Hunt and Einstein (1981; Einstein & Hunt, 1980) presented individuals with a word list containing six words from each of six taxonomic categories (e.g., fruits, animals) intermixed in random order. One group sorted the items into taxonomic categories (to encourage organizational processing), another group rated the pleasantness of each item (to encourage item-specific processing), and a third group performed both tasks. Surprise free recall and recognition tests were then administered.

Regarding the effects of distinctive processing on memory, free recall was greater for the group performing both orienting tasks than for the groups performing either task alone. This pattern obtained even when controlling for processing time on the items (by having a subset of participants perform the same task twice), indicating that the effects of performing both organizational and item-specific processing—i.e., distinctive processing—were qualitative and not merely quantitative differences in the amount of processing time. As important, the two orienting tasks showed differential effects on secondary measures of memory. Clustering in recall (i.e., the extent to which items from the same taxonomic category were output together during recall) was greater for individuals who performed the sorting task than for individuals who performed the pleasantness rating task, consistent with the idea that organizational processing leads to the development of superordinate dimensions or categories that later guide retrieval search. In contrast, recognition test performance was greater for individuals performing the pleasantness rating task than for individuals performing the sorting task, consistent with the idea that item-specific processing supports the discrimination of target items from similar non-target items. An increasing amount of research has since replicated and extended these findings, establishing that organizational and item-specific processing make unique contributions to memory and that the two together support the highest levels of memory overall.

Distinctive processing in skilled memory

Of course, organizational processing depends on having and using knowledge of shared features or categories that define similarities among items and that will define an appropriate search set at retrieval. Similarly, item-specific processing depends on having and using knowledge of individual item characteristics that differentiate items within the search set from one another. Importantly, individuals may differ in the quantity or quality of knowledge they bring to bear in organizational and item-specific processing of items in different domains.

For example, one could organize *Denver Broncos, Carolina Panthers*, and *Chicago Bears* under the category of "things that exist on planet Earth". Although true, this category superordinate would do little to constrain the set of items to be searched at retrieval. More effective superordinates include "sports teams", "football teams", or "professional American football (NFL) teams". However, the extent to which an individual can employ one of these more effective categories will depend upon their level of knowledge. Whereas an avid NFL follower would be able to use the more effective category "NFL teams", someone less sports-savvy might be limited to the less constraining "sports teams" category.

Likewise, during item-specific processing, one could encode that *Denver Broncos* contains the letter "d". However, even if the search set was constrained to NFL teams, the letter "d" is not particularly diagnostic, because 11 other NFL team names include the letter "d" (and countless sports team names more generally). More diagnostic information would include "a team in the AFC West Division" (one of four) or "the leader of the AFC West" (one of one). Importantly, the extent to which an individual can encode information about an item that is highly diagnostic in the context of similarity shared with other items will depend on their level of knowledge. Given the potent combination of "the NFL team who leads the AFC West", our NFL fan would be much more likely to later recall *Denver Broncos* than would our non-enthusiast armed with "a sports team with the letter 'd' in its name".

Although simplistic, this example is intended to illustrate how the effectiveness of organizational and item-specific processing can vary depending on the kind of knowledge available during processing. We assume that HK individuals possess both more effective organizational knowledge and more effective item-specific knowledge than LK individuals.[1] As mentioned above, the contribution of domain-relevant knowledge to organizational processing has long been recognized in the literature on skilled memory. In contrast, scant research has investigated the extent to which knowledge effects on memory are also attributable to item-specific processing, or to distinctive processing more generally. To our knowledge, only one recent study has directly explored the role of distinctive processing in skilled memory. Van Overschelde, Rawson, Dunlosky, and Hunt (2005) used the isolation paradigm (e.g., Hunt, 1995; von Restorff, 1933), in which a target item either differs from other to-be-learned list items along one key dimension (i.e., an isolate list) or is similar to other to-be-learned list items along that key dimension (i.e., a homogeneous control list). The standard finding is that memory for the target is greater when presented in the isolate list versus the homogeneous control list, presumably because the isolate list supports the processing of item-specific information about the target that is diagnostic of that item in the organizational context of the list.

Van Overschelde et al. presented individuals who had either high or low knowledge about NFL football either with an isolate list containing nine NFL teams and one college team (the target) or a homogeneous control list containing 10 college teams (the target plus nine other college teams). HK individuals' recall of the target was greater when presented in the isolate list versus the

[1] Note that our claim that LK individuals have less effective organizational and item-specific knowledge does not imply that LK individuals know nothing about the items (i.e., that domain items are nonsensical or completely meaningless to LK individuals). Rather, LK individuals have minimal knowledge about the *domain-relevant* meanings of items. For example, the items used here include football team names, such as *Miami Dolphins*. LK individuals almost certainly know what Miami is and what dolphins are, and they are likely even to infer that *Miami Dolphins* refers to a sports team of some sort. What LK individuals are unlikely to know are the domain-relevant features that *Miami Dolphins* shares with other teams on the list and the domain-relevant features that make *Miami Dolphins* unique from other items along that dimension of similarity. LK individuals may detect similarities and differences among items on the list (e.g., team names refer to a place and an animal, but some of the places are cities and some are states, and some of the animals are birds and some are not), but these will not be as effective for promoting memory as domain-relevant dimensions of similarity and difference.

homogeneous control list. In contrast, LK individuals' recall of the target did not significantly differ when presented in the isolate list versus the homogeneous control list. When processing the isolate list, HK individuals were presumably able to recognize the difference between the target college team and the NFL teams, whereas LK individuals were not. That is, HK individuals engaged in distinctive processing of the target item in the isolate list, whereas LK individuals only engaged in organizational processing. However, given that only one experiment has directly investigated the role of distinctive processing in skilled memory, further research is clearly needed to provide more conclusive support for distinctiveness theory of skilled memory.

Accordingly, the present research further tested the distinctiveness theory of skilled memory by adapting the basic method used by Hunt and Einstein (1981; Einstein and Hunt, 1980). This method allows a clearer demonstration of the separate contributions of item-specific and organizational processing to skilled memory than the isolation paradigm used in Van Overschelde et al. (2005). In two experiments, individuals with either high or low knowledge about NFL football were presented with a list of items drawn from taxonomic categories either from the domain of NFL football or from an unrelated control domain (cooking), to establish that any differences observed in memory between HK and LK individuals in the NFL domain were due to differences in domain-specific knowledge rather than to domain-general differences in memory abilities or strategies. Individuals in each knowledge group sorted the items into taxonomic categories, rated the pleasantness of each item, or performed both tasks. They then took a surprise free recall test after a short filled delay and a recognition test one day later.

Predictions of the distinctiveness theory

This orienting-task method yields a rich data set that affords examination of several measures of interest. For some measures, the distinctiveness theory shares predictions with organization-based theories. However, several key patterns are uniquely predicted by the distinctiveness theory. Before reporting the experiments, we briefly overview these measures of interest and outline the predictions that follow from the distinctiveness theory.

Free recall

First, we examined overall levels of free recall to establish the basic knowledge effects on memory that have been shown in a wealth of previous research. Specifically, HK individuals were predicted to recall more domain-relevant information (i.e., the football items) than LK individuals, whereas HK and LK individuals were not predicted to differ in recall of domain-irrelevant information (i.e., the cooking items). This prediction follows from all theories of skilled memory and is not unique to distinctiveness theory.

In contrast, the distinctiveness theory makes unique predictions for the effects of orienting task on recall. According to this theory, the overall knowledge effect on recall is due not only to better organizational processing but also to better item-specific processing. If so, then recall will be greater for HK individuals who complete both the sorting task and the pleasantness rating task (i.e., who are encouraged to process both organizational and item-specific information) than for HK individuals who perform only sorting or only pleasantness rating. The prediction for the sorting versus pleasantness rating groups is somewhat less straightforward. On one hand, the pleasantness rating group is not overtly encouraged to engage in organizational processing. On the other hand, findings reported in the basic memory research on distinctive processing described above (e.g., Einstein & Hunt, 1980; Hunt & Einstein, 1981) suggest that individuals spontaneously engage in some organizational processing when presented with lists of items from familiar taxonomic categories (such as *fruit* or *vehicles*, as opposed to ad hoc categories such as *things that are green*). Thus, HK individuals given only pleasantness rating task instructions may nonetheless recognize categorical relationships among items and spontaneously engage in organizational processing. If so, they will benefit from combination of this covert organizational processing and the item-specific processing overtly encouraged by the pleasantness rating task. Thus, the distinctiveness theory predicts that HK individuals who only perform the pleasantness rating task will outperform those who only perform the sorting task.

These predictions of the distinctiveness theory contrast with those of the organization-based theories. If knowledge effects on memory are primarily driven by organizational processing, one would not expect recall to differ as a function of whether the pleasantness rating task is performed. If anything, one would expect HK individuals who only perform the pleasantness rating task to be at a disadvantage relative to the other two groups who are overtly encouraged to engage in organizational processing.

Measures of organizational processing

To establish the separate contributions of organizational and item-specific processing, we also examined four secondary measures. The two measures of organizational processing were category access (i.e., the percentage of categories from which at least one item is recalled) and clustering in recall, both of which have been shown to increase in study conditions that support organizational processing (e.g., Einstein & Hunt, 1980; Hunt & Einstein, 1981; Hunt et al., 1986; Hunt & McDaniel, 1993; Lorch & Lorch, 1995, 1996; Rawson

& Kintsch, 2002). Thus, although no measure provides a pure indication of just one cognitive process, category access and clustering are thought to primarily reflect the extent to which information is organized around categorical superordinates in memory and the extent to which those category superordinates are then used to guide search at retrieval.

We predicted that HK individuals would outperform LK individuals on these measures for the football categories but not for the cooking categories (cf. Claessen & Boshuizen, 1985; Huet & Mariné, 2005). For proper emphasis, however, we should note that these measures are of lesser concern for present purposes, given that the role of organizational processing in skilled memory is widely assumed. Additionally, organization-based theories and distinctiveness theory make the same predictions for these measures, and thus their examination is not particularly useful for testing the distinctiveness theory. Accordingly, we report these measures for purposes of completeness but consider them only briefly in subsequent results and discussion sections.

Measures of item-specific processing

Of greater interest are the other two secondary measures, the number of items recalled from each accessed category (referred to as *items per category accessed*, or IPCA) and recognition. These two measures have been shown to increase in study conditions that support item-specific processing (e.g., Dobbins, Kroll, Yonelinas, & Liu, 1998; Einstein & Hunt, 1980; Gruppuso, Lindsay, & Kelley, 1997; Hunt, 2003; Hunt & McDaniel, 1993; Lorch & Lorch, 1995, 1996). Thus, IPCA and recognition are assumed to reflect the extent to which individuals can differentiate target items from one another and from related, non-target items within an accessed search set.

The key prediction of the distinctiveness theory is that performance on the item-specific processing measures will be greater for HK individuals than for LK individuals, but only within the knowledge domain (i.e., HK individuals will outperform LK individuals for football items but not for cooking items). Relatively few studies have examined recognition performance for HK and LK individuals and have produced mixed results (Brandt, Cooper, & Dewhurst, 2005; Long & Prat, 2002; Schustack & Anderson, 1979).[2] Furthermore, no studies of skilled memory have measured IPCA. Thus, in addition to testing predictions of distinctiveness theory, the present research will contribute by providing further evidence for an influence of knowledge on recognition and by introducing another measure of item-specific processing to this literature.

The distinctiveness theory also makes unique predictions for the effects of orienting task on IPCA and recognition. According to distinctiveness theory, the benefit of performing the pleasantness rating task will depend on the level of relevant knowledge, with greater gains from the pleasantness rating task predicted for HK individuals than for LK individuals, but only within the football domain. In this domain, HK individuals are better equipped with diagnostic information about the items, whereas HK and LK individuals should not differ in the extent to which performing the pleasantness rating task benefits memory in the cooking domain.[3] In contrast to predictions of distinctiveness theory, organization-based theories do not make any straightforward predictions for performance on the item-specific processing measures.

Experiment 1

Methods

Participants and design

Undergraduates ($n = 189$) participating to satisfy a course requirement in General Psychology were randomly assigned to one of three orienting task groups (sorting, pleasantness rating, or both). We analyzed data from participants who were either relatively high or low in football knowledge, as determined by performance on a post-experimental knowledge test. The knowledge domain from which to-be-remembered items were drawn (football or cooking) was a within-participant manipulation. Thus, the study involved a 3 (orienting task) $\times$ 2 (knowledge level) $\times$ 2 (item domain) mixed factor design.

Materials

Materials included 40 items, with five items from each of eight categories (four NFL football categories and four cooking categories; see Appendix A). Normative exemplar generation data were available for

[2] Brandt et al. (2005) noted that studies not finding knowledge effects on recognition typically involve text materials; these studies also typically involve immediate tests. By comparison, the present research involved item lists and a delayed test.

[3] With respect to the effects of the orienting tasks, a brief but important aside is in order. We are not claiming that the orienting tasks lead to the exclusive processing of one kind of information or another. "Individual-item information will include features shared by related words, and logically taxonomic categorization must require some determination of the individual-item characteristics" (Einstein & Hunt, 1980, p. 594). Similarly, none of the secondary measures provide a "pure" estimate of either organizational or item-specific processing, uncontaminated by the other. These predictions are thus a matter of degree rather than all-or-none.

five categories, from a recent update and extension of the Battig and Montague (1969) norms (Van Overschelde, Rawson, & Dunlosky, 2004). For these categories, we chose items with intermediate to low generation proportions (mean = .15), to avoid items with which LK individuals may be familiar. For the remaining three categories, we presented 10 undergraduates with the category names and asked them to write down items for each category. We included items on the final list that were infrequently or never generated by these pilot participants. The football knowledge test was adapted from Van Overschelde et al. (2005) and included 30 multiple-choice questions with five alternative responses (the fifth alternative was "I don't know"). The cooking knowledge test was developed and tested by Soederberg Miller (2001). The original test consisted of 20 multiple-choice questions with four alternative responses. For each question, we added a fifth "I don't know" response.

Procedures

For incidental test instructions, participants were initially told that the experiment was exploring 'how knowledge influences people's judgments about different objects, events, ideas, etc'. Participants were then given task-specific instructions according to the experimental group to which they had been assigned. A computer then presented the 40 items one at a time in a new random order for each participant. For the sorting group, eight buttons appeared on the screen below each item, displaying the names of the eight taxonomic categories and the participant clicked on a button to indicate their categorization decision. The item was then replaced with the next one, and so on until all items had been categorized. Categorization accuracy was uniformly high for both kinds of item in both knowledge groups, from 91% to 95%.

For the pleasantness rating group, five buttons appeared on the screen below each item. Each button displayed a number from 1 to 5, and the ends of the scale were labeled with the words "not at all pleasant" and "very pleasant". Participants rated how pleasant they personally thought the item was by clicking on a button. The item was then replaced with the next one, and so on until all items had been rated. For the group performing both tasks, performance of the two tasks was massed, in that they first rated the pleasantness of an item and then categorized the item before moving on to the next item.

After all items had been presented, all participants read short texts and answered questions about them for 18 min to provide a filled interval between item presentation and recall. Participants were then instructed to recall as many of the list items as possible, entering their responses into a recall field one at a time. After an item was entered, it was removed from the recall field to a display-only field. Thus, participants could examine previously recalled items, but they could not edit the order in which they generated responses.

Participants returned one day later for a recognition test, including the original 40 items plus 40 distractors (five new items from each of the eight categories). Items were presented one at a time on the computer screen, in a new random order for each participant. After the recognition test, participants completed the knowledge tests. The computer presented the questions one at a time, and football and cooking knowledge questions were presented in a fixed, intermixed order.

Results and discussion

For ease of exposition, all omnibus analyses of variance (ANOVAs) are reported in Appendix B. For paired comparisons below, we report the difference between means (M_d) and the 95% confidence interval (CI) around the difference. Because football and cooking items were not matched on various factors known to influence memory (e.g., word frequency, concreteness, category size), the absolute magnitude of performance in the two domains is not comparable. Rather, comparison of performance for HK and LK individuals within each domain is of greatest interest (i.e., performance for HK and LK individuals should differ in the football domain but not in the cooking domain). Thus, we focus analyses and discussion on the qualitative difference in the pattern of performance for HK and LK individuals between the two domains.

Knowledge tests

Individuals who correctly answered 20 or more of the 30 questions on the football knowledge test were classified as HK participants, and individuals who correctly answered 10 or fewer questions were classified as LK. All of these participants correctly answered nine or fewer questions on the cooking knowledge test. The number of HK and LK participants included in analyses for each group is reported in Table 1, along with mean scores on the football and cooking knowledge tests for each group. Table 1 also includes knowledge scores corrected for guessing (number of correct responses—the number of incorrect responses, for those questions in which participants did not select "I don't know").

Free recall

For two-word items (e.g. Baltimore Ravens, Oysters Rockefeller), responses were only scored as correct if they contained both words. Responses with minor spelling or inflection errors (e.g., "deglaze" instead of "deglazing") were counted as correct. Overall, commission

Table 1
Sample size and mean performance on knowledge tests as a function of group in Experiment 1

Orienting task	Sorting	Pleasantness	Both
High knowledge	$n = 26$	$n = 25$	$n = 25$
Football knowledge test	24.9 (.4)	25.0 (.3)	25.2 (.4)
Score corrected for guessing	19.5 (.8)	19.6 (.6)	21.0 (.8)
Cooking knowledge test	2.5 (.4)	2.6 (.5)	3.0 (.5)
Score corrected for guessing	−5.2 (.6)	−4.0 (.7)	−4.2 (.8)
Low knowledge	$n = 20$	$n = 25$	$n = 23$
Football knowledge test	6.8 (.6)	6.3 (.5)	5.3 (.8)
Score corrected for guessing	−1.3 (1.1)	−2.2 (.7)	−1.4 (.6)
Cooking knowledge test	2.0 (.3)	2.4 (.4)	2.8 (.6)
Score corrected for guessing	−5.1 (.8)	−4.6 (.8)	−4.0 (.8)

Note. Test performance is reported as percentages. Scores corrected for guessing reflect the number of correct responses—the number of incorrect responses, for those questions in which participants did not select "I don't know". Standard errors of the mean are reported in parentheses.

errors were low ($M < 1.0$), with no significant differences between groups.

Fig. 1 displays mean recall by knowledge level and item domain. Replicating previous findings that knowledge promotes memory, free recall of football items was greater for HK individuals than for LK individuals ($M_d = 32.2$, CI = 27.5, 36.9). This effect was not due to HK individuals having better memory in general, because recall of cooking items was lower for HK versus LK individuals ($M_d = 6.4$, CI = 2.1, 10.7).

Fig. 2 reports recall as a function of orienting task. As in the basic memory research, free recall was greater for individuals who performed both sorting and pleasantness ratings during encoding than for individuals who only did one or the other (e.g., Hunt & Einstein, 1981).[4] Extending beyond this research, however, we found that the extent to which the orienting tasks benefited memory depended on the level of relevant knowledge. As predicted by distinctiveness theory, for HK individuals, free recall of football items was greater for those performing both orienting tasks versus those performing the sorting task or the pleasantness rating task ($M_d = 16.4$, CI = 8.5, 24.3, and $M_d = 10.6$, CI = 2.5, 18.7). The difference between the latter two groups approached significance and favored the pleasantness rating group ($M_d = 5.8$, CI = −2.0, 13.6). In contrast, for LK individuals, free recall of football items did not significantly differ with orienting task (CIs <−3.3, >7.5). Presumably, HK individuals have more effective knowledge about the items and the categories to which they belong and thus are better able to profit from the processing encouraged by the orienting tasks.

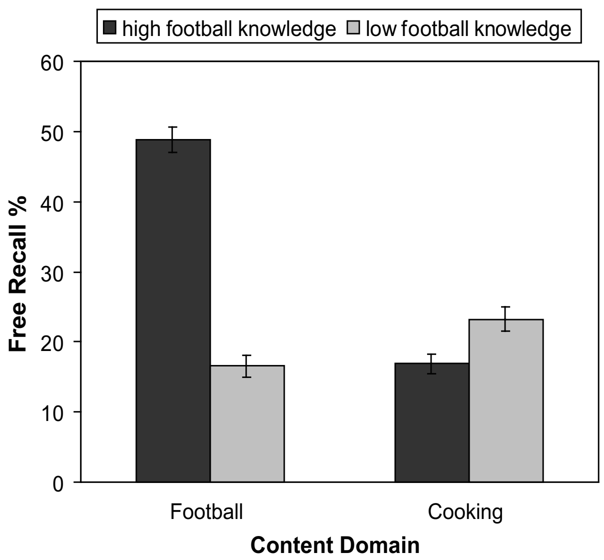

Fig. 1. Mean free recall as a function of knowledge level and item domain in Experiment 1. Error bars are standard errors.

Examination of performance in the cooking domain suggests that the benefit of pleasantness rating for HK individuals in the football domain was not due to some domain-general item-specific processing strategy. For HK individuals, free recall of cooking items did not differ significantly for the group performing both tasks versus the sorting group, and performance for the pleasantness rating group was actually lower than in either of the other two orienting task groups

[4] Items were presented for a longer time overall in the group that made both kinds of judgment than in the other two groups. However, Hunt and Einstein (1981) included comparison groups that equated for processing time on the items and found that the effects of performing both organizational and item-specific processing were qualitative and not merely quantitative differences in amount of processing time. Additionally, in the present research, performance was not always superior for individuals who performed both tasks, suggesting that time on task alone is not sufficient to account for the effects.

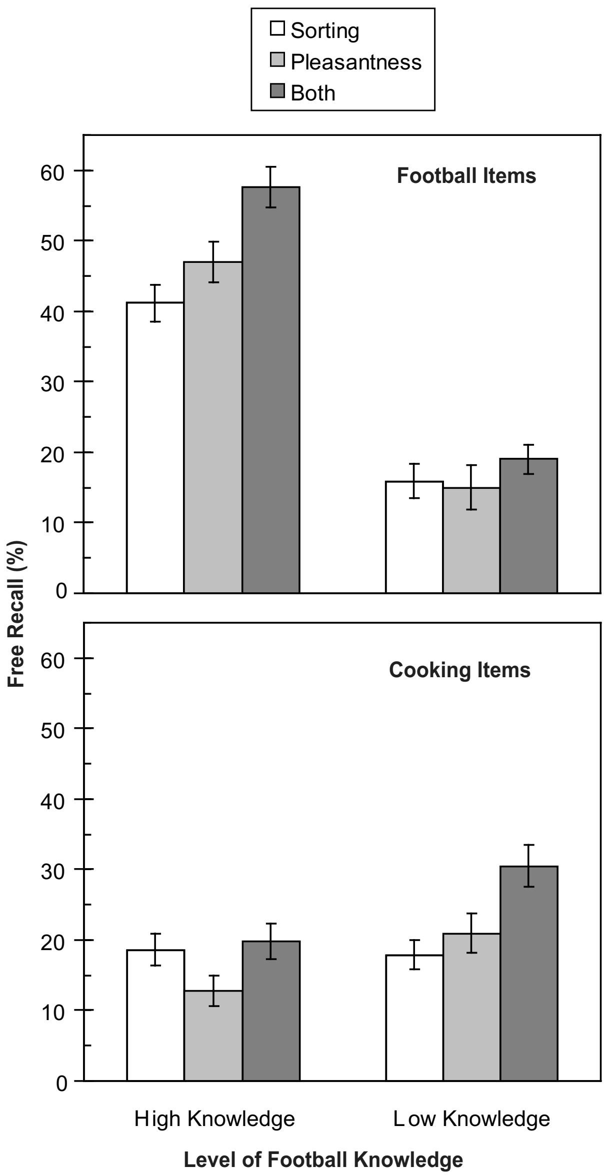

Fig. 2. Free recall as a function of knowledge level and orienting task in Experiment 1, for football items (top panel) and cooking items (bottom panel). Error bars are standard errors.

($M_d = 7.0$, CI = .2, 13.8, and $M_d = 5.8$, CI = −.4, 12.0). Furthermore, in contrast to the pattern in the football domain, HK individuals benefited less from performing the pleasantness rating task in the cooking domain than did LK individuals. For LK individuals, free recall of cooking items was greater for the group performing both orienting tasks than for the sorting group or the pleasantness rating group ($M_d = 12.6$, CI = 5.0, 20.2, and $M_d = 9.6$, CI = 1.3, 18.0); performance in the latter two groups did not significantly differ (CI = −4.6, 10.5).

Before turning to examination of the secondary measures, a brief discussion is in order concerning the finding of modest effects of orienting task on memory for the cooking items (here and in other measures reported later). In retrospect, some effect of orienting task in this domain is not surprising, given that individuals who have low knowledge about cooking (based on a measure that primarily assesses knowledge of cooking techniques and preparations) will likely still have some domain-relevant knowledge about some of our items (e.g., tongs, pots, and ladles). Indeed, a post hoc analysis revealed that a disproportionate number of items were recalled from the *utensils* category. Of the total number of cooking items recalled across the two knowledge groups, 41% were cooking utensils, 32% were spices, 16% were cooking techniques, and 11% were entrée names. In hindsight, individuals may have been more familiar with items in the *utensils* category and possibly the *spices* category than anticipated. To foreshadow, we addressed this concern in Experiment 2 by replacing some of these items with lower-familiarity items, to reduce the domain-relevant knowledge that individuals have about these items.

Consideration of one other unexpected pattern is also in order. Despite the fact that cooking knowledge was similar in the HK and LK groups, the LK group showed better performance than the HK group for cooking items. One possibility is that memory for the cooking items was less influenced by output interference in the LK group than in the HK group, in which early recall of football items might have interfered with later recall of cooking items. We conducted a post hoc analysis of the data from participants who recalled at least one item from each domain and who recalled at least four items total. For each participant, we divided recalled items into quartiles based on output position and then computed the percent of items recalled in each quartile that were cooking items (cf. Schwartz, Fisher, & Hebert, 1998). In the HK group, mean percentages in quartiles 1–4, respectively, were 18.5, 24.2, 31.7, and 43.4. In the LK group, mean percentages were 60.7, 54.1, 43.9, and 42.9. The difference between the percentage in the first versus fourth quartile was significant for both groups but in opposite directions. HK individuals were less likely to recall cooking items in the first versus fourth quartile (CI = −35.4, −14.3), whereas LK individuals were more likely to recall cooking items in the first versus fourth quartile (CI = 4.7, 31.0). This pattern suggests that memory for cooking items in the HK group may have been constrained by interference from early output of football items, which may explain the higher performance for cooking items in the LK group. Note, however, that any advantages for cooking items in the LK group versus the HK group were modest, suggesting that the sizeable advantages for football items in the HK group versus the LK group cannot be solely attributed to differential output interference. Nonetheless, we address this concern in Experiment 2 by manipulating item domain between-participants rather than within.

In sum, the free recall data replicate basic findings from previous research, showing the strong effects of knowledge on memory for domain-relevant information. More important, they also provide initial support for the distinctiveness theory. We now turn to examination of secondary measures that provide converging evidence for the contribution of both organizational processing and item-specific processing to the overall knowledge effect on memory.

Measures of organizational processing

Category access was computed as the percentage of categories from which at least one item was recalled, regardless of whether that item was correct, partially correct, or a categorical commission (to minimize the extent to which the measure reflected item-specific memory, given that discrimination of target items from non-targets is largely based on item-specific information). Mean category access is reported in Table 2 (far right column). Consistent with the claim that knowledge supports organizational processing, category access for football categories was greater for HK individuals than for LK individuals ($M_d = 25.5$, CI = 17.5, 33.5). This effect was apparently not due to HK individuals engaging in more or better organizational processing in general, because HK and LK individuals did not significantly differ in category access for cooking categories, (CI = −13.9, 6.1).

Category access as a function of orienting task is also reported in Table 2. Consistent with previous research, category access was greater for the sorting group than for the pleasantness rating group (collapsing across knowledge groups and category domains, $M_d = 15.5$, CI = 7.4, 23.7). Performing both tasks did not improve category access above performing sorting alone (across knowledge groups and category domains, CI = −6.9, 9.1). The effect of sorting on category access was evident in both category domains for both knowledge groups, which is not surprising given that category labels were explicitly provided during the task.

For the second measure of organizational processing, we computed two clustering scores for each participant (Roenker, Thompson, & Brown, 1971), one for items recalled from football categories and another for items recalled from cooking categories. Zero represents chance-level clustering and 1.0 represents perfect clustering. To minimize the extent to which the measure reflected item-specific memory, we included correct items, partially correct items, and commissions in the analysis (e.g., if an individual recalled "Baltimore Ravens, Texas Giants, Philadelphia Eagles," the individual would be given credit for consecutively producing three items from the football team category even though the second item was not correct). Analyses necessarily excluded any individual who did not recall enough items in a domain to permit computation of a clustering score. The resulting number of participants did not allow meaningful interpretation of differences in clustering scores as a function of orienting task, but the analyses collapsing across this variable are still informative.

Consistent with the assumption of both distinctiveness theory and organization-based theories that knowledge supports organizational processing, clustering for football items was greater for HK individuals (.41, $SE = .04$) than for LK individuals (.23, $SE = .12$), CI = −.03, .40. HK and LK individuals did not significantly differ in clustering for cooking items ($M = .15$, $SE = .12$, and $M = .24$, $SE = .10$, respectively), CI = −.40, .21.

In sum, the overall pattern of category access and clustering adds to the body of research establishing that knowledge supports organizational processing, which in turn can support memory for domain-relevant information. More important for testing distinctiveness theory, to what extent do knowledge effects on memory also arise from item-specific processing? We now turn to the measures that will address this question.

Items per category accessed

Given that a category is accessed, IPCA is computed as the percentage of correct items recalled from that cat-

Table 2
Mean category access as a function of orienting task, category domain, and knowledge group, Experiment 1

Orienting task	Sorting	Pleasantness	Both	Across groups
Football categories				
High knowledge	95.2 (2.2)[ab]	89.0 (3.8)[b]	97.8 (1.5)[a]	93.8 (1.7)
Low knowledge	70.6 (7.5)[c]	59.8 (6.6)[c]	76.3 (5.9)[c]	68.3 (3.9)
Cooking categories				
High knowledge	75.0 (4.9)[a]	48.0 (6.6)[b]	65.2 (5.8)[ab]	62.0 (3.6)
Low knowledge	69.1 (5.9)[ab]	53.3 (5.5)[b]	77.5 (5.1)[a]	65.8 (3.4)

Note. Category access is reported as the percentage of categories from which at least one item was recalled. Standard errors of the mean are reported in parentheses. Knowledge level (high or low) refers to level of football knowledge. Within each category domain, means in the same row that share a superscript are not significantly different from one another (95% CI includes 0), and means in the same column that share a superscript are not significantly different from one another (95% CI includes 0).

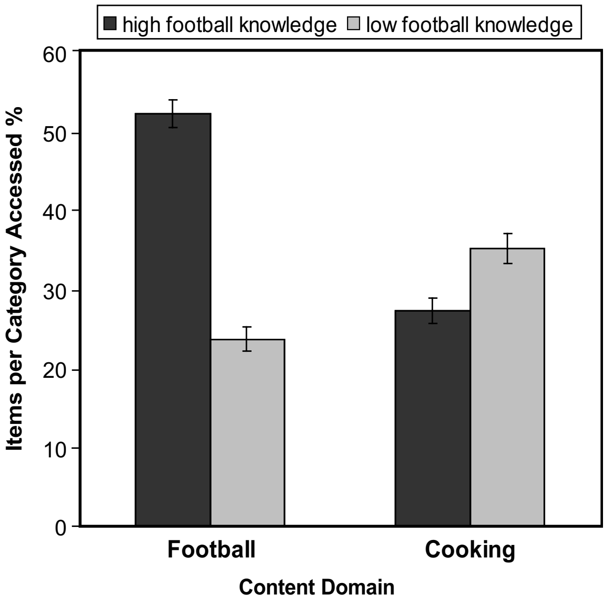

Fig. 3. Mean items per category accessed as a function of knowledge level and item domain in Experiment 1. Error bars are standard errors.

egory. Mean IPCA is displayed in Fig. 3. As predicted by distinctiveness theory, IPCA for football items was greater for HK individuals than for LK individuals, $M_d = 28.6$, CI = 23.9, 33.3. This effect was not due to HK individuals engaging in more or better item-specific processing in general, because IPCA for cooking items was lower for HK individuals than for LK individuals, $M_d = -7.9$, CI = −12.7, −3.0.

IPCA as a function of orienting task is displayed in Fig. 4. As predicted by distinctiveness theory, the extent to which the orienting task benefited memory depended on the level of relevant knowledge. For HK individuals, IPCA for football items was lower for the sorting group than for the pleasantness rating group or the group performing both tasks ($M_d = -11.0$, CI = −19.0, −3.1, and $M_d = -15.7$, CI = −22.9, −8.4); the latter two groups did not significantly differ from one another (CI = −3.57, 12.8). In contrast, for LK individuals, performing the pleasantness rating task did not improve IPCA for football items, with no significant differences between task groups, (CIs < −4.8, >8.0).

The pattern in the cooking domain suggests that the benefit of the pleasantness rating task for HK individuals in the football domain was not due to a domain-general item-specific processing strategy. For HK individuals, there were no significant differences between task groups in IPCA for cooking items (CIs < −3.6, >9.9). Furthermore, in contrast to the pattern in the football domain, HK individuals benefited less from performing the pleasantness rating task in the cooking domain than did LK individuals. For LK individuals, IPCA for cooking items was lower for

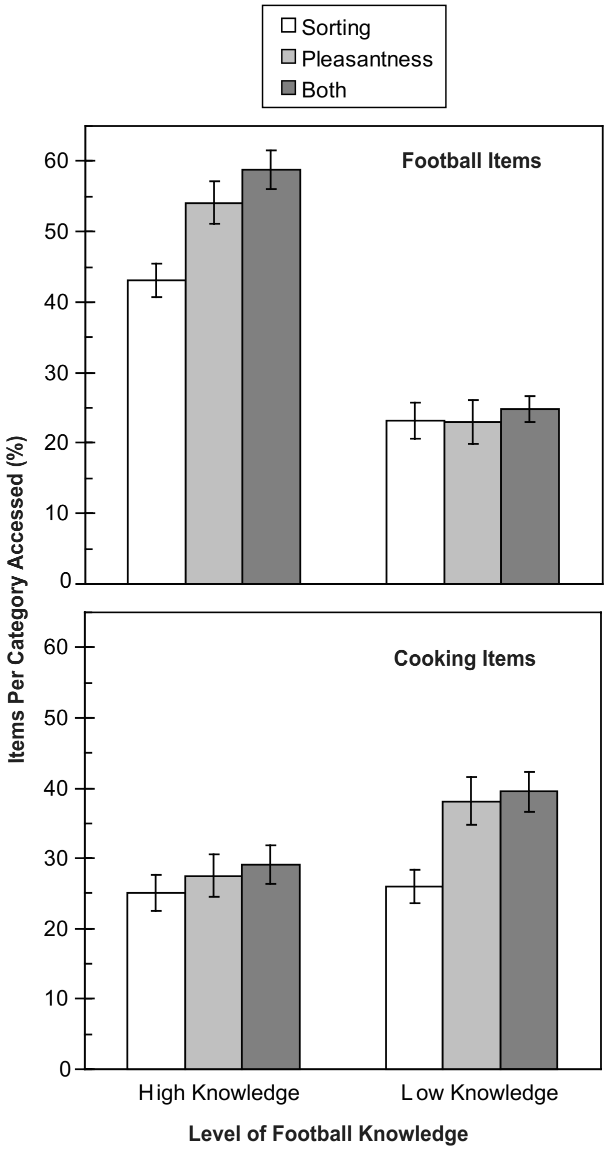

Fig. 4. Items per category accessed as a function of knowledge level and orienting task in Experiment 1, for football items (top panel) and cooking items (bottom panel). Error bars are standard errors.

the sorting group than for the pleasantness rating group or for the group performing both tasks ($M_d = -12.1$, CI = −21.1, −3.1, and $M_d = -13.5$, CI = −21.0, −6.0); the latter two groups did not significantly differ from one another (CI = −7.7, 10.5). These effects in the cooking domain may be due to unintended familiarity with some cooking items and differential output interference for HK and LK individuals, which will be addressed in Experiment 2.

Recognition performance

Before reporting these results, we note that interpreting the pattern of recognition performance requires some caution, given that the recognition test was admin-

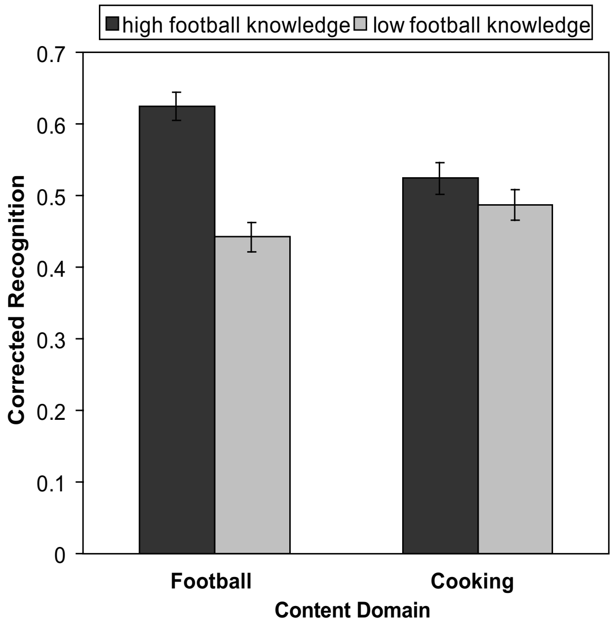

Fig. 5. Mean corrected recognition as a function of knowledge level and item domain in Experiment 1. Error bars are standard errors.

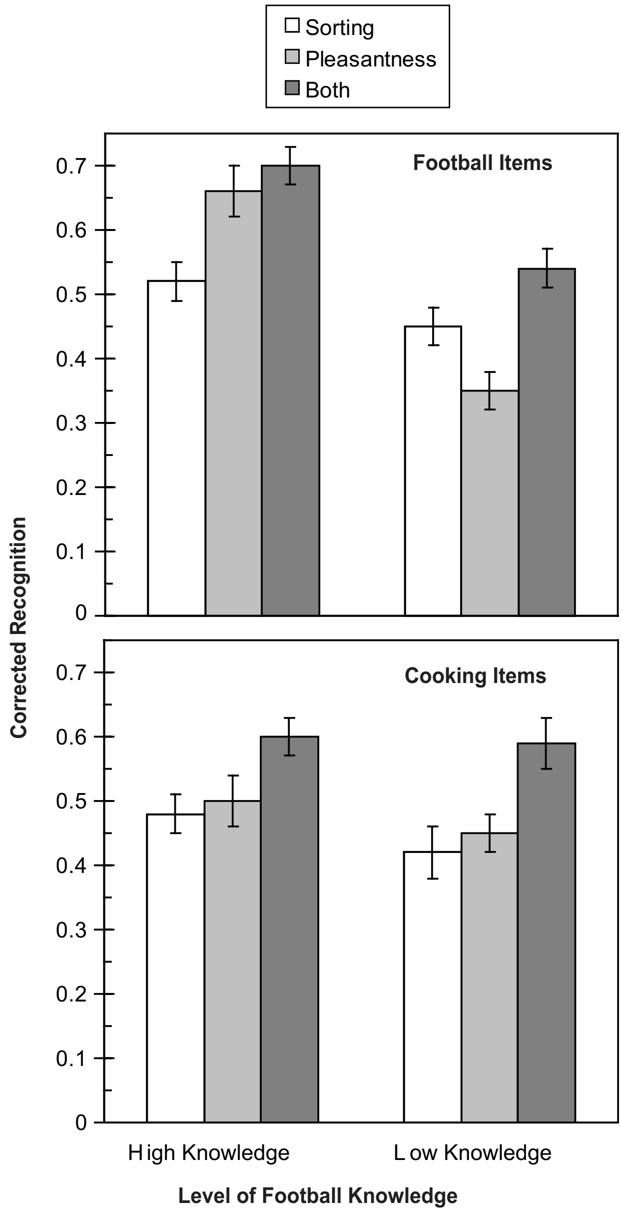

Fig. 6. Corrected recognition as a function of knowledge level and orienting task in Experiment 1, for football items (top panel) and cooking items (bottom panel). Error bars are standard errors.

istered after the free recall test. As a result, recognition performance in the various groups may have been influenced by the extent to which retrieval practice during the recall test was successful (see Roediger & Karpicke, 2006), although the observation of some qualitative differences in the pattern of recall versus recognition in both experiments suggests that the overall pattern of recognition performance was unlikely due solely to testing effects.

Mean corrected recognition [(hits – false alarms)/# of target items] as a function of knowledge level and content domain is displayed in Fig. 5.[5] As predicted by distinctiveness theory, recognition of football items was greater for HK individuals than for LK individuals ($M_d = .18$, CI = .13, .24), whereas recognition of cooking items did not significantly differ for HK and LK individuals (CI = −.03, .10).

Recognition as a function of orienting task is displayed in Fig. 6. For HK individuals, recognition of football items was lower in the sorting group than in the pleasantness rating group or the group performing both tasks, ($M_d = -.14$, CI = −.23, −.05, and $M_d = -.18$, CI = −.26, −.10); the latter two groups did not differ significantly (CI = −.05, .14). In contrast, for LK individuals, football item recognition was lower in the pleasantness rating group than in the group performing both tasks or the sorting group ($M_d = -.10$, CI = −.19, .003, and $M_d = -.19$, CI = −.28, −.09); the group performing both tasks outperformed the sorting group ($M_d = .09$, CI = .004, .19).

In contrast to the different effects of orienting task for HK and LK individuals in the football domain,

[5] Although not of primary interest here, some previous research has examined the effect of item-specific orienting tasks on hit and false alarm rates separately (e.g., Dobbins et al., 1998; Gruppuso et al., 1997; Hunt, 2003). Thus, for interested readers, we also report hit and false alarm rates for Experiment 1 in Appendix C and for Experiment 2 in Appendix F. In brief, the overall pattern conforms to what would be expected based on results reported by Hunt (2003), in which item-based distinctive processing increased hit rates but had a minimal influence on false alarm rates.

HK and LK groups exhibited very similar effects of orienting task in the cooking domain. For both HK and LK individuals, recognition was greater in the group performing both tasks than in the sorting group or the pleasantness rating group (CIs >.01, >.20); the latter two groups did not differ (CIs <−.06, >.13). The similar pattern for HK and LK groups in the cooking domain suggests that the benefit of pleasantness rating for the HK group in the football domain was not due to a domain-general item-specific processing strategy.

Experiment 2

Taken together, the results of Experiment 1 support the key predictions of the distinctiveness theory of skilled memory. HK individuals outperformed LK individuals on free recall within their knowledge domain but not outside their domain. As uniquely predicted by distinctiveness theory, the highest levels of recall were observed when HK individuals engaged in both item-specific and organizational processing (i.e., distinctive processing). In further support of the theory, HK individuals outperformed LK individuals on secondary measures that heavily reflect item-specific processing, but only within their knowledge domain. Additionally, HK individuals benefited more than LK individuals from an orienting task encouraging item-specific processing within their knowledge domain but not outside their domain.

Whereas the pattern of performance for HK and LK individuals in the target domain (NFL football) largely conformed to predictions, an unanticipated pattern of performance obtained in the control domain (cooking). LK individuals tended to outperform HK individuals in the cooking domain, with overall greater performance in free recall and IPCA. On one hand, this pattern provides evidence that the advantage of HK individuals in the football domain was due to greater levels of domain-specific knowledge rather than to better domain-general memory abilities or strategies. On the other hand, post hoc analyses suggested that output interference may have reduced recall of cooking items in the HK group, which raises the possibility that output interference may have reduced recall of football items in the LK group.

Experiment 2 was designed to replicate the key findings of Experiment 1 and to address the unanticipated results in the control domain. To eliminate any influence of output interference from recall of items in one domain on recall in the other domain, item domain was manipulated between-participants in Experiment 2. Additionally, given evidence that participants may have had a higher degree of domain-relevant familiarity with some items in the cooking categories than originally intended, these items were replaced with lower-familiarity items in Experiment 2.

Methods

Participants and design

Undergraduates ($n = 394$) participating to satisfy a course requirement in General Psychology were randomly assigned to one of six groups, based on orienting task (sorting, pleasantness rating, or both) and item domain (football or cooking). We analyzed data from those participants who were either relatively high or low in football knowledge, as determined by performance on the post-experimental knowledge test. Thus, the study involved a 3 (orienting task) × 2 (knowledge level) × 2 (item domain) design, with all factors between-participants.

Materials and procedures

Materials included two lists of 36 items, with six items from each of six categories from either football or cooking (new or replacement items are marked in Appendix D). The football and cooking knowledge tests were the same as in Experiment 1. The procedure was also the same as in Experiment 1, with the following exceptions: participants performing both orienting tasks first categorized an item and then rated the pleasantness of that item (rather than in the opposite order, as in Experiment 1). The recognition test included the original 36 items viewed by a participant (either football or cooking items, depending on group assignment), along with 36 distractors (six new items from each of the six categories).

Results and discussion

All omnibus ANOVAs are reported in Appendix E. As a reminder, comparison of the absolute magnitude of performance in the two content domains (football and cooking) are not meaningful, given that the football items and cooking items are not matched with respect to various other factors that are known to influence memory. Rather, comparison of performance for HK and LK individuals within each domain is again of greatest interest (i.e., performance for HK and LK individuals should differ in the football domain but not in the cooking domain).

Knowledge tests

Individuals who correctly answered 19 or more questions on the football knowledge test were classified as HK participants, and individuals who correctly answered nine or fewer questions were classified as LK. All of these participants correctly answered seven or fewer questions on the cooking knowledge test. The number of HK and LK participants included in analyses

Table 3
Sample size and mean performance on knowledge tests as a function of group in Experiment 2

Orienting task	Sorting	Pleasantness	Both
High knowledge	$n = 45$	$n = 46$	$n = 50$
Football knowledge test	22.3 (.4)	22.3 (.3)	21.9 (.3)
Score corrected for guessing	17.4 (.7)	17.2 (.5)	16.6 (.5)
Cooking knowledge test	2.9 (.3)	2.3 (.3)	2.7 (.3)
Score corrected for guessing	−5.3 (.5)	−4.1 (.5)	−4.4 (.5)
Low knowledge	$n = 48$	$n = 45$	$n = 46$
Football knowledge test	5.6 (.4)	5.2 (.3)	5.5 (.4)
Score corrected for guessing	−2.6 (.6)	−2.2 (.6)	−1.3 (.6)
Cooking knowledge test	2.2 (.3)	2.5 (.3)	2.6 (.3)
Score corrected for guessing	−5.0 (.6)	−3.9 (.5)	−4.9 (.5)

Note. Test performance is reported as percentages. Scores corrected for guessing reflect the number of correct responses—the number of incorrect responses, for those questions in which participants did not select "I don't know". Standard errors of the mean are reported in parentheses. Results for each knowledge group are collapsed across domain list (approximately half of the participants in each group were presented with the list of football items and the other half were presented the list of cooking items).

for each group is reported in Table 3, along with mean raw scores and corrected scores on the football and cooking knowledge tests.

Free recall

Free recall responses were scored as in Experiment 1. Fig. 7 displays mean recall by knowledge level and item domain. Free recall of football items was greater for HK individuals than for LK individuals ($M_d = 28.8$, CI = 25.2, 32.4). Free recall for cooking items did not significantly differ for HK and LK individuals (CI = −4.2, 1.6).

Fig. 8 reports recall as a function of orienting task. For HK individuals, free recall of football items was significantly greater in the group performing both tasks versus the sorting group ($M_d = 14.4$, CI = 7.4, 21.4) and marginally greater than in the pleasantness rating group ($M_d = 5.8$, CI = −1.6, 13.2). The difference between the latter two groups was also significant ($M_d = 8.6$, CI = 1.0, 16.3). In contrast, for LK individuals, free recall of football items did not significantly differ as a function of orienting task (CIs < −3.0, >3.8).

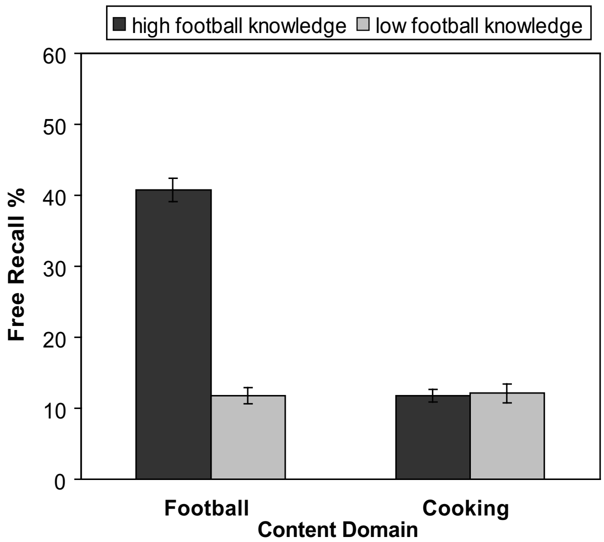

Fig. 7. Mean free recall as a function of knowledge level and item domain in Experiment 2. Error bars are standard errors.

For the cooking items, free recall for HK individuals was significantly lower in the pleasantness rating group than in the group performing both tasks ($M_d = -6.3$, CI = −10.9, −1.7) and marginally lower than in the sorting group ($M_d = -3.3$, CI = −7.5, .9); the latter two groups did not significantly differ (CI = −1.6, 7.6). None of the LK groups differed from one another (CIs < −5.3, >4.5).

Thus, we again replicated the basic knowledge effects on memory, with HK individuals outperforming LK individuals within their knowledge domain. In contrast to Experiment 1, HK and LK individuals did not differ in recall for cooking items, presumably because any effects of output interference were eliminated by manipulating item domain between-participants. Concerning the effects of orienting task, the predictions of the distinctiveness theory were again supported, with HK individuals showing greater benefits of orienting task than LK individuals within their knowledge domain but minimal differences outside of their domain.

Measures of organizational processing

Mean category access is reported in Table 4 (far right column). Consistent with the claim that knowledge supports organizational processing, category access for football categories was greater for HK individuals than for LK individuals (CI = 19.7, 32.7), whereas HK and LK individuals did not significantly differ in category access for cooking categories (CI = −12.7, 4.5).

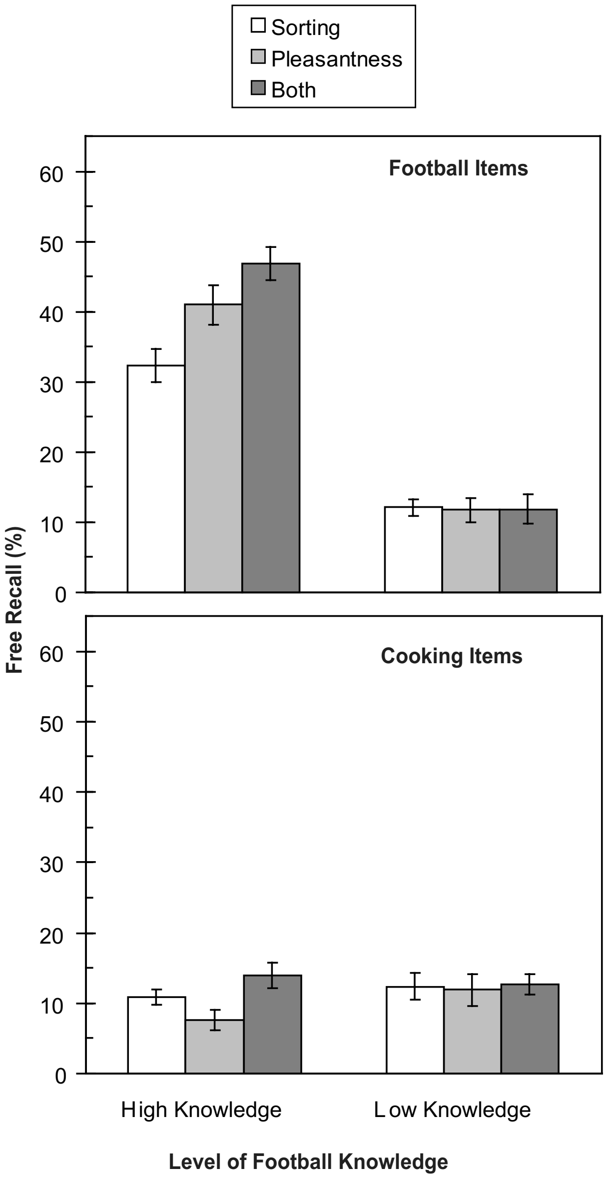

Fig. 8. Free recall as a function of knowledge level and orienting task in Experiment 2, for football items (top panel) and cooking items (bottom panel). Error bars are standard errors.

Category access as a function of orienting task is also reported in Table 4. Consistent with previous research, category access was greater in the sorting group than in the pleasantness rating group (across knowledge groups and category domains, $M_d = 9.6$, CI = 2.2, 17.0), although the effect was weaker in the football domain than in the cooking domain. Performing both tasks did not improve category access above performing the sorting task alone (across knowledge groups and category domains, $M_d = 3.5$, CI = −4.4, 9.6).

For each participant, we computed a clustering score as in Experiment 1. Clustering could not be computed for 47 participants (e.g., because they did not recall more than one item from each accessed category). The resulting number of participants thus did not allow meaningful interpretation of differences in clustering scores as a function of orienting task. Collapsing across this variable, clustering for football categories was greater for HK individuals (.40, $SE = .03$) than for LK individuals (.06, $SE = .08$; CI = .18, .49), whereas HK and LK individuals did not significantly differ in clustering for cooking categories ($M = .24$, $SE = .09$, and $M = .39$, $SE = .08$, respectively; CI = −.10, .40).

Items per category accessed

Of greater interest are results for the secondary measures of item-specific processing. Mean IPCA as a function of knowledge level and item domain is displayed in Fig. 9. As predicted by distinctiveness theory, IPCA for football items was greater for HK individuals than for LK individuals ($M_d = 25.7$, CI = 22.1, 29.4), whereas IPCA for cooking items did not significantly differ for HK and LK individuals (CI = −2.8, 4.0).

IPCA as a function of orienting task is displayed in Fig. 10. As predicted by distinctiveness theory, the effect of orienting task again depended on the level of relevant knowledge. For HK individuals, IPCA for football items was lower in the sorting group than in the pleasantness rating group or the group performing both tasks ($M_d = -13.1$, CI = −20.0, −6.3, and $M_d = -16.5$, CI = −23.1, −9.9); the latter two groups did not significantly differ (CI = −9.2, 2.5). In contrast, for LK individuals, performing the pleasantness rating task did not improve IPCA for football items, with no significant differences between task groups (CIs < -4.3, > 3.8).

In the cooking domain, the pattern of IPCA performance for HK and LK individuals was similar, again suggesting that the benefit of the pleasantness rating task for HK individuals in the football domain was not due to a domain-general item-specific processing strategy. For HK individuals, the only significant difference was the slight advantage for the group performing both tasks over the sorting group (CI = 0, 9.8; other CIs < -8.4, > 3.3). For LK individuals, there were no significant differences between task groups (CIs < -7.3, > 2.2).

Recognition performance

Mean corrected recognition is displayed in Fig. 11. In further support of distinctiveness theory, recognition of football items was greater for HK individuals than for LK individuals ($M_d = .18$, CI = .13, .23), whereas recognition of cooking items did not significantly differ for HK and LK individuals ($M_d = -.02$, CI = −.07, .03).

Recognition as a function of orienting task is displayed in Fig. 12. For HK individuals, recognition of football items was greater in the pleasantness rating group than in the sorting group ($M_d = .13$, CI = .05, .20). In contrast, for LK individuals, recognition of football items in the pleasantness rating and sorting

Table 4
Mean category access as a function of orienting task, category domain, and knowledge group, Experiment 2

Orienting task	Sorting	Pleasantness	Both	Across groups
Football categories				
High knowledge	91.3 (2.2)[a]	88.2 (4.3)[a]	92.9 (2.5)[a]	90.8 (1.8)
Low knowledge	67.4 (4.0)[b]	65.9 (5.0)[b]	60.3 (5.6)[b]	64.7 (2.8)
Cooking categories				
High knowledge	67.4 (4.2)[a]	43.9 (4.8)[b]	66.0 (5.4)[a]	60.0 (3.1)
Low knowledge	72.0 (5.3)[a]	55.3 (5.3)[b]	63.9 (5.1)[ab]	64.1 (3.1)

Note. Category access is reported as the percentage of categories from which at least one item was recalled. Standard errors of the mean are reported in parentheses. Knowledge level (high or low) refers to level of football knowledge. Within each category domain, means in the same row that share a superscript are not significantly different from one another, and means in the same column that share a superscript are not significantly different from one another ($p < .05$).

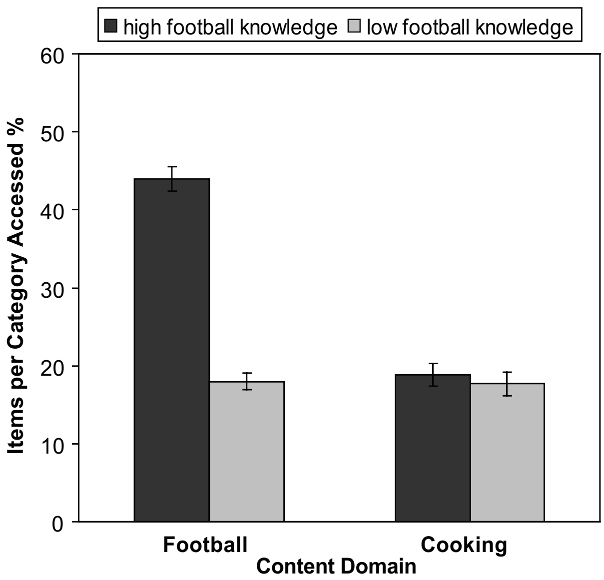

Fig. 9. Mean items per category accessed as a function of knowledge level and item domain in Experiment 2. Error bars are standard errors.

groups did not significantly differ ($M_d = .03$, CI = −.06, .12). Whereas HK individuals showed a greater benefit of the pleasantness rating task than LK individuals in the football domain, HK and LK individuals exhibited similar effects in the cooking domain. In both knowledge groups, recognition of cooking items in the pleasantness rating and sorting groups did not significantly differ (CIs $< -.04$, $> .10$). Finally, groups performing both tasks significantly outperformed single-task groups in the following cases: performing both tasks led to higher recognition than performing the sorting task for HK individuals in the football domain ($M_d = .19$, CI = .12, .27). Performing both tasks also led to higher recognition than performing either task alone for HK individuals in the cooking domain (CIs $> .003$, $> .14$) and for LK individuals in the football domain (CIs $> .02$, $> .19$).

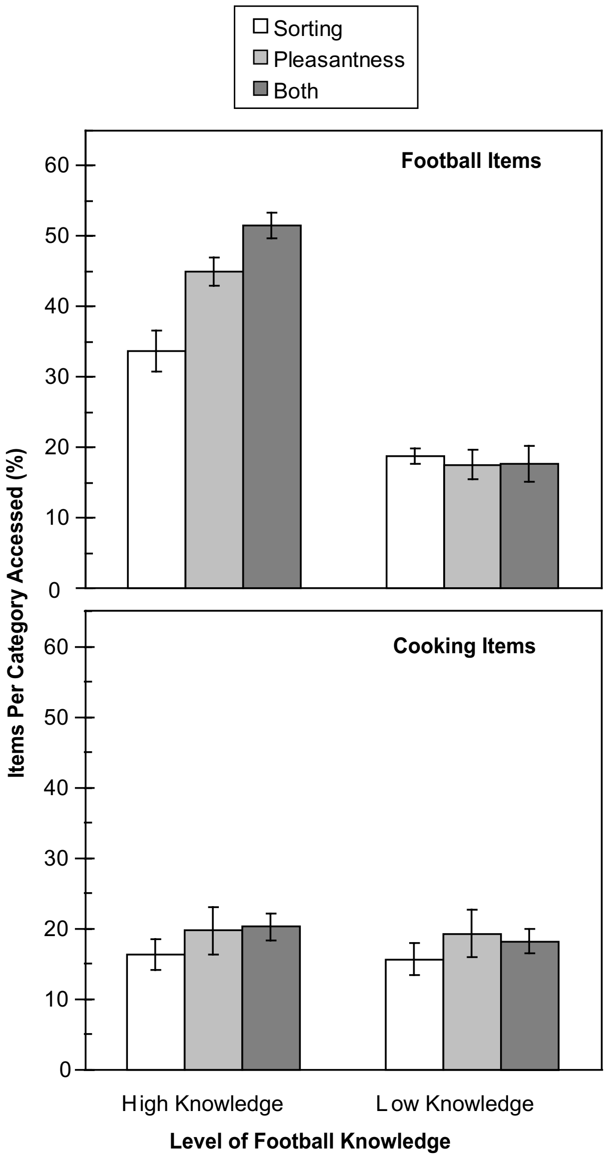

Fig. 10. Items per category accessed as a function of knowledge level and orienting task in Experiment 2, for football items (top panel) and cooking items (bottom panel). Error bars are standard errors.

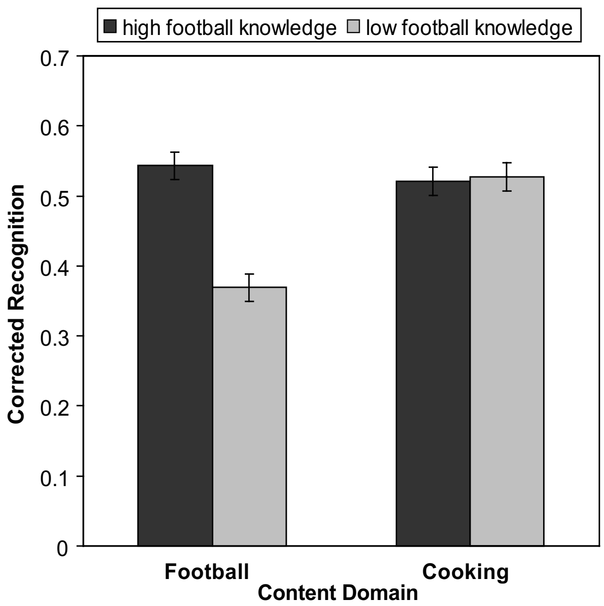

Fig. 11. Mean corrected recognition as a function of knowledge level and item domain in Experiment 2. Error bars are standard errors.

Performance as a function of level of cooking knowledge

Thus far, the predictions of the distinctiveness theory have been tested using football as the knowledge domain and cooking as the control domain. To provide further support for the distinctiveness theory, we also examined performance on each measure as a function of cooking knowledge, using football as the control domain. For these analyses, the HK group included individuals who correctly answered eight or more questions on the cooking knowledge questionnaire, and the LK group included individuals who did not correctly answer any cooking questions. Perhaps not surprising, few participants in each experiment exhibited higher levels of cooking knowledge, so we report results collapsed across Experiments 1 and 2 and across orienting task (the HK and LK groups included similar proportions of individuals from each of the orienting task groups). Mean performance for each measure of interest is reported in Table 5.

Despite the somewhat modest level of cooking knowledge in the HK group, the trends are quite consistent with the overall pattern found in the analyses above. Individuals with higher levels of cooking knowledge had higher free recall than individuals with low cooking knowledge, but only within the cooking domain. Consistent with distinctiveness theory, HK individuals also outperformed LK individuals on IPCA and recognition within the cooking domain but not within the football domain. These results thus provide converging evidence for distinctiveness theory in another knowledge domain.

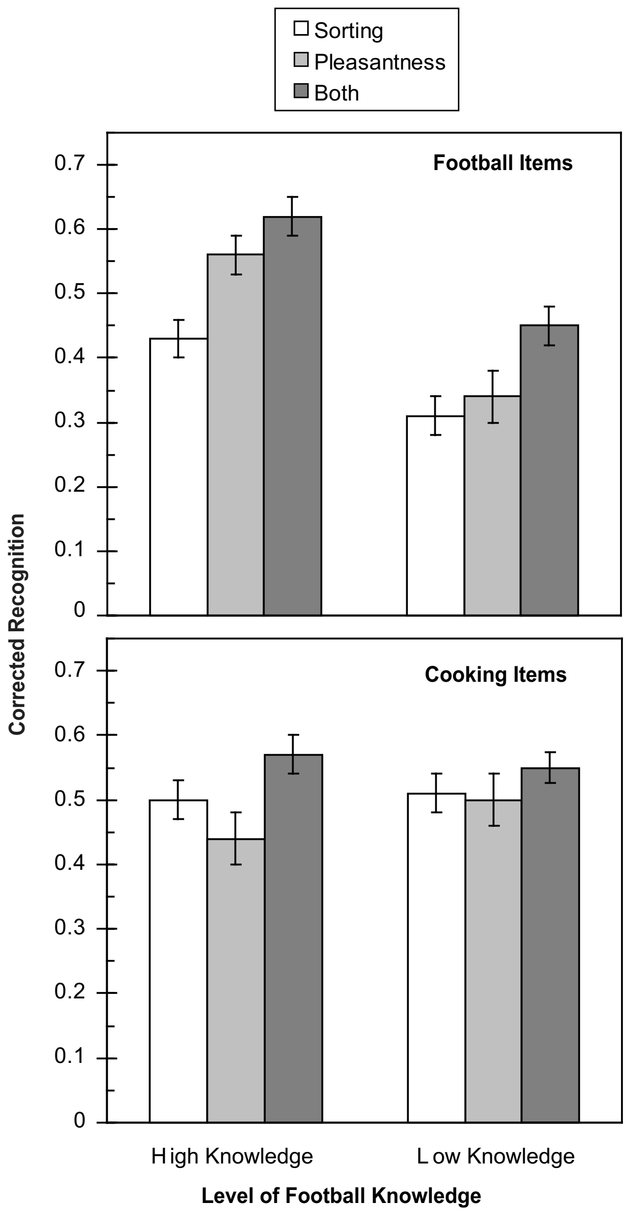

Fig. 12. Corrected recognition as a function of knowledge level and orienting task in Experiment 2, for football items (top panel) and cooking items (bottom panel). Error bars are standard errors.

General discussion

In two experiments, we replicated the robust effects of knowledge on memory for domain-relevant information shown in previous research. To date, theoretical accounts of knowledge effects on memory have focused on the idea that knowledge supports more effective organizational processing, which in turn facilitates later access to the organized information. Here, we have proposed the distinctiveness theory of skilled memory, which extends beyond earlier accounts by stating that knowledge benefits memory by supporting more effec-

Table 5
Performance as a function of level of cooking knowledge, Experiments 1 and 2 combined

Cooking knowledge	Higher ($n = 24$)	Lower ($n = 105$)	95% CI
Knowledge questionnaire			
Cooking items (out of 20)	9.4 (0.3)	0 (0)	
Football items (out of 30)	14.0 (1.5)	14.7 (0.8)	−4.2, 2.8
Free recall (%)			
Cooking items	26.6 (4.4)	13.2 (1.1)	7.0, 19.6
Football items	25.0 (4.3)	29.6 (2.0)	−14.0, 4.8
Category access (%)			
Cooking items	72.8 (7.6)	59.6 (3.2)	−2.1, 28.4
Football items	82.3 (5.4)	82.1 (2.6)	−11.9, 12.2
Items per category accessed (%)			
Cooking items	33.2 (4.0)	22.3 (1.5)	3.5, 18.2
Football items	29.1 (3.9)	34.1 (1.9)	−13.5, 3.5
Corrected recognition			
Cooking items	.61 (.05)	.51 (.02)	.01, .19
Hits (proportion)	.85 (.03)	.74 (.02)	.03, .19
False alarms (proportion)	.25 (.03)	.23 (.02)	−.07, .10
Football items	.51 (.04)	.49 (.02)	−.07, .11
Hits (proportion)	.72 (.03)	.75 (.02)	−.09, .05
False alarms (proportion)	.21 (.04)	.26 (.02)	−.12, .04

Note. Standard errors of the mean are reported in parentheses. CI, confidence interval around the difference between means.

tive distinctive processing of domain-relevant information. According to distinctiveness theory, organizational processing is an important contributor to skilled memory, but its efficacy also depends on effective processing of item-specific information that is diagnostic of particular items in the context of similarity defined by organization.

Indeed, HK individuals' free recall was greater in conditions that encouraged distinctive processing (i.e., both organizational and item-specific processing) than in conditions that only encouraged organizational processing. In further support of distinctiveness theory, several results established that knowledge supports more effective item-specific processing. On measures that heavily reflect item-specific processing (IPCA and recognition), HK individuals outperformed LK individuals, but only within their domain. Additionally, HK individuals showed greater gains than LK individuals overall from an orienting task that encouraged item-specific processing (pleasantness rating), but only within their domain. Certainly, some particular aspects of the results were unanticipated (e.g., a performance advantage for LK individuals over HK individuals in the control domain in Experiment 1), most of which were eliminated by the methodological changes in Experiment 2. However, the most important point is that the overall pattern is difficult to explain solely with recourse to organizational processing. In contrast, the distinctiveness theory provides a relatively parsimonious account of the overall qualitative pattern of knowledge effects across several different memory measures and several encoding conditions.

Thus far, we have emphasized the assumption of distinctiveness theory that the potency of organizational processing depends on effective processing of item-specific information. However, distinctiveness theory assumes that the reverse is true as well. Item-specific processing alone does not support the highest levels of skilled memory. "Differences are only distinctive in the context of perceived similarity … difference outside the context of similarity is not diagnostic" (Hunt & Lamb, 2001, p. 1365). The extent to which HK individuals profit from their wealth of item-specific knowledge depends on their ability to perceive key dimensions of similarity that define the item-specific knowledge that will be diagnostic for a given episode. The dependence of effective item-specific processing on organizational processing explains why LK individuals did not benefit from only performing the pleasantness rating task, whereas HK individuals did within their domain: although not explicitly encouraged to process organizational information, HK individuals in the pleasantness rating group were likely able to perceive the categorical relationships among items spontaneously (cf. Einstein & Hunt, 1980; Hunt & Einstein, 1981) and thus profit from the processing of item-specific information in the context of that similarity, whereas LK individuals were presumably less able to do so.

In sum, we argue that theoretical accounts of skilled memory that only take organizational processing into account are incomplete. That is, organizational processing alone will seldom be sufficient to explain knowledge effects on memory. Basic research on memory has established that memory is best under the combined influence of both organizational and item-specific processing—i.e., distinctive processing—and we argue that skilled memory is no exception. The distinctiveness theory of skilled memory extends earlier theories by assuming that the efficacy of organizational processing also depends on effective item-specific processing to support discrimination of items within the organizational structure from one another and from related non-target information within the search set.

We suspect this theoretical claim will not be viewed as particularly contentious. If our suspicion is correct, the notable absence of the item-specific processing assumption from most of the theoretical and empirical work on skilled memory is somewhat surprising.[6] To our knowledge, the present research represents only the second attempt to directly test this important assumption and provides an important extension beyond the initial work (Van Overschelde et al., 2005). In addition to further developing and testing theories of skilled memory, the current work also makes an empirical contribution to the literature by examining multiple measures and encoding tasks that are either understudied or altogether new to the skilled memory literature. Finally, the present research also contributes to the basic memory research on distinctive processing, by showing that knowledge level defines an important boundary condition on the efficacy of orienting tasks used to encourage distinctive processing.

The role of distinctive processing in skilled memory may be even greater than described so far, if one treats the 'item' level as relative rather than absolute. Depending on the hierarchical structure of the information to be encoded, what serves as a category at one level of analysis may be treated as an item at a higher level of analysis (e.g., see Hunt, 2003, for discussion of item-based versus event-based distinctive processing). For example, even within the relatively simple conceptual structure of the present materials, the highest level of an individual's representation may have been defined by two very general superordinates, *football categories* and *cooking categories*. Each of these top-level superordinates would then encompass several different 'items,' such as *football teams* and *penalties,* or *entrée names* and *spices*. These mid-level 'items' are only defined as categories with respect to the lower-level items they encompass (e.g., *Tennessee Titans, Beef Wellington*). Presumably, item-specific information is necessary to differentiate between items within any given level. Thus, in the present situation, HK individuals could rely on knowledge not only to differentiate between particular items within a football category, but also to differentiate between the football categories themselves (e.g., to differentiate studied categories from other possible but not presented categories, such as *football coaches, rules, record holders, divisions*, etc.). Although speculative, this account explains the finding that HK individuals accessed a greater number of football categories than LK individuals, despite the fact that category superordinates were explicitly provided to both knowledge groups during the organizational orienting task.

In conclusion, the present results strongly support the claim of distinctiveness theory that knowledge effects on memory are attributable to item-specific processing in addition to organizational processing, and the specification of both mechanisms and their interaction will lead to more complete theoretical accounts of skilled memory.

[6] Given that template theory is a member of the family of EPAM models, it does include a discrimination net. However, this discrimination net is primarily involved in perceptual pattern recognition, rather than in the processing of distinctive semantic information as conceptualized in the distinctiveness theory here.

Appendix A. Materials for Experiment 1

Team names	Entrée names
Baltimore Ravens	Veal Saltimbocca
Tennessee Titans	Chicken Cacciatore
Miami Dolphins	Trout Almondine
Philadelphia Eagles	Beef Wellington
St. Louis Rams	Oysters Rockefeller
Penalties	Spices
False start	Rosemary
Delay of game	Paprika
Encroachment	Thyme
Pass interference	Sage
Roughing kicker	Cilantro
Positions	Utensils
Fullback	Whisk
Lineman	Tongs
Punter	Strainer
Center	Pots
Tight end	Ladle
Player names	Cooking techniques
Tom Brady	Emulsifying
Warren Sapp	Blanching
William Perry	Braising
Randy Moss	Sautéing
Jeff Garcia	Deglazing

Appendix B. Omnibus analyses of variance for Experiment 1

Free recall: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1, 123) = 91.12$, $MSE = 109.54$, $p < .001$
Knowledge level	$F(1, 123) = 56.14$, $MSE = 190.02$, $p < .001$
Orienting task	$F(2, 123) = 9.72$, $MSE = 190.02$, $p < .001$
Item domain × knowledge level	$F(1, 123) = 209.59$, $MSE = 109.54$, $p < .001$
Item domain × orienting task	$F < 1$
Knowledge level × orienting task	$F < 1$
Three-way interaction	$F(2, 123) = 7.02$, $MSE = 109.54$, $p = .001$
Category access: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1, 123) = 31.62$, $MSE = 564.52$, $p < .001$
Knowledge level	$F(1, 123) = 10.88$, $MSE = 659.61$, $p = .001$
Orienting task	$F(2, 123) = 11.58$, $MSE = 659.61$, $p < .001$
Item domain × knowledge level	$F(1, 123) = 23.71$, $MSE = 564.52$, $p < .001$
Item domain × orienting task	$F < 1.63$
Knowledge level × orienting task	$F < 1$
Three-way interaction	$F < 1$
Clustering scores: 2 (item domain) × 2 (knowledge level)	
Item domain	$F < 1$
Knowledge level	$F < 1$
Item domain × knowledge level	$F(1, 57) = 1.79$, $MSE = 0.36$, $p = .19$
Items per category accessed: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1, 115) = 21.67$, $MSE = 130.74$, $p < .001$
Knowledge level	$F(1, 115) = 33.58$, $MSE = 193.16$, $p < .001$
Orienting task	$F(2, 115) = 8.38$, $MSE = 193.16$, $p < .001$
Item domain × knowledge level	$F(1, 115) = 150.29$, $MSE = 130.74$, $p < .001$
Item domain × orienting task	$F < 1$
Knowledge level × orienting task	$F < 1$
Three-way interaction	$F(2, 115) = 6.38$, $MSE = 130.74$, $p = .002$
Adjusted recognition: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1, 137) = 3.42$, $MSE = 0.02$, $p = .067$
Knowledge level	$F(1, 137) = 22.62$, $MSE = 0.04$, $p < .001$
Orienting task	$F(2, 137) = 13.95$, $MSE = 0.04$, $p < .001$
Item domain × knowledge level	$F(1, 137) = 18.45$, $MSE = 0.02$, $p < .001$
Item domain × orienting task	$F < 1$
Knowledge level × orienting task	$F < 2.18$
Three-way interaction	$F(2, 137) = 4.75$, $MSE = 0.02$, $p = .01$

Appendix C. Mean hit and false alarm rates from the recognition test in Experiment 1

Orienting task	Sorting	Pleasantness	Both	Across groups
Football categories				
Hits				
High knowledge	.76 (.03)[a]	.85 (.02)[b]	.89 (.02)[b]	.83 (.01)
Low knowledge	.65 (.03)[c]	.73 (.03)[cd]	.76 (.03)[d]	.72 (.02)
False alarms				
High knowledge	.24 (.03)[a]	.19 (.03)[a]	.19 (.03)[a]	.21 (.02)
Low knowledge	.20 (.03)[a]	.38 (.03)[b]	.21 (.03)[a]	.27 (.02)
Cooking categories				
Hits				
High knowledge	.78 (.02)[a]	.73 (.05)[a]	.89 (.02)[b]	.80 (.02)
Low knowledge	.78 (.04)[a]	.76 (.03)[a]	.90 (.02)[b]	.82 (.02)

Appendix C (*continued*)

Orienting task	Sorting	Pleasantness	Both	Across groups
False alarms				
High knowledge	.30 (.03)[a]	.23 (.03)[a]	.29 (.03)[a]	.28 (.02)
Low knowledge	.37 (.04)[a]	.31 (.03)[a]	.30 (.03)[a]	.32 (.02)

Note. Standard errors of the mean are reported in parentheses. Within each category domain, for each response type (hit or false alarm), means in the same row that share a superscript are not significantly different from one another (95% CI includes 0), and means in the same column that share a superscript are not significantly different from one another (95% CI includes 0).

Appendix D. Experimental materials for Experiment 2 (* denotes new item)

Team names	Entrée names
Baltimore Ravens	Veal Saltimbocca
Tennessee Titans	Chicken Cacciatore
Miami Dolphins	Trout Almondine
Philadelphia Eagles	Beef Wellington
St. Louis Rams	Oysters Rockefeller
Arizona Cardinals*	Saag Paneer*
Penalties	Spices
False start	Cilantro
Delay of game	Paprika
Encroachment	Thyme
Pass interference	Sage
Roughing kicker	Nutmeg*
Intentional grounding*	Saffron*
Positions	Utensils
Fullback	Potato ricer*
Tight end	Mandoline*
Punter	Cheesecloth*
Center	Food mill*
Linebacker*	Balloon whisk*
Wide receiver*	Zester*
Player names	Cooking techniques
Tom Brady	Emulsifying
Warren Sapp	Blanching
William Perry	Braising
Randy Moss	Deglazing
Brian Urlacher*	Brining*
Terrell Owens*	Clarifying*
Stadiums	Chefs
Superdome*	Joel Robuchon*
Soldier Field*	Mario Batali*
Lambeau Field*	Paula Deen*
Sun Devil Stadium*	Craig Claiborne*
Mile High Stadium*	Bobby Flay*
Arrowhead Stadium*	Rick Bayless*
Plays/formations	Cookbooks
Flea flicker*	Joy of cooking*
Quarterback sneak*	The greens cookbook*
Deep route*	Southern living*
Empty backfield*	Moosewood cookbook*
Four receiver set*	Silver palate*
Play-action pass*	Good housekeeping illustrated*

Appendix E. Omnibus analyses of variance for Experiment 2

Free recall: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1,260) = 164.01$, $MSE = 85.32$, $p < .001$
Knowledge level	$F(1,260) = 140.28$, $MSE = 85.32$, $p < .001$
Orienting task	$F(2,260) = 5.60$, $MSE = 85.32$, $p = .004$
Item domain × knowledge level	$F(1,260) = 174.30$, $MSE = 85.32$, $p < .001$
Item domain × orienting task	$F(2,260) = 2.84$, $MSE = 85.32$, $p = .060$
Knowledge level × orienting task	$F(2,260) = 5.18$, $MSE = 85.32$, $p = .006$
Three-way interaction	$F(2,260) = 3.12$, $MSE = 85.32$, $p = .046$
Category access: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1,262) = 37.47$, $MSE = 480.59$, $p < .001$
Knowledge level	$F(1,262) = 16.52$, $MSE = 480.59$, $p < .001$
Orienting task	$F(2,262) = 6.00$, $MSE = 480.59$, $p = .003$
Item domain × knowledge level	$F(1,262) = 33.79$, $MSE = 480.59$, $p < .001$
Item domain × orienting task	$F(1,262) = 4.41$, $MSE = 480.59$, $p = .013$
Knowledge level × orienting task	$F(1,262) = 1.75$, $MSE = 480.59$, $p = .176$
Three-way interaction	$F < 1$
Clustering scores: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1,221) = 1.66$, $MSE = .302$, $p = .199$
Knowledge level	$F(1,221) = 1.63$, $MSE = .302$, $p = .203$
Orienting task	$F < 1.02$
Item domain × knowledge level	$F(1,221) = 11.45$, $MSE = .302$, $p = .001$
Item domain × orienting task	$F < 1$
Knowledge level × orienting task	$F < 1$
Three-way interaction	$F < 1$
Items per category accessed: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1,255) = 109.73$, $MSE = 94.29$, $p < .001$
Knowledge level	$F(1,255) = 104.24$, $MSE = 94.29$, $p < .001$
Orienting task	$F(2,255) = 9.53$, $MSE = 94.29$, $p < .001$
Item domain × knowledge level	$F(1,255) = 118.08$, $MSE = 94.29$, $p < .001$
Item domain × orienting task	$F(1,255) = 1.55$, $MSE = 94.29$, $p = .214$
Knowledge level × orienting task	$F(1,255) = 5.24$, $MSE = 94.29$, $p = .006$
Three-way interaction	$F(2,255) = 3.89$, $MSE = 94.29$, $p = .022$
Adjusted recognition: 2 (item domain) × 2 (knowledge level) × 3 (orienting task)	
Item domain	$F(1,260) = 12.33$, $MSE = .020$, $p = .001$
Knowledge level	$F(1,260) = 20.58$, $MSE = .020$, $p < .001$
Orienting task	$F(2,260) = 15.88$, $MSE = .020$, $p < .001$
Item domain × knowledge level	$F(1,260) = 31.82$, $MSE = .020$, $p < .001$
Item domain × orienting task	$F(1,260) = 4.91$, $MSE = .020$, $p = .008$
Knowledge level × orienting task	$F < 1$
Three-way interaction	$F(2,260) = 1.80$, $MSE = .020$, $p = .168$

Appendix F. Mean hit and false alarm rates from the recognition test in Experiment 2

Orienting task	Sorting	Pleasantness	Both	Across groups
Football categories				
Hits				
High knowledge	.68 (.03)^{a}	.79 (.02)^{b}	.79 (.03)^{b}	.76 (.02)
Low knowledge	.67 (.03)^{a}	.69 (.03)^{a}	.71 (.03)^{a}	.69 (.02)
False alarms				
High knowledge	.25 (.03)^{a}	.23 (.03)^{ab}	.17 (.02)^{b}	.21 (.02)
Low knowledge	.37 (.04)^{c}	.35 (.03)^{cd}	.26 (.03)^{d}	.33 (.02)

Appendix F (*continued*)

Orienting task	Sorting	Pleasantness	Both	Across groups
Cooking categories				
Hits				
High knowledge	.71 (.03)[a]	.71 (.04)[a]	.77 (.02)[a]	.73 (.02)
Low knowledge	.70 (.04)[a]	.72 (.04)[a]	.75 (.02)[a]	.72 (.02)
False alarms				
High knowledge	.22 (.03)[a]	.27 (.05)[a]	.20 (.02)[a]	.23 (.02)
Low knowledge	.18 (.02)[a]	.21 (.03)[a]	.20 (.02)[a]	.20 (.01)

Note. Standard errors of the mean are reported in parentheses. Within each category domain, for each response type (hit or false alarm), means in the same row that share a superscript are not significantly different from one another (95% CI includes 0), and means in the same column that share a superscript are not significantly different from one another (95% CI includes 0).

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