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Feature accessibility in conceptual combination: Effects of context-induced relevance

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In conceptual combinations such as *peeled apples*, two kinds of features are potentially accessible: phrase features and noun features. Phrase features are true only of the phrase (e.g., "white"), whereas noun features are true of both the phrase and the head noun (e.g., "round"). When people comprehend such combinations, phrase features are verified more quickly and more accurately than noun features. We examine relevance as an explanation for this phrase feature superiority. If relevance is the critical factor, then contexts that explicitly make noun features relevant and phrase features irrelevant should reverse the phrase feature superiority (i.e., they should make noun features easier to verify than phrase features). Consistent with the relevance hypothesis, brief contexts that made noun features relevant also made those noun features more accessible than phrase features, and vice versa. We conclude that the phrase feature superiority effect is attributable to the discourse strategy of assigning relevance to modifiers in combinations, unless a context indicates otherwise.

How do people understand conceptual combinations such as *pet bird* or *peeled apples*, in which the first word is the modifier and the second is the head noun? Perhaps the most parsimonious mechanism is suggested by compositional theories of semantics. Compositional models posit a two-stage process in which the features of each member of the conceptual combination are first accessed independently and are only later, in a second stage, combined to yield the features of the conceptual combination (Springer & Murphy, 1992). This compositional combination is appealing and sometimes could work. For a concept such as *red apples*, the feature "red" and the features of "apples" combine to yield apples that have the color red.

However, there are many conceptual combinations for which the strict compositional model fails. For example, the feature "white" of peeled apples cannot come from either the modifier peeled or the head noun apples because neither peeled things nor apples are generally white. Similarly, for the combination *pet bird*, most people agree that this could mean a bird that talks, even though neither pets nor birds typically talk (Hampton, 1987). These features emerge from the combined concept as a whole, not from its constituent parts. Such features are called *phrase features*, because they are true of the combination but are true of neither the head noun nor the modifier in isolation. That is, peeled apples are white, though neither apples nor peeled things in general are white. Phrase features are contrasted with *noun features*, which are true of both the combined concept and the head noun in isolation. For instance, "round" is a noun feature in that both peeled apples and apples in general are round.[1]

In order to account for emergent phrase features, some combinatorial models incorporate elaborative mechanisms. Smith, Osherson, Rips, and Keane (1988), for example, proposed a three-stage model. Like the compositional model, their first and second stages involve an initial spreading activation process that activates the features of each member of the combination, followed by a feature combination stage. However, after the activation and combination of features, world knowledge is used to construct more elaborate representations. Thus, for the combination *leather seats*, the spreading activation process would yield the features of "leather" and of "seats," which would then be combined. Finally, a slower elaborative process could generate emergent features such as "found in luxury automobiles" (Weber, 1989, cited in Springer & Murphy, 1992). The elaboration process may be in the form of inference from world knowledge or retrieval from a phrasal lexicon (Gray & Smith, 1995; Hampton, 1987, 1988; Jackendoff, 1995; Medin & Shoben, 1988; Murphy, 1988, 1990).

Response time studies of feature accessibility seem to provide evidence against not just the compositional model, but against all of the multistage models described above. According to such models, the features of a combination's constituents are accessed first, with the features that are true only of the combination being accessed later in the elaborative stage. Thus, for the combination peeled

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apples, the noun feature "round" should be accessible before the phrase feature "white." This is because "round" is accessed in the initial feature activation stage from the constituent apples, whereas "white" can only be generated in a subsequent elaboration stage from our knowledge of apples and what they look like after being peeled. To test this hypothesis, Springer and Murphy (1992) asked people to verify noun features such as *peeled apples are round* and phrase features such as *peeled apples are white*. Their results were as clear as they were surprising: Phrase features are verified more quickly and more accurately than noun features. Similar findings were reported by Potter and Faulconer (1979) and by Hampton and Springer (1989).

What accounts for this differential accessibility of phrase and noun features? Gagné and Murphy (1996) suggested that the given–new convention might explain the phrase feature superiority. The given–new convention states that information is differentially processed according to whether it is "given" or "new" information (Haviland & Clark, 1974). More specifically, new information is processed prior to given information (Hornby, 1974; Singer, 1976). Gagné and Murphy reasoned that phrase features might be more accessible than noun features because phrase features are new information, whereas noun features are given information. Phrase features are new information because they are true of the combined concept but are not true of either constituent in isolation; they are new to the combination. Noun features, though, are given information because they are true of both the combined concept and the head noun in isolation; they are given in the head noun.

To assess this given–new hypothesis, Gagné and Murphy (1996) embedded conceptual combinations in discourse contexts that were designed to assign new information status to either the modifier or the head noun. For example, if the modifier peeled is repeated twice in a paragraph but the noun apples appears only once, then the repeated modifier might become the given information and the noun would then be the new information. However, this and other similar manipulations failed to eliminate the phrase feature superiority. Phrase feature statements such as *peeled apples are white* were still verified more quickly than were noun feature statements such as *peeled apples are round*. Gagné and Murphy concluded that the given–new convention was not responsible for the phrase feature superiority.

In this paper, we examine relevance (cf. Grice, 1975) as an explanation for the phrase feature superiority. Relevance may explain the phrase feature superiority by positing a default discourse strategy of assuming that, in the absence of an informative context, phrase features are more relevant than noun features. Why would comprehenders make this assumption? We suggest that when the phrase "peeled apples are . . ." is encountered, people assume that peeled apples (instead of just apples) were mentioned in order to highlight some way in which peeled apples might differ from other apples. In other words, phrase features become relevant because they differentiate the combined concept from other members of the head noun category. Thus, phrase features such as "white" and "sticky" would be relevant and appropriate completions of the phrase "peeled apples are . . ." In contrast, the feature "round" does not distinguish peeled apples from apples in general and therefore would be an inappropriate and unexpected completion. This default assumption of relevance, rather than the given–new convention, might explain the phrase feature superiority.

Relevance may sometimes be confounded with Gagné and Murphy's (1996) variable of new versus given information. A feature can be relevant precisely because it is new. For instance, consider this example: "The fire engine was racing to a burning house when it crashed into a retaining wall. The fire engine had spun out of control." Here, the information that the fire engine "had spun out of control" is both new and relevant. However, to see that "newness" is independent of relevance, consider this alternative example: "The fire engine was racing to a burning house when it crashed into a retaining wall. The fire engine was bright red." In this example, the second sentence provides new information, but it is irrelevant. Gagné and Murphy recognized the distinction between given–new and relevance. They noted that their discourse contexts did not directly influence which information was relevant and which was not. Perhaps this was why those contexts did not affect the differential accessibility of noun and phrase features. We tested this hypothesis in the present experiment.

Many studies have demonstrated that relevant contexts facilitate access to the features of simple concepts (e.g., apples), using sentence verification (McKoon & Ratcliff, 1988; Tabossi, 1982; Tabossi & Johnson-Laird, 1980), lexical decision (Tabossi, 1988), and naming tasks (Hess, Foss, & Carroll, 1995). We used a similar paradigm but tested combined concepts rather than simple concepts. Our hypotheses are that relevant contexts will also facilitate feature verification in combined concepts and that this will hold true irrespective of whether it is a noun feature or a phrase feature. If noun features are relevant, then they should be more accessible than phrase features. If phrase features are relevant, then they should be more accessible than noun features. If relevance is responsible for the phrase feature superiority in neutral contexts, then this superiority should not only be eliminated but should be reversed by contexts that make noun features relevant and phrase features irrelevant.

Given the effects of relevance on features of simple concepts, our hypotheses about relevance and combined concepts may seem obvious. However, recall that other researchers have failed to explain the differential accessibility of noun and phrase features. In fact, Gagné and Murphy (1996) concluded just the opposite of our relevance hypothesis: "Using a context that emphasizes a particular feature makes that feature more difficult to verify than when the feature has not been emphasized in the preceding context" (p. 96). Also, to predict a reversal of such a robust phenomenon as the phrase feature supe-

riority is quite a strong hypothesis. For these and other reasons,[2] our predictions are far from accepted wisdom.

Accordingly, adjective–noun and noun–noun combinations of the sort used by Gagné and Murphy (1996) were embedded in contexts that made either a phrase feature or a noun feature relevant. For the compound peeled apples, for example, either the shape or the color was relevant to the context. Consider the following two contexts: the first in which shape is relevant, and the second in which color is relevant. The alternative verification sentences are at the end of the contexts.

Noun−relevant (shape) context: Alan and Susan were bored one Sunday afternoon, and they decided to play lawn bowling in their back yard. But they didn't have any lawn balls, so they searched around the house. The first things they found were a pair of peeled apples that were going to be used with dinner. They were a little sticky, but they worked just fine.

Phrase−relevant (color) context: Alan was a famous French chef who used fresh fruit to garnish his meals. Each night, he spent half an hour selecting the perfect fruit for the centerpiece. Last night, Alan decided to make a colorful centerpiece. He used orange slices, kiwi, and peeled apples. The centerpiece was gorgeous, until the guests began to eat it.

Noun feature verification: Peeled apples are round.

Phrase feature verification: Peeled apples are white.

We expected phrase features to be verified faster than noun features when they were relevant, and the reverse to be true when noun features were relevant. For instance, when color is relevant, the phrase feature "white" of peeled apples should be more accessible. But when shape is relevant, the noun feature "round" should be more accessible.

METHOD

Participants

Thirty-seven Princeton University undergraduates participated for partial course credit or for pay. All were native speakers of American English.

Design and Materials

The experiment was a 2 (context) × 2 (feature) within-subjects design, with response time and accuracy as dependent measures in a sentence verification paradigm. Feature types were noun and phrase features, as described above. Noun and phrase features were matched for number of syllables. Contexts were brief (typically three or four sentences) and included the critical combined concept (e.g., *peeled apples*) only once. Some contexts and verification sentences were taken from Gagné and Murphy (1996, Experiment 4), although the contexts were edited to make them consistent with our purposes. Examples of the materials are provided in the Appendix. In any given experimental list, 10 contexts emphasized the noun feature, and 10 contexts emphasized the phrase feature, without explicitly stating either feature. Thus, in each list, 20 experimental target sentences were true. Twenty filler contexts concluded with false target sentences (e.g., *Pepperoni pizza is vegetarian*), also taken from Gagné and Murphy's study. To encourage attention to the context paragraphs, each context was followed by a comprehension question. For example, the comprehension questions for the two "peeled apples" scenarios were "Did they bowl in their front yard?" and "Did Alan have his assistant prepare the centerpiece?" For half of these questions, the correct answer was "yes"; for the other half, the correct answer was "no." These questions were fully counterbalanced across conditions. Four lists were constructed such that each consisted of 5 true items in each of the four experimental conditions and 20 false filler items, for a total of 40 items per list. Item order was random for each participant.

Procedure

The procedure followed that of Gagné and Murphy (1996, Experiment 4). The participants read a context paragraph on a computer monitor and pressed the space bar on completion (self-paced). A probe sentence was then presented immediately thereafter in the center of the screen. The participants pressed one of two labeled keys to indicate whether the sentence was true or false. After this response, a comprehension question was presented in the center of the screen, and the participants responded by pressing the appropriate key. This sequence was repeated for all 40 items in the list. The participants were instructed to read the paragraphs at their own pace but to respond to the sentences as quickly as possible without making errors. The task lasted approximately 20 min.

RESULTS

The data of 1 error-prone participant were replaced by data from another participant, providing data from 36 participants in all. Two repeated measures analyses of variance were performed: one using participants as a random factor (F_1) and one using items as a random factor (F_2). Response times of less then 500 msec or more than 5,000 msec (2.6% of the data) were removed from the analyses, as were incorrect responses (12.5%). The comprehension questions were answered with equivalent accuracy rates (90%) across the conditions ($p > .15$). Thus, any differences in verification time across experimental conditions cannot be attributed to differences in comprehension or attention in the different conditions.

Mean response times and percent correct as a function of condition are presented in Table 1. As expected, both response times and accuracy were best in the target-relevant conditions. When phrase features were relevant, they were verified more quickly and more accurately than noun features. But when noun features were relevant, they

Table 1
Means and Standard Deviations of Response Times (in Milliseconds) and Accuracy Rates as a Function of Context Type and Feature Type

	Feature		
	Noun	Phrase	*M*
Noun-Relevant Context			
Response time (msec)			
M	1,980	2,117	2,049
SD	577	551	
Accuracy (%)	89	82	86
Phrase-Relevant Context			
Response time (msec)			
M	2,222	1,921	2,071
SD	621	452	
Accuracy (%)	81	89	85

were verified more quickly and accurately than phrase features. This predicted context × feature type interaction was reliable for both response time [$F_1(1,35) = 21.41$, $p < .01$; $F_2(1,19) = 9.95$, $p < .01$] and accuracy [$F_1(1,35) = 6.67$, $p < .05$; $F_2(1,19) = 8.12$, $p = .01$]. There were no reliable main effects, including no reliable overall phrase feature superiority [$F_1(1,35) = 2.91$, $p = .10$; $F_2(1,19) = 0.82$, $p > .10$]. The main effect of context did not approach significance in either analysis for either dependent measure (all ps $> .40$), indicating that the noun- and phrase-relevant contexts were equally facilitatory. Finally, response times and accuracy in this experiment were comparable to those in other experiments that found the phrase feature superiority using either no contexts (Springer & Murphy, 1992) or neutral contexts (Gagné & Murphy, 1996). This suggests that the contexts that we used did not require extra effort or processing beyond that ordinarily required for items presented in isolation or in neutral contexts. In short, the effects of making one or another feature type relevant is not attributable to any additional, integrative processing beyond what is generally required for sentence verification without any context.

One plausible objection to our finding is that perhaps the contexts were so semantically constrained that the target features were activated by the contexts themselves, and, thus, the experiment had nothing to do with relevance and conceptual combination per se. While we cannot rule out this possibility in the present experiment, other evidence supports our relevance explanation: We also eliminated the phrase feature superiority in another experiment (Estes & Glucksberg, 1999, Experiment 2) in which only a single word (the word *even*) was used as our contextual manipulation of relevance. Target sentences were, for example, *Peeled apples are round*, *Peeled apples are white*, *Even peeled apples are round*, and *Even peeled apples are white*. The idea here was that modifying a combination with the word *even* leads the reader to expect information that the combination has in common with the head noun—that is, noun features. In other words, *even* makes noun features relevant and phrase features irrelevant. We found that the word *even* did slow verification of phrase features but not noun features. This strongly suggests that the effect of relevance is independent of any contextual activation of the target feature.

DISCUSSION

These results are clear: Relevant information is more accessible than irrelevant information, irrespective of whether it is a phrase or noun feature. When noun features are relevant, they are accessed more quickly than phrase features. When phrase features are relevant, they are accessed more quickly than noun features. Apparently, when people understand conceptual combinations in which any number of features are potentially available, feature accessibility is selective, favoring features that are relevant in the particular context. If the context does not make any particular feature relevant, a default strategy is employed. In adjective–noun and noun–noun combinations, the default discourse strategy is to treat the information provided by the modifier as relevant. Hence, when such combinations are encountered in isolation, phrase features are accessed preferentially over noun features. But, as our data indicate, this strategy can be completely overridden by appropriate contexts.

Earlier, we outlined a two-stage compositional model of conceptual combination (cf. Springer & Murphy, 1992) and a three-stage model incorporating world knowledge (Murphy, 1988; Smith et al., 1988), both of which predict that noun features should be accessed prior to phrase features. The phrase feature superiority seems to contradict this prediction, and we found no main effect advantage of noun feature verification in the present experiment. Do these results, then, disconfirm the models? We do not believe so, because sentence verification experiments measure feature accessibility relatively late in the comprehension process. The claim that noun features are accessed before phrase features is a claim about immediate processing. Thus, a more direct test of these two- and three-stage models would probe features very early in the comprehension process. Moss, Tyler, Dalrymple, and Hampton (1997) did just that. In a lexical decision task, they used concept combinations as primes, and probes were either features true of the noun or features true only of the phrase. At a 300-msec stimulus onset asynchrony (SOA), only phrase features were primed. This is consistent with the phrase feature superiority in sentence verification experiments. At a 100-msec SOA, both feature types were primed, showing that, in early processing, phrase features are as accessible as noun features. However, this early accessibility of phrase features is further evidence against both the simple and the augmented compositional models of conceptual combination. Thus, although our results do explain why the phrase feature superiority occurs at later stages of processing, our experiment was not a direct test of combinatorial models.

Given the relatively late probe of the sentence verification paradigm, our study may be framed in the context of encoding specificity (Tulving & Thomson, 1973). Consider the concept "piano." In the context of moving a piano, the feature "heavy" should be more accessible than the feature "musical" and so should serve as a better retrieval cue for the item "piano." In the context of playing a piano, the reverse should hold: "music" is more relevant to that context than is "heavy," and so it should now be the more effective retrieval cue. Anderson and Ortony (1975) presented to-be-remembered items in contexts that favored one or another feature of those concepts and then assessed the relative effectiveness of the alternative features as retrieval cues for that concept in a delayed cued-recall test. Features relevant to the original study context (e.g., "heavy" for moving a piano) were more ef-

fective retrieval cues than features that were not relevant (e.g., "heavy" for playing a piano; see also Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974).

We can thus frame our results as a special case of encoding specificity. When combinations appear either in isolation or in neutral contexts, phrase features will be more accessible than noun features because of the default strategy of focusing on the information provided by the modifier. However, when such compounds appear in contexts in which noun features are relevant, then the relative accessibility of noun and phrase features is completely reversed. People no longer use a default strategy but selectively encode and retrieve features that are relevant in the context. We conclude that the phrase feature superiority effect in the absence of context is the result of a default comprehension strategy that assigns relevance to features introduced by the modifier in adjective–noun and noun–noun combinations.

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NOTES

1. There are phrase features that negate noun features, such as in diced apples, where the apples are no longer round. However, these types of negations are not relevant to the purposes of this research. See Estes and Glucksberg (1998) for a direct manipulation of these sorts of combined concepts, and see Franks (1995) for an excellent discussion of "functional negators" more generally.

2. The combination of concepts involves processes that are not involved in understanding simple concepts. For instance, the modifying concept may function as a local context for the head concept and so could compete with more global contexts, such as our context paragraphs (Hess et al., 1995). In addition, the modifier of a combined concept is often idiosyncratically construed (Wisniewski, 1996) and may be represented in terms of only one of its features (Estes & Glucksberg, 2000), with some features emerging and others being deleted (Franks, 1995; Hampton, 1987, 1988; Medin & Shoben, 1988; Murphy, 1988). These and other differences between simple and combined concepts make it problematic to generalize effects of relevance from simple concepts to combined concepts.

APPENDIX
Examples of Stimuli

Noun context: Tom's thirtieth birthday was coming up. He decided to have a party for his friends. Tom's wife wanted the party to be a big bash that would remind him of his college days, with everyone ending up intoxicated. She bought lots of domestic beer for the bash.
Phrase context: Tom's thirtieth birthday was coming up. He decided to have a party for his friends. Tom's wife wanted the party to be a big bash, but she was also worried because she had just received a large credit card bill. To compromise, they bought domestic beer for the bash.
Noun feature: Domestic beer is alcoholic.
Phrase feature: Domestic beer is cheap.

Noun context: Fred was a real terror of a child. For shooting paper balls through a straw at his teacher, he got lunch duty. The lunch ladies didn't want him around either. As soon as he got to the cafeteria, he threw a rotten banana across the kitchen, yelling "Miss Coldfield, my boomerang didn't come back to me!"
Phrase context: Fred was a modern artist. He was pessimistic, and his paintings were dark and forceful, despite the fact that he included edible subjects in all of his paintings. One afternoon, Fred decided to paint a fruit, so to keep with his pessimistic and dark theme, he painted a rotten banana.
Noun feature: Rotten bananas are curved.
Phrase feature: Rotten bananas are brown.

Noun context: This new store just opened on Main Street. It sells "whole-earth" food, which is basically just food that is good for you and is grown naturally and isn't wasteful. For instance, coconut is good, but you can't eat the shell. Baked potatoes, on the other hand, are better because you can eat the whole thing, not just the insides.
Phrase context: Lola and Herb had been married twenty years before they had their first big fight. They were eating dinner, and Herb managed to make Lola really mad. But since they never fought, they didn't know how to just talk it out. Instead, Lola grabbed some food and hurled it at Herb. Fortunately for him, it was a baked potato, and it didn't hurt much.
Noun feature: Baked potatoes have skin.
Phrase feature: Baked potatoes are soft.

Noun context: Johnny was a typical six year old—full of energy and mischievous. He especially liked to prank people with his rubber snake, Slither. One morning Johnny got up early and put Slither on his sister's pillow. When she woke up, her scream could be heard throughout the house.
Phrase context: Johnny was a typical six year old—full of energy and mischievous. He especially liked to prank people. One morning Johnny tried to prank his sister, but she knew that it was only a rubber snake that he had set on her pillow.
Noun feature: Rubber snakes are scary.
Phrase feature: Rubber snakes are harmless.

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