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Contextual Activation of Features of Combined Concepts

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Abstract

We examine how context affects the accessibility of features of combined concepts. A 'contrast hypothesis' suggests that contrasting a to-be-verified feature in the context hinders its later verification. Results of Experiment 1 instead support a priming hypothesis whereby features are differentially activated by contexts. Experiment 2 demonstrates that this priming effect is positive rather than negative, even when feature verification follows a contextual combined concept that is inconsistent with the to-be-verified feature. We conclude that context can differentially activate features of combined concepts, and that it may do so by way of semantic priming.

Introduction

The question of how concepts combine has received considerable attention recently in the cognitive sciences. This attention may be attributable to the question's broad implications. Concept combination has implications for the structure of concepts (e.g., Franks, 1995; Hampton, 1988; Markman & Wisniewski, 1997; Rips, 1995), the compositionality of semantics (e.g., Kamp & Partee, 1995; Osherson & Smith, 1981), and the comprehension of language (e.g., Gagne & Shoben, 1997; Wisniewski, 1997), among other things. But despite this varied research, little is known of the role that context plays in the comprehension of combined concepts. Does context influence the ease of comprehension? And if so, how? In two experiments, we examine how context affects the accessibility of features of combined concepts.

Combined concepts (e.g., 'peeled apples') may be thought of as consisting of two types of features. *Noun features* are features that are true of both the combined concept and the head noun in isolation. For instance, both 'peeled apples' and 'apples' are "round". However, other features of combined concepts are not true of either of its constituent concepts in isolation. An example of one such *phrase feature* is the feature "white" of 'peeled apples'; neither apples nor peeled things in general are white, though 'peeled apples' are white.

Springer and Murphy (1992) investigated the activation of these different types of features of combined concepts. Participants indicated whether sentences such as 'Peeled apples are round' and 'Peeled apples are white' were true or false. Springer and Murphy found a *phrase feature priority*: phrase features (e.g., "white") were verified faster than were noun features (e.g., "round").

The Role of Context in Comprehension

Relevant contexts facilitate the comprehension of combined concepts. Murphy (1990) found that comprehension of adjective-noun phrases is faster than comprehension of noun-noun phrases after neutral contexts. However, given a relevant context, the difference between adjective- and noun-noun phrases disappears. Gerrig and Murphy (1992) demonstrated that comprehension of an ambiguous combined concept is facilitated by a context suggesting an appropriate interpretation. For example, comprehension of 'snake frown' is facilitated by a preceding context that indicates that a 'dog smile' is a smile in response to a dog.

Gagne and Murphy (1996) examined the effect of context on the availability of noun and phrase features of combined concepts. Specifically, they sought to determine if the given-new contract could account for Springer and Murphy's (1992) finding that phrase features are available prior to noun features. The given-new contract posits that comprehension is influenced by whether information is given (i.e., previously stated or presupposed) or new (Haviland & Clark, 1974), with new information being processed more quickly than given information. Gagne and Murphy's argument is that head nouns of combined concepts are considered given information, whereas the modifier concept is new information. Intuitively stated, the modification of a noun signals that the combined concept somehow differs from the noun in isolation, according to Gricean principles. If a speaker intends to emphasize the round shape of an apple, there is no need to refer to it as a 'peeled apple' because apples in general are round. And furthermore, because apples are round, modifying 'apples' with 'peeled' may serve to shift the focus away from this noun feature and toward features that emerge from the modification instead.

Gagne and Murphy (1996) varied the given-new structure of combined concepts. To accomplish this, they constructed contexts that repeated either the modifier or the head concept in one experiment. For instance, a context might

include 'peeled carrots' and 'peeled apples'. By repeating the modifier, it might come to be considered the given information, and the head noun might then become the new information. If new information is indeed preferentially processed, and this preferential processing can account for the phrase feature priority, then the above manipulation should cause noun features to be verified faster. But a context including 'peeled apples' and 'chopped apples' should yield the usual phrase feature priority, because repeating the head noun serves to establish it as given and the modifier as new information. Results did not support the given-new hypothesis: Phrase features were verified more accurately (though not more quickly) than noun features after either context.

Gagne and Murphy's Experiment 3 employed contexts that either repeated the critical combined concept (e.g., included 'peeled apples' twice), or repeated only the head noun (e.g., included 'organic apples' and 'fresh apples'). The given-new hypothesis again failed to receive support; accuracy for phrase features was higher than that for noun features, regardless of the context. Gagne and Murphy did, however, find that context can influence feature accessibility in combined concepts: Feature verification is faster after a context that contains the critical combined concept twice than after a context that does not include the critical combined concept at all.

Gagne and Murphy next constructed contexts to emphasize the particular feature to be verified, rather than the concept as a whole. By contrasting the critical feature in the context, they reasoned, emphasis would be on that feature, and the phrase feature priority might be upended. To illustrate, a context that includes 'peeled apples' and 'diced apples' contrasts and should emphasize the noun feature "round", while a context embedding 'peeled apples' and 'whole apples' contrasts and emphasizes the phrase feature "white", they argued. This emphasis should lead the noun feature to be verified more quickly and/or accurately following the former context, whereas the phrase feature should be verified more easily following the latter context in which it is contrasted. But contrary to this prediction, they found a significant context-type by feature-type interaction (see Table 1). Gagne and Murphy conclude that "features that have been previously contrasted are harder to verify than features that were not contrasted in the preceding paragraph." We will refer to Gagne and Murphy's conclusion as the *contrast hypothesis*.

Table 1: Mean response times in milliseconds (and accuracy rates in parentheses) for Gagne & Murphy (1996, Exp. 4).

	Feature-type	
Context-type	Noun feature	Phrase feature
Noun-emphasis	2603 (.70)	2334 (.81)
ex: peeled, diced apples →	round	white
Phrase-emphasis	2408 (.83)	2535 (.82)
ex: peeled, whole apples →	round	white

A Semantic Priming Account

An alternative hypothesis of the context effect on the accessibility of features of combined concepts becomes apparent when we recast the data according to the contextual consistency of the critical features. Rather than viewing a context including 'peeled apples' and 'diced apples' as emphasizing the noun feature "round" by virtue of its being contrasted, we suggest viewing this context as consistent with verification of "white" because this feature is true of both peeled and diced apples. Conversely, because "round" is true of 'peeled apples' but false of 'diced apples', this context is inconsistent with verification of the noun feature. Similarly, a context with 'peeled apples' and 'whole apples' may not emphasize the phrase feature "white" by contrasting it, but is instead consistent with the noun feature "round" and inconsistent with the phrase feature "white". Thus, Table 1 can be recast as Table 2.

Table 2: Recasting of Gagne & Murphy (1996, Exp. 4).

	Feature-type	
Context-type	Noun feature	Phrase feature
Consistent	2408 (.83)	2334 (.81)
Inconsistent	2603 (.70)	2535 (.82)

Table 2 reveals that consistent contexts (e.g., 'peeled apples' and 'whole apples' for verification of "round"; 'peeled apples' and 'diced apples' for verification of "white") led to faster verification than did inconsistent contexts (e.g., 'peeled apples' and 'diced apples' for verification of "round"; 'peeled apples' and 'whole apples' for verification of "white"). And the phrase feature priority was present, but small. In the accuracy data, only the verification of noun features after an inconsistent context resulted in an appreciable difference from the other conditions.

Priming may be a better explanation of the results of Gagne and Murphy's Experiment 4 than the given-new hypothesis or the contrast hypothesis. Consistent contexts likely active the critical feature twice, whereas inconsistent contexts activate it only once. This differential activation may account for their results. We conducted 2 experiments to test this semantic priming hypothesis.

Experiment 1

Can the differential accessibility of noun and phrase features be affected by the activation of particular features in a preceding context? The purpose of Experiment 1 was to determine if the finding of Gagne and Murphy's Experiment 4 could be attributed to priming of critical features. We tested this by including only one relevant combined concept in the context, as opposed to the two relevant combined concepts used by Gagne and Murphy. Thus, our contexts included either 'diced apples' or 'whole apples', but did not include 'peeled apples'.

The semantic priming hypothesis predicts main effects of both feature-type, such that phrase features are verified faster and/or more accurately than noun features (cf. Springer & Murphy, 1992), and context-type, such that consistent contexts will lead to easier verification than will inconsistent contexts. The contrast hypothesis—that contextual contrast of the critical feature is responsible for the result—predicts only the phrase feature priority and does not predict any consistency effect because the context includes only one combined concept. If a main effect of consistency is obtained, the result would not be attributable to a contextual contrast.

Materials and Design

The experiment employed a 2 (consistency) X 2 (feature-type) within-subjects design, with response time and accuracy as dependent measures. Feature-types were noun and phrase features, as described above. Contexts were brief, and included one combined concept that shared only its head noun with the critical combined concept. Most contexts and feature verification sentences were taken from Gagne and Murphy (1996, Exp. 4), though the contexts were slightly shortened and altered to accommodate the removal of one of the combined concepts. There were 20 experimental contexts, each having two variations (e.g., containing either a consistent or an inconsistent combined concept). There were also 20 filler contexts with corresponding false sentences (e.g., 'Pepperoni pizza is vegetarian'), also taken from Gagne and Murphy (see Table 3 for examples of stimuli).

Table 3: Examples of stimuli used in Experiment 1.

Contexts	
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 use DICED APPLES/WHOLE APPLES in his creation.	
Verification sentences	
Noun feature:	Peeled apples are round.
Phrase feature:	Peeled apples are white.

Noun and phrase features were matched for number of syllables. Combined concepts embedded in contexts were in lower-case font. Each context contained only one of the combined concepts, and the contextual combined concept and to-be-verified feature determined the consistency of any given item. For instance, if the context contains 'diced apples', the noun feature "round" is inconsistent and the phrase feature "white" is consistent. If the context includes 'whole apples', "round" is consistent and "white" is inconsistent. In addition, a comprehension question was constructed (or, again, taken from Gagne and Murphy, 1996) for each context. For instance, the 'peeled apples' sequence ended with 'Did Alan have his assistant prepare the centerpiece?'. Half of these questions were true, and the truth/falsity of the questions was fully counterbalanced across conditions.

Four lists were constructed such that each consisted of 5 items in each of the 4 experimental cells. Each experimental context appeared in only one of the four cells in each of the lists, with each context rotated through every cell. Item order was randomized within list for each participant.

Participants and Procedure

Forty Princeton University undergraduates participated for partial course credit. All were native speakers of American English, and none participated in both experiments. The procedure followed that of Gagne and Murphy (1996, Exp. 4). Participants read a context paragraph on a computer monitor and pressed the space bar upon completion. Immediately thereafter a probe sentence was presented in the center of the screen. Participants pressed one of two labeled keys to indicate whether the sentence was true or false. After this response, a comprehension question was presented on the screen, and again participants indicated their response by pressing the appropriate key. This sequence was repeated for all 40 items. 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 25 minutes.

Results and Discussion

Accuracy of responses to the comprehension questions did not differ across conditions, $p > .15$, with a mean accuracy of 95%. Hence, the contexts were indeed comprehended equally in each of the conditions. There was no effect of list, $F < 1$, and thus reported analyses collapse across lists. Two repeated measures ANOVAs were conducted: one used participants as a random variable (F_S) and one used items as a random variable (F_I). Incorrect responses (15%) are not included in analyses of response times, nor are response times greater than 10,000 or less than 500ms (1%). See Table 4.

Table 4: Mean response times in milliseconds (and accuracy) by condition in Experiment 1.

	Feature-type	
Context-type	Noun feature	Phrase feature
Consistent	2759 (.81)	2700 (.88)
Inconsistent	3068 (.84)	2846 (.86)

Consistency had a reliable main effect on response time, F_S (1,39) = 5.51, $p < .05$ and F_I (1,18) = 5.34, $p < .05$, such that consistent contexts led to faster feature verification. The main effect of feature-type on response time was significant by participant analysis, F_S (1,39) = 4.53, $p < .05$, and marginal

by item analysis, F_I (1,18) = 3.07, $p < .10$, thus replicating the phrase feature priority. There was also a marginal effect of feature-type on accuracy, F_S (1,39) = 2.99, $p < .10$. No other differences in accuracy were found, and the consistency by feature-type interaction also failed to reach significance in either analysis for either dependent measure.

These results demonstrate that the semantic priming hypothesis can account for the effect of context on the differential accessibility of features of combined concepts. Contextual combined concepts that activate a to-be-verified feature facilitate later verification of that feature in a target combined concept with the same head noun. For instance, the feature "round" is verified of 'peeled apples' faster after a context containing 'whole apples' than after a context containing 'diced apples'.

The results in Table 4 parallel those in Table 2. That is, our Experiment 1 findings are the same as Gagne and Murphy's Experiment 4 findings. Our data replicate the phrase feature priority and show the consistency effect postulated from their data. In both experiments, the verification of noun features following inconsistent contexts seems particularly difficult, accounting for much of the consistency effect. The contrast hypothesis is also called into question: We obtained the same results, but *without* contrasting the critical feature in the context.

Experiment 2

The findings of Experiment 1 render our priming hypothesis more specific and simultaneously more generalizable than the contrast hypothesis. It is more specific in that the priming account does not simply describe the effect, but also explains the process by which context affects feature accessibility. It is more generalizable in that it appears to account for the effect of contexts with single (Experiment 1 above) or multiple (Gagne & Murphy, 1996, Experiment 4) combined concepts. However, Gagne and Murphy confounded the contextual contrast and the order of that contrast (due to their differing hypothesis), and thus the priming hypothesis has yet to be explicitly tested in a controlled experiment with two, rather than one, combined concepts embedded in the context. A more precise manipulation would be useful.

Another issue is whether the priming effects are positive or negative. It may be the case that consistent contexts produce facilitation while inconsistent ones result in inhibition or interference. Alternatively, the different contexts might both yield facilitation. To determine the direction of the differential priming effects found in Experiment 1, we included unrelated baseline contexts in Experiment 2. For instance, prior to verifying a feature of 'peeled apples', participants read a context about a philosophy major and a business major who roomed together in college.

There is reason to doubt that the priming we suggest for inconsistent stimuli would be positive. Positive priming in inconsistent contexts would require a duration of activation of the critical feature across another combined concept not having that feature and across the remainder of the context. For instance, in order for verification of 'Peeled apples are round' to be positively primed by its inconsistent context, activation of "round" from 'peeled apples' in the context must persist through several more seconds of reading (see Table 5 below). But semantic priming has been found to decay rapidly (e.g., Gough, Alford, & Holley-Wilcox, 1981; Meyer, Schvaneveldt, & Ruddy, 1973, cited in Tweedy, Lapinski, & Schvaneveldt, 1977), often persisting through no more than one intervening item. Hence, positive priming from an inconsistent context might be unlikely. More recently, however, Joordens, Becker, and colleagues (Becker, Moscovitch, Behrmann, & Joordens, 1997; Joordens & Becker, 1997) showed that semantic processing can produce priming effects across many intervening items and a duration of several seconds. Due to the semantic nature of our context paragraphs, then, positive priming—even following inconsistent contexts—would not be surprising after all.

The purpose of Experiment 2 was to extend the consistency effect found in Experiment 1 to contexts containing not one but two embedded combined concepts, and to determine the direction of the differential priming effects.

Materials and Design

The experiment used a 2 (feature-type) X 3 (context-type) within-subject design. The materials of Experiment 1 were augmented in two ways: to accommodate the addition of the target combined concept, and to include unrelated baseline contexts. The non-target combined concept always appeared second in the context (after the embedded target combined concept), prior to feature verification (see Table 5 for examples of stimuli).

Table 5: Examples of stimuli used in Experiment 2.

Contexts	
Alan was a famous French chef who used fresh fruit to garnish his meals. Each night, he spent half an hour selecting the perfect PEELED APPLES for the centerpiece. Last night, Alan decided to use DICED APPLES/WHOLE APPLES in his creation.	
Verification sentences	
Noun feature:	Peeled apples are round.
Phrase feature:	Peeled apples are white.

Six lists were created such that each list contained 30 experimental items (5 items in each of the 6 experimental cells) and 30 filler items. Each item was rotated through every experimental cell of the design. As in Experiment 1, verification sentences of the filler items were false, and half of the comprehension questions were true. The truth/falsity of the questions was again fully counterbalanced across

conditions, and order of items was randomized within list for each participant.

Participants and Procedure

Forty-two Princeton University undergraduates participated for partial course credit or for pay. Participants were randomly assigned to one of the six lists, and the procedure and instructions were identical to those used in Experiment 1. The task took an average of 35 minutes to complete.

Results and Discussion

List had no significant effect on response time or accuracy, $p > .05$, so all reported analyses are collapsed across lists. A 2 (feature-type) X 3 (context-type) ANOVA yielded a significant effect of feature-type on the accuracy of responses to the comprehension questions, $F_I (1,29) = 8.02$, $p < .05$: comprehension questions following verification of phrase features were less accurate than following verification of noun features. Incorrect responses (8%) and response times less than 500ms or greater than 10,000ms (1%) were removed from analyses of the response time data.

Only the consistency manipulation had an effect on response times: Consistent contexts led to faster feature verification than did unrelated baseline contexts, $F_S (2,82) = 10.99$, $p < .01$ and $F_I (2,58) = 9.68$, $p < .01$. Planned comparisons revealed that inconsistent contexts also led to faster verification than did unrelated contexts, $t_S (41) = 4.63$, $p < .01$ and $t_I (29) = 4.04$, $p < .01$, though there was no reliable difference in response times for verification following consistent and inconsistent contexts, p's > .50. A significant consistency by feature-type interaction was found in the accuracy data, $F_S (2,82) = 5.19$, $p < .01$ and $F_I (2,58) = 7.08$, $p < .01$. Finally, we examined the two baseline conditions to see if the phrase feature priority holds when verification follows an unrelated context. The only effect was a marginal effect of feature-type on accuracy in the participant analysis, $t_S (41) = 1.95$, $p = .06$, all others $p > .10$ (see Table 6).

Table 6: Mean response times in milliseconds (and accuracy) by condition in Experiment 2.

	Feature-type	
Context-type	Noun feature	Phrase feature
Consistent	2274 (.88)	2302 (.83)
Inconsistent	2442 (.82)	2201 (.92)
Unrelated	2591 (.84)	2537 (.91)

In summary, as compared to unrelated baseline contexts, verification of features of combined concepts is speeded by preceding contexts that are either consistent or inconsistent with the to-be-verified feature. Because the effect of inconsistent contexts was facilitation, results of Experiment 2 do not support the contrast hypothesis—that contextual contrast of to-be-verified features makes later verification of those features more difficult. Furthermore, the priming effect of the context is not reliably greater following consistent than following inconsistent contexts, as one might have expected. However, this lack of a difference may be attributable to the inclusion of the unrelated baseline contexts, for the following reason. Semantic priming has strategic as well as automatic components; the proportion of trials in which the prime (context, in this case) is related to the probe influences priming effects (Tweedy & Lapinski, 1981; Tweedy, Lapinski, & Schvaneveldt, 1977). The unrelated baseline contexts may have affected participants' task strategy, in comparison to Experiment 1.

There was an unanticipated consistency by feature-type interaction in the accuracy data. We also failed to obtain support for phrase feature priority overall. This is not surprising, given its subtle nature (Gagne & Murphy, 1996). These might also be attributable to the finding that the comprehension questions in Experiment 2 were answered more accurately following noun feature verification than phrase feature verification. If participants paid less attention to these contexts for some reason, then context effects would dissipate in these conditions.

General Discussion

Springer and Murphy (1992) found that phrase features are verified more quickly than are noun features of combined concepts. Gagne and Murphy (1996) sought to examine the influence of context on this phrase feature priority. They argued that the given-new contract (Haviland & Clark, 1974) could explain this phrase feature priority. Though they did find that context can effect the accessibility of features of combined concepts, the given-new hypothesis failed to account for their results. Instead, Gagne and Murphy offered the observation that contrasting the to-be-verified feature in a preceding context makes that feature more difficult to verify later—the contrast hypothesis.

We favored a priming account of their data, and tested this in two experiments. We proposed that preceding contexts might affect the availability of features of combined concepts by simply activating those features or not. In addition to demonstrating the phrase feature priority following a context paragraph, Experiment 1 also replicated the result of Gagne and Murphy (1996, Exp. 4), but with only one combined concept in the context. Because the context did not contain two combined concepts, the result cannot be attributed to contextual contrast, and hence the contrast hypothesis is questioned. Contexts containing combined concepts consistent with the critical feature resulted in faster verification of that feature than did contexts inconsistent with the critical feature. The priming hypothesis better accounted for the data: it proved more specific and more generalizable.

In Experiment 2 we altered the contexts so that the critical combined concept and another combined concept were included. We also included baseline contexts, which allowed us to determine the direction of the contextual priming effect. We found that both consistent *and* inconsistent contexts

facilitated verification of features of combined concepts, and this positive priming did not reliably differ between consistent and inconsistent contexts. We have shown that context can differentially activate features of combined concepts, and that it may do so by way of semantic priming.

Another issue relevant to these experiments is compositionality. The phrase feature priority appears to run counter to a compositional semantics, which predicts a two-stage model of concept combination (Springer & Murphy, 1992). A compositional model would predict that features of the constituents are first activated independently, and then in a second stage the intensions of the constituents are combined. Thus, features true of the noun in isolation (e.g., "round") should be available prior to features that emerge only after the combination stage (e.g., "white"). The phrase feature priority seems at odds with this. However, more recent evidence indicates that both noun and phrase features are activated very early, but noun features quickly lose their activation (Moss, Tyler, Dalrymple, & Hampton, 1997). For instance, "yellow" is a noun feature of 'rotten bananas', and "brown" is a phrase feature. At a 100ms SOA in a lexical decision task, both "yellow" and "brown" are primed by 'rotten bananas'. But by 300ms, "yellow" is no longer primed, though "brown" still is. This suggests that noun features are indeed initially activated. So it may be the case that compositionality is not addressed by sentence verification tasks, which tap into later stages of processing. Both early and late processing are interesting and informative research topics.

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