Imagery and the Interpretation of Ambiguous Noun-Noun Combinations

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Abstract

Novel ambiguous N-N combinations were created that had both a thematic relation and a property mapping interpretation (e.g., a cheetah truck = a fast truck vs. a truck for transporting cheetahs). Experiment 1 asked people to generate their own interpretations, which were then classified as involving thematic relations, property mapping or other. Experiment 2 asked people to choose which of the two interpretations was most plausible. Both Experiments showed that instructions to work rapidly through the task led to more thematic relational interpretations, whereas instructions to visualize and reflect more deeply on the problem led to more property mapping. Implications for models of conceptual combination are discussed.

N-N Combination

A number of languages, such as English, Dutch and German, include a mechanism for constructing novel noun phrases by concatenating bare nouns. There already exist many such NN combinations in the language (for example *fire truck* or *steam train*), but the mechanism is also productive allowing construction of indefinitely many novel noun phrases (for example *steam truck* or *fire train).* The mechanisms by which such phrases can be allocated an interpretation have been extensively studied in recent years. For example, Wisniewski (1996, 1997) collected a large database of people's free interpretations of novel combinations. From a qualitative analysis of the data, three main categories of interpretation emerged, each with parallels among more familiar noun phrases. Relation-linking, or thematic relation interpretations as they are also termed, involve the interposition of a semantic relation between the two nouns. The second noun is taken as the head noun (that is it determines the broad referential class of the combination) and the first noun modifies that class through some additional semantic constraint. For example a *robin snake* could be interpreted as a snake that primarily feeds on robins. Here the semantic relation "feeds on" has to be added to the two simple concepts in order to provide the interpretation. Note that there may be indefinitely many such relations that could be found in different cases.

The second category of interpretation described by Wisniewski involved property mapping, by which a salient property of the first (modifier) noun is taken as modifying the second (head) noun. In the case of a *robin snake* an alternative interpretation using property mapping would take a salient feature of robins – such as their red breasts – and map this to the head noun concept snake, thus giving the interpretation of a snake with a red patch on its breast. The success of such interpretations has been shown to depend on two important factors. First the modifier noun should have a well-known and distinctive property – robins should be known for having red breasts. Second, the head noun should have a dimension that can be readily modified by this property. In the case of snakes, this could be problematic since it is not clear in what sense a snake has a breast (Costello & Keane, 2001; Estes & Glucksberg, 2000).

The third kind of interpretation, that will not concern us in this paper is hybridization – where a novel concept is created that belongs (at least to some extent) in both categories. This type of interpretation was generally quite rare in Wisniewski's database.

Models of N-N Combination

Several distinct models have emerged for the explanation of N-N combinations (Gagné, 2000; Murphy, 1990; Wisniewski & Love, 1998). Gagné's CARIN model proposes a single process that incorporates both the relation and the property forms of combination. CARIN proposes that there are a limited number of fairly general semantic relations that are used in the large majority of cases – relations such as USED FOR, MADE OF or FOUND IN. Selection of the appropriate relation is driven by the past history of combinations using the particular modifier involved. Thus people are fastest to generate interpretations that use a relation that is of high frequency for the modifier (Gagné & Shoben, 1997). Should any such relation prove hard to find (as may occur with some novel combinations) then a relation IS SIMILAR TO may be employed, together with the retrieval of a suitable property that can be mapped from the modifier to the head noun. The model therefore predicts that property mapping will be used relatively infrequently, and should take longer to generate, predictions borne out by Gagné (2002).

The major competitor to CARIN is a proposal by

Wisniewski and Love (1998) for a dual processing system. According to this proposal, relations and properties are two independent strategies that may be employed for interpreting NN combinations. In support of this idea, Wisniewski and Love showed that the interpretation of ambiguous combinations such as *spear chisel* or *ant vegetable* could be influenced by priming with 10 combinations that could only be interpreted with either one or the other strategy. They therefore argued that both interpretation strategies are available, and that consequently there may be two independent ways in which an interpretation is sought for a novel combination (for priming of interpretations see also Estes, 2003; Gagné & Shoben, 2002).

Current aims of the research

The aim of our studies was to examine the two interpretation strategies in the light of processing demands. If, as CARIN would predict, property interpretations are used only as a "last resort" when no other thematic interpretation suggests itself, then whenever a reasonable thematic interpretation is available, it should be the preferred interpretation. It should not matter whether participants are working with or without time pressure – the thematic interpretation should normally be preferred.

On the other hand, if there are two processes of interpretation involved, manipulation of the cognitive load may influence which interpretation is arrived at. Specifically if (as is suggested by previous research, Gagné, 2002) relational interpretations are quicker and easier to generate whereas property interpretations take longer, then requiring participants to answer as quickly as possible should favor the relational interpretation of an ambiguous combination. On the other hand, instructions to retrieve and visualize the meanings of the nouns and to reflect carefully on the best interpretation may bias the interpretation in the direction of property interpretations (Wisniewski & Middleton, 2002).

Visualization may be particularly important for the generation of property interpretations because individual information about each concept needs to be retrieved. A thematic relation can be fairly unconstrained by the meaning of the modifier (e.g., a chocolate box, a horse box and a pencil box may all use the CONTAINS relation, regardless of the large semantic differences between chocolate horses and pencils). On the other hand a property relation requires that the salient property of the modifier become available, which will only happen if the distinctive meaning of the modifier is first retrieved.

Accordingly we conducted two studies in which ambiguous NN combinations were given to people to interpret, either under time pressure, or with instructions to respond carefully and after due reflection and visualization of the concepts involved. We argue that CARIN should predict no effect of this manipulation on the level of relation versus property interpretations generated, since if a relational interpretation is available it should always be selected first.

The dual process model would agree with the prediction that relation interpretations will be more likely to be generated when under time pressure, since property interpretations require more detailed retrieval of meanings. For the slow visualization condition however, the dual process model makes no clear prediction, although it would be easier to accommodate a switch in preference with condition within the dual process framework.

Experiment 1

In the first study, participants were presented with N-N pairs and asked to generate their own interpretations. Half performed the task under time pressure, and half were asked to imagine the object first. Proportions of relation and property interpretations were then calculated.

Method

Participants. Forty undergraduate students at City University, London participated for credit. All had English as a first language.

Materials. Property interpretations require a salient modifier property that is relevant to the head noun (Estes & Glucksberg, 2000). In order to generate suitable materials, 30 dimensional adjectives were used in an analogy task that was given to 10 participants to complete. For example participants had to complete phrases such as "*as strong as a _____*". The resulting responses were combined with head nouns in order construct ambiguous N-N combinations such as *ox rope*, which has either the interpretation "a strong rope" or "a rope for use with oxen". Other materials were selected from previous research to generate a total of 25 N-N pairs. The Appendix lists the materials used.

Design and Procedure. Participants were randomly allocated to one of two conditions (20 per condition), and instructions were manipulated between the two. For the Fast condition, the following instructions were given:

> "On the following pages you will find pairs of words. Please think of the first meaning for the phrase that comes to mind. Work as fast as you can through the list. Some phrases may be ambiguous but it is the first meaning you think of that you should give. Please write this meaning in the space next to each pair."

For the Slow condition, the instructions were instead:

> "On the following pages you will find pairs of words. Please read each word very carefully and try to form an image of what kind of thing it may be referring to. Then write a meaning in the space provided that best explains the phrase. Some phrases may be ambiguous

but it is the meaning that on consideration you believe best that you should give."

In order to encourage participants to switch interpretation strategies, four unambiguous NN combinations were used as warm-up items at the start of the list, two with unambiguous property interpretations (e.g., *razor insult*), and two with unambiguous relation interpretations (e.g., *grocery bicycle)*. Two different random list orders were used.

Results and Discussion

Responses were judged by two independent judges, one of whom was blind to the aims of the study. Each response was categorized as Relation, Property or Other. Judges agreed on the classification of 85% of all responses, and disagreements were resolved by discussion. Responses categorized as Other were removed from further analysis. Table 1 shows the mean (and standard deviation) number of interpretations (out of 25) that were categorized as Property or Relation in each condition. (Because 18-29% of responses were rejected as Other, the number of interpretations of each type was free to vary independently).

Table 1: Interpretations generated in Experiment 1

	Condition	
Interpretation	Fast	Slow
Relation	12.6 (5.3)	3.4 (4.0)
Property	8.0 (3.6)	14.4 (4.5)

Table 1 shows a clear cross-over interaction in the preference for a relation or property interpretation as a function of condition. In the Fast condition, relations were used more often that properties, whereas in the Slow condition the pattern was reversed.

ANOVA was run with condition and interpretation type as factors, and with either participants or items as random effects. Neither main effect was significant across both analyses, but the interaction was highly significant (Min $F'(1,56) = 31.1$, $p < .001$).

As expected by CARIN, relations were the preferred interpretation in the Fast condition, consistent with a strategy that considers relations first. However CARIN would not predict the switch to property interpretation in the Slow condition. While not predicting the cross-over interaction, the dual process approach could accommodate this result. It would have to propose that in the slow visualization condition the property interpretation generates a more satisfying interpretation than the relational interpretation. Because the meaning of the modifier is retrieved more fully and a fit found to a dimension of the head, it may be that participants found the resulting interpretation pragmatically more relevant than the more general relation interpretation.

In order to confirm the generality of our results, Experiment 2 used a different dependent measure, and extended the number of conditions to include a neutral control condition, to test the role of imagery in our instructions.

Experiment 2

Experiment 1 asked participants to generate their own responses. In Experiment 2 we instead presented people with two alternative interpretations and asked them to choose the one that they thought the more plausible. It is unclear why a single process model such as CARIN would predict any difference in the selection of a property or a relation interpretation as more plausible as a function of time pressure. On the other hand, if understanding property interpretations is more cognitively demanding, we expect that time pressure will lead to people preferring the relational interpretations, whereas without time pressure they may show no preference. If in addition the instruction to form images leads to discovery of the salient property of the modifier noun, then in the Imagery condition a preference should be expressed for the property interpretation being more plausible.

Method

Participants. Forty-eight students at universities in London participated without reward. Four were discarded because they failed to comply with instructions. One additional participant was recruited in order to rebalance the design.

Materials. A new set of materials was constructed using the same method as before. In addition, 3 different modifier nouns were selected for each head noun, all with the same property and relation interpretations. For example red colored wallpaper, or wallpaper with a pattern depicting a fruit was represented with the three pairs *Cherry wallpaper, Raspberry wallpaper* and *Strawberry wallpaper.* One of each of these pairs was allocated to each of the three conditions, so that three lists of 22 items each were created. A full list of materials is shown in the Appendix.

Design and Procedure. Three conditions were used, varying only in the instructions provided at the start. All participants contributed to each condition. Booklets were constructed with three sections, each with a different instructional condition. Each section contained one of the lists of NN combinations, so that for example section A would contain *cherry wallpaper*, section B *raspberry wallpaper,* and section C *strawberry wallpaper.* Allocation of list to the three conditions was fully rotated across booklets. Order of the three conditions within booklets was also balanced. Each section of the booklet began with an instruction sheet as follows:

Fast condition: “Please read and complete as fast as you can, you have 4 minutes in total”

Control condition: “There is no time limit, please read and choose the most plausible interpretation”

Imagery condition: “Please take your time and form an image of each noun before you choose the most plausible interpretation. For example for encyclopedia writer imagine an encyclopedia and imagine a writer and then select your answer.”

Each section of the booklet contained the list of 22 items with a 1- 5 scale for recording judgments. The scale was printed underneath two interpretations, one on the left and one to the right. One interpretation was a relation and one was based on a property. The scale ratings 1-2 and 4-5 were used to indicate that either the left or the right interpretation was more plausible or most plausible, with the middle value of 3 reserved for a judgment that the two interpretations were equally plausible. Half the property interpretations were placed on the left and half on the right, and order was randomized within each list. There was no time restriction in any condition.

Results

Participants preferred one or other of the interpretations (rather than selecting the middle value of 3) on 86% of trials, and this value did not change significantly with condition. Mean scale values were calculated for each participant and each item under each of the three instructional conditions. A preference for the plausibility of the relation interpretation was scored as a low number and a preference for the property interpretation was scored as a higher number while 3 was the centre of the scale. Means (and SD) were 2.86 (.59) for the Fast condition, 2.96 (.52) for the Control condition, and 3.31 (.50) for the Deep condition.

Neither the Fast nor the Control conditions showed any significant preference for the relation or the property interpretations (means not significantly different from 3), and nor did they differ significantly from each other. However the Imagery condition showed a significant preference for the property interpretation ($t(44) = 4.1$, $p < .001$). Repeated measures ANOVA by subjects and by items was conducted with one factor of condition. The main effect of condition was significant (Min F’ $(2, 131) = 6.81$, $p < .005$), and post hoc comparisons confirmed that the mean rating for the Imagery condition was significantly greater than that for the other two conditions, which did not differ. Overall, 19 of the 22 sets, and 32 of the 45 participants had the highest mean rating in the Imagery condition.

When data just from the first condition presented were analyzed as a between-participants design, the interaction of condition and response was significant ($F(2,42) = 17.7$, $p < .001$), and the control condition differed significantly from both the others. Respectively, the Imagery condition had 11.4 property interpretations and 7.5 thematic, the Control 9.3 and 9.5, and the Fast condition 6.4 property and 13.1 thematic interpretations. It is therefore possible that the difference between the Fast and Control conditions in the main ANOVA was masked by carry-over strategy effects affecting the second and third conditions presented.

Discussion

Experiment 2 tested the generality of the findings from Experiment 1 by asking participants to select one of two interpretations for an ambiguous N-N phrase, rather than to generate their own. The results were broadly in line with the earlier effect. When asked to form images of the concepts involved there was a greater preference for the property interpretations, compared with either a speeded judgment or a standard condition with neutral instructions. It would appear therefore that both time pressure and imagery instructions were responsible for the effect observed in Experiment 1. It is notable that the preference for property interpretations was found even when cognitive load was reduced (comprehension rather than production), and when the instructions to imagine each concept in turn may have encouraged people to visualise relations between the items, rather than properties that could be transfered.

The preference for relation interpretation in the Fast condition was not significant overall, although it did appear when the Fast condition was presented first. Given that the relation interpretations were all plausible (pig house = a house for pigs), CARIN would have predicted that they would be the interpretation that was most easily arrived at. Note however that the materials for Experiment 2 were different from those in the earlier experiment. Note also that when the interpretations are *given* to the participant to read then different processes are most likely invoked in judging which is to be preferred. We hypothesize that the two interpretations were well balanced in the default case of the Control and Fast conditions, but that instructions to visualize the concepts led to a bias towards the property interpretation for reasons similar to the preference for generating property interpretations in Experiment 1.

It was particularly notable that the size of the effect in Experiment 2 was much smaller than in the first experiment. When participants had to generate their own interpretations, there was a much larger effect of instruction. This difference could be expected, given that a production task is likely to place a heavier cognitive load on the participant, and so be more sensitive to instructions.

General Discussion

Two accounts of conceptual combination for N-N combinations have been compared. The CARIN model

(Gagné, 2002) argues for a single process based on the retrieval and confirmation of an appropriate thematic relation. Only in the case that such a relation fails to be retrieved may people then turn to property interpretations, under the general relation of IS LIKE. Alternatively, Wisniewski and others have argued that property interpretations are generated by a separate independent process.

The results of our experiments favor the second of these two accounts. Given that under time pressure people are able to generate and choose relational interpretations just as readily as property interpretations, it is not clear why they should then show a marked preference for generating and selecting property interpretations rather than relation interpretations in the Deep/Imagery conditions.

Generating and comprehending property interpretations for NN combinations appears to be a more effortful process. Whereas the relations involved in interpretation are often quite general (for example CARIN proposes a limited set of 15 such relations), the property interpretations require more detailed information to be retrieved about the modifier category. Experiment 1 clearly indicated that where a relation interpretation exists, then the "first meaning that comes to mind" is more often a relation. However when given the time to consider the meaning of each noun in a more reflective mode, a strong preference was shown for generating a property relation.

Our results place new constraints on models of how N-N phrases are interpreted. They strongly suggest that there are strategic effects involved (in keeping with earlier demonstrations of priming effects on interpretation, Wisniewski & Love, 1998), and that a single process account is unlikely to capture the full range of observable phenomena.

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Appendix

1) Materials used in Experiment 1

Unambiguous Fillers

Butcher Surgeon	Grocery Bicycle
Razor Insult	Adultery Sermon

Ambiguous Targets

Cheetah Train	House Truck	Spider Chair	Porcupine Cushion
Skyscraper Plant	Fossil Book	Book Magazine	Rock Head
Ox Rope	Sheet Space	Strawberry Box	Ice Foot
Fox Puzzle	Snail Cart	Mule Manager	Butterfly Girl
Mouse Teacher	Feather Purse	Ant Vegetable	Elephant Boat
Oven Room	Pig Socks	Doughnut Table	Skunk Perfume
		Zebra Jeep	

2) Materials used in Experiment 2

Modifier 1	Modifier 2	Modifier 3	Head noun	Relation Interpretation	Property Interpretation
dung	skunk	trash	perfume	perfume used to cover dung odor	stinky perfume
tower	giraffe	skyscraper	tree	tree that looks like a tower	tall tree
frost	ice	snow	toe	toe covered by frost	cold toe
stick	sheet	paper	space	space for sticks	thin space
stove	fire	oven	room	room that the stove is in	hot room
pin	razor	knife	beak	bird's beak shaped like a pin	sharp beak
kitten	baby	child	shelf	shelf holding kitten ornaments	weak shelf
iron	rock	steel	doughnut	iron shaped like a doughnut	hard doughnut
mouse	rabbit	hare	teacher	person who teaches mice to perform at the circus	timid teacher
leopard	zebra	tiger	socks	therapeutic socks used on leopards	yellow and black spotted socks
quill	feather	cotton	purse	purse that holds quills	light purse
cherry	strawberry	raspberry	wallpaper	wallpaper with a cherry pattern	red wallpaper
cheetah	rocket	bullet	truck	special truck for transporting cheetahs	fast truck
snail	sloth	turtle	train	a line of snails marching closely	slow train
fox	dingo	wolf	holiday	holiday watching wild foxes	wild holiday
book	block	slab	magazine	magazine about books	thick magazine
octopus	arachnid	spider	table	table serving octopus	table with eight legs
dinosaur	antique	fossil	scientist	scientist who studies dinosaurs	very old scientist
hedgehog	cactus	porcupine	cushion	cushion with hedgehog design	prickly cushion
mule	bull	donkey	manager	person who is in charge of mules at a zoo/fair	stubborn manager
peacock	flower	butterfly	dress	dress with peacocks on it	pretty dress
pig	sow	hog	house	house for pigs	dirty house