EMERGENT ATTRIBUTES IN COMBINED CONCEPTS

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The aim of this chapter is to review recent evidence on the creative processes involved when concepts are combined in conjunctions. Shoben and Wisniewski (each in this volume) have written about their research into a particularly interesting form of conceptual combination, namely noun-noun and adjective-noun modification in English. Many of these combinations are "non-predicating" in the simple sense that the combined concept does not refer to a category formed by the conjunction of the two constituent concept categories. For example "school furniture" does not normally refer to the overlap of the two sets of schools and furniture. If it did, then presumably it would refer to an empty set in the normal world. These combinations are of particular interest for the study of creative cognitive processes, because when faced with novel combinations out of context, one is forced to a leap of the imagination to construct a sensible interpretation. This process is used to good effect by the *Farside* cartoonist Gary Larson. In numerous cartoons he takes an unusual conceptual combination and draws an interpretation with comic effects. For example, in one cartoon two cave men ride through the air on their "time log", while in another a most un-warlike tribe of savages are playing "jungle triangles".

In contrast, the main focus of my own research (Hampton, 1986, 1987, 1988a, 1988b, 1991, 1996a, 1996b) has been conceptual combinations that are (at least *prima facie*) predicating or intersective conjunctive combinations - where the complex concept refers (apparently) to the overlap of things which are in both constituent concept categories. There are some noun-noun and adjective-noun combinations that have this interpretation - for example "pet fish" or "veterinary surgeon". To force a more explicit conjunctive interpretation and to remove the multiple ambiguity that is possible in novel combinations, the research has used relative clause constructions. So to refer to the overlap between two sets A and B, I have used the expressions "A which are also B", and "B which are also A". (Logically equivalent expressions in terms of their set extensions, although not always psychologically equivalent.)

Interest in these conjunctive concepts has focused on two aspects, one extensional and the other intensional. The extensional aspect concerns how the category membership of such concepts is related to the category membership of their two constituents (Hampton, 1988b, 1996a). If the concepts are true conjunctions, then category membership in the conjunctive concept should be restricted to just those instances which are members of both constituent concept categories. The second, intensional, question concerns what attributes are seen as characterizing or defining the conjunction, and how these relate to the attributes of each constituent concept (Hampton, 1987; Hampton & Dillane, 1993).

The issue of creativity enters this process with the demonstration that in spite of their apparent simplicity such combinations are not straight-forwardly compositional. Across a range of experiments and materials it appears, for example, that people are prepared to loosen the criterion for category membership when considering conjunctive classes. People will frequently place in the conjunctive category items which they have excluded from one of the constituents. For example they may judge Chess to be a typical game, but judge it not to be a sport. However when asked subsequently whether it is a "Sport which is a Game", they often say yes. Hampton (1988b) argued that people are judging membership in conjunctive concept categories on the basis of similarity to a composite prototype representation of the conjunction. Such similarity-based

categorization then gives rise to non-logical effects (Hampton, 1995). The broadening of category criteria seen in these studies can be seen as closely related to issues of polysemy, and the flexible shift in the meaning of terms across different contexts (see Murphy, this volume).

On the intensional side, we find that most of the attributes of the constituent concepts are also commonly considered to be true of the conjunction - a result called *Attribute Inheritance*. Attribute Inheritance is a common characteristic of knowledge representation systems in Artificial Intelligence (and has been developed as a basic mechanism of object-oriented computer programming languages). If a property is generally true of a class, then it should also be generally true of subsets of that class. For example if it is true that all fish have gills, then having gills should also be true of Scottish fish, pet fish, salmon, tropical fish or any other subset of the general class. It follows that if one forms the conjunction (set overlap) of two categories, then all the attributes which are true of each category should also be true of the conjunction.

However attribute inheritance for common semantic categories does not always follow this axiom. The problem is that as Rosch and Mervis (1975) and others (Hampton, 1979, 1981) have shown, many of the attributes which people list as true of a category, are not universally true of that category. People asked to describe a category such as "bird" by listing different properties will typically generate a list such as the following:

has wings
flies
has feathers
is light-weight
has a beak
lays eggs
has two legs
migrates in winter

No differentiation is made by subjects between attributes which are true of the whole class (such as having feathers, a beak and two legs), and those which are true of a majority of the class (such as flying, being light-weight and migrating in winter). When one examines the pattern of Attribute Inheritance for such categories (Hampton, 1987), it appears that people do follow the logical rule for those attributes which they consider necessary or universally true of the class. Other attributes however, properties which are only "generally true" of one constituent category, may sometimes not get inherited. I call this case "attribute inheritance failure" - properties that are true of a constituent, but not of the conjunction. The converse of inheritance failure is the finding of "emergent attributes". These are attributes which are never generated as true of either constituent, nor judged to be true of either constituent, but which are nonetheless considered to be true of the conjunction. It is these emergent attributes that are perhaps the most interesting source of creativity in the process of concept conjunction, using "creativity" in the sense in which Barsalou (this volume) uses it -- of mundane processes that generate apparently novel information. It is on emergent attributes that this chapter will focus. Table 1 shows the different possible outcomes of an attribute inheritance experiment.

INSERT TABLE 1 ABOUT HERE

Emergent attributes

Why do we see emergent attributes in concept conjunctions, and what can we learn from them about the nature of semantic representations of concepts and the creative processes that use them?

Emergent attributes probably arise from two different processes. The first is based on a knowledge of particular object classes in the world that happen to fall in the conjunction. For example, "pets which are also birds" are judged to *live in cages* and to *talk*, and these properties are considered false of "pets" or "birds" considered separately. The fact that pet birds talk could not be derived from any knowledge of pets or birds - it is an accidental fact about the domestication of particular bird species like parrots and mynah birds. (There are probably good justifications that can be offered to explain why these birds make popular pets. The point is that one could not predict *a priori* that pet birds would have this property). These extension-based emergent attributes should not therefore be considered as the result of creative cognitive processes - they break what Lance Rips has called the No Peeking Principle (Rips, 1995). Elsewhere (Hampton, 1988b) I refer to such examples as cases of extensional feedback. This is to say that we use a conceptual combination such as "pet bird" to identify an extensional set of instances (parrots, parakeets etc.) and then knowledge of these individuals takes over.

The second process for generating emergent properties involves construction of a possible scenario for the conjunctive category. When faced with a novel conjunction - for example "snake that is also a pet", or "hand grenade that is also a toy", we are required to turn to what Rips, or Murphy would refer to as the "theory" of the domain in which the concepts are embedded (Murphy & Medin, 1985). We need to construct a mental model of a member of the conjunctive category, and to resolve some of the possible conflicts between the two concepts. If someone was unfamiliar with pet birds, it is still possible that they would come up with the attribute *live in cages*. They might produce this attribute through noting the inconsistency of keeping a domesticated animal that is able to fly long distances, is hard to catch, can feed itself in the wild and is not desirous of human company. (Alternatively they might suppose that pet birds have *clipped wings*). Similarly the idea of a pet snake, or even a pet skunk brings to mind the problems that are potentially involved in a scenario in which a snake or skunk is allowed into the relatively civilised environment of one's home. It could therefore be inferred from consideration of such scenarios that the pet snake should have no venom gland, and that the pet skunk should have no capability to stink up the house. In order to achieve this, either surgery (or possibly genetic engineering) might be proposed. Emergent properties then may arise as a solution to a perceived problem arising from the combination of the two concepts.

Emergent attributes - evidence

It is often easier to generate examples of emergent attributes in an anecdotal fashion, than to obtain hard evidence for them. I propose to review in broad terms the results of a number of studies in which emergent attributes figured as a topic of interest. Most of the studies involved attribute generation and rating tasks. Groups of subjects generated attributes for two constituents, and for their conjunction. Further groups then rated the full list of attributes for their applicability or appropriateness as descriptions of the two constituents and their conjunction. Emergent attributes are defined in these studies as those which are rated as true of neither constituent, but are nonetheless rated as true of

the conjunction. The final study to be reported involved asking subjects to give descriptions of conjunctions of sets that do not normally overlap.

In each case, there are a lot of data which I will not be discussing. Fuller accounts can be found elsewhere for many of the studies. My intention in this chapter is to focus on the following simple questions. What is the rate of emergent attributes in conjunctions, what kind of attributes are they, and what processes have given rise to them? We can then use this information to get some idea of the level of creativity involved in the interpretation of such phrases.

a) Conjunctions of semantic categories

Table 2 shows examples of emergent properties that were found in the study reported in Hampton (1987). To recap the procedure, different groups of subjects first generated attributes which they felt were true of either one or the other constituent, or of the conjunction. From these listings, a final list of all attributes generated to the pair of categories was drawn up and new groups of subjects made ratings of how "important" each attribute was for either one or the other constituent or for their conjunction. From these importance ratings, a scale of importance was created, and emergent attributes were identified as those with a rating above the midpoint of the scale for the conjunction, but below the midpoint of the scale for each of the constituents (full details can be found in Hampton, 1987). Two methods of scoring were used to identify emergent attributes. A strict scoring required the attribute to be rated as Unimportant for both constituents and Important for both ways of ordering the conjunction ("Birds which are Pets", and "Pets which are Birds"). Under strict scoring only a total of 3 attributes out of 174 were classified as emergent. A more lenient method of scoring allowed the attribute to be important for either version of the conjunction, and produced 11 emergent attributes. These are shown in Table 2. (Five other conjunctions had no emergent attributes at all.)

INSERT TABLE 2 ABOUT HERE

It will be seen in Table 2 that emergent properties are more common in categories that have a low set overlap - for example most Pets are not Birds, and most Birds are not Pets, and this pair of categories show more emergent properties. Where the degree of overlap is quite high (as with Machines and Vehicles, or Sports and Games) the level of emergent attributes is much lower. It is also apparent that the incidence of emergent attributes is quite low (of 37 attributes judged to be unimportant for both constituents, only some 8% were judged important for both forms of the conjunction).

The actual examples of emergent attributes show that most of them are of the extensional feedback kind - Pet Birds which talk. Other attributes like *Is small* or *Is large* need to be treated with caution since they are inherently relative to some unspecified standard. In view of the small number of emergent attributes, it must be concluded that there is relatively little evidence for creative emergence as a result of problem solving or conflict resolution in these conjunctions.

b) Conjunctions with a negated constituent

In another series of experiments, (Hampton, 1989), a similar procedure was applied to conjunctions in which the constituent in the relative clause was negated. We now have conjunctions like

Buildings which are not Dwellings
Vehicles which are not Machines

In a study of attribute inheritance with these categories, subjects this time rated the proportion of each category for which an attribute was true. By using negated constituents a test of emergent properties can be applied which should rule out those that are the result of extensional feedback. If an attribute is judged to be true of none of the head noun category (e.g. Buildings), then it should follow that it is also true of none of any subset of the category (e.g. Buildings which are not Dwellings).

Emergent attributes were defined then as those rated as having a frequency of 0% for the head noun category A, but a frequency greater than zero for "A which are not B". (We cannot define emergence here in terms of attributes that are false for the relative clause constituent, since there is no logical link between the frequency of an attribute for class B and its frequency for the class "not B". Whether a property is 100% or 0% true of Dwellings, we can make no inference about its frequency for some class that is "not Dwellings").

Across six category pairs, there were 51 attributes with median rated proportion for A of 0%, and of these 24 were also considered to be 0% true of "A which are not B" (i.e. they followed the logic of the situation). 11 violated the constraint but only slightly (median of 0-5% for the conjunction) and so could be the result of statistical noise. Only 6 attributes in the whole study had ratings of 10% or more for the conjunction "A which are not B", and 0% for the category A alone. These six "emergent attributes" are shown in Table 3.

INSERT TABLE 3 ABOUT HERE

The emergent attributes are evidence for a broadening of conceptual categories once they are modified. Dwellings are not seen as for relaxation out of the home - people typically imagine that a dwelling and a home are synonymous. When asked to consider dwellings which are not buildings, then the category of temporary dwellings - like a tent used on a camping trip - come to be included in the more general category. The same appears to work for the Vehicles example - an extending of the category from mechanical means of transport to a broader category of any means of transport. Stretching of concepts appears to be a source of emergent attributes - and a part of creative cognition as well, as has often been identified in the problem solving tradition of psychology (see for example, Boden, 1991; Johnson-Laird, 1988). It is also notable however that, just as with the first study, relatively few truly emergent attributes were found, and those that were depended largely on finding familiar instances, rather than creating novel solutions to the problem.

c) Personality traits

While considering different studies of attribute inheritance, it is worthwhile to describe briefly a study by Hampson (1990). Hampson took pairs of personality traits which could either be congruent (*Unsociable and unfriendly*) or incongruent (*Thorough and haphazard*). Earlier work by Asch (1946) showed how almost any pair of traits can be imagined to co-occur in an individual. In Hampson's study groups of subjects generated behaviours which were either likely or unlikely for each trait considered alone, and for the traits in conjunction. Other groups then made likelihood ratings of the behaviours for each constituent and their conjunction. The results were analysed for attribute inheritance along the same lines as in Hampton (1987). For congruent traits, Hampson found complete attribute inheritance. If a behaviour was likely for either constituent then it was likely for the conjunction, and if it was unlikely for both

constituents it was unlikely for the conjunction. This pattern occurred for 31 of the 32 attributes. For incongruent pairs of traits, however 16 out of 25 behaviours that were likely for at least one constituent were inherited by the conjunction, while the other 9 failed to be inherited. Some interaction between the traits was thus occurring for the incongruent traits. Interestingly, from the point of view of the present chapter, there were no emergent attributes observed in any of the trait pairs. Although subjects were encouraged to imagine behaviours that would be likely for people with incongruent traits, they did not apparently generate behaviours that were at the same time unlikely of the two constituent traits.

While inheritance failure is not as clear an example of creative processing as is emergence, it can also be seen as evidence for a form of creativity. When two incongruent traits are combined, and behaviors considered likely for one constituent are now no longer considered probable for the conjunction, then this is evidence that a novel concept has been constructed out of the two constituent traits. Certain behaviors are inherited, and others are not, and this process of selectivity shows the creation of a novel personality trait.

d) Social categories

A richer domain for investigating how fuzzy categories combine is the area of social categorization, involving occupational and social stereotypes. A recent project that I have been conducting with Margaret Dillane and Laura Oren, involves taking inconsistent social stereotypes, and forming their conjunctions. Earlier studies that followed this procedure (e.g. Kunda, Miller & Clare, 1990; Hastie, Schroeder & Weber, 1990) found that people are inclined to generate emergent attributes in order to "explain" the apparent contradiction. If asked to describe a "Harvard-educated carpenter", subjects in the Kunda et al. study might describe possible reasons why a Harvard educated person should become a carpenter - college drop-out, disillusionment with the business world, or alternatively an ambition to build very high quality craft-designed furniture.

Kunda et al. applied a relatively qualitative research method to the problem. Hastie et al. used a more quantitative approach in their second experiment. Congruent and incongruent pairs of stereotypes were constructed, such as *Feminist Social Worker* and *Republican Bank Teller* (which were congruent) versus *Feminist Bank Teller* and *Republican Social Worker* (which were incongruent). Subjects rated such conjunctions and their individual component concepts on a series of 15 bipolar personality dimensions, such as *Ambitious - Unambitious*, or *Warm - Cold*. The results were then analysed individually for each subject, to find cases where the rating on a dimension for the conjunction fell at least one scale step outside the range defined by the two component concepts. These cases were taken as evidence of emergent properties, since they showed a judgment of a personality trait that was neither simply inherited from one of the constituent concepts, nor an average of the two constituents. A high proportion of conjunctive ratings were of this kind, 23% for congruent and 33% for incongruent conjunctions. This study therefore confirms that social categories are a rich source of emergent properties. Hastie et al. also asked subjects to think aloud while making their judgments, and analysed the possible sources of emergent attributes into three processes. First, some people brought to mind a relevant case from memory - they knew someone who was at least similar to the stereotype being constructed, and so could use that case as a basis for generalisation. Second, people sometimes appealed to general rules about life

- for example that any woman doing a man's job would have to have certain qualities. In this case a more deductive inference was made, through identifying the conjunction as an example of some more general category. Third, a final strategy was to conduct a "mental simulation" of the scenario, including mental images and elaboration of how the person would react to the incongruent situation in which they found themselves. This third strategy is probably the closest to the process of creativity, involving as it does imagination and the creation of a novel scenario.

We were interested in studying this process of resolving incongruent social stereotypes, and in seeing whether it could be affected by a manipulation of the background "theory" that people applied to the task. To manipulate the background context, we asked people to adopt the point of view of a particular social group - a manipulation that was first introduced into the field by Barsalou and Sewell, and which was shown to have a marked effect on typicality ratings in taxonomic and goal-derived categories (Barsalou, 1987).

Our task involved people making judgments about two constituent categories which were always incongruent pairs -- for example a Socialist, and a Stockbroker -- and then about their conjunction -- a Socialist Stockbroker. In doing the task, people were asked to take one of two points of view; either that of a Socialist, or that of a Stockbroker. The procedure involved different groups of subjects who first generated possible descriptive attributes for either constituent or the conjunction from either point of view. A second set of subjects then rated the appropriateness of the descriptions generated for each of the categories from each point of view.

Point of view had a huge effect on the attributes considered true of the conjunction. The most common pattern, found in seven of the eight sets of materials for the first experiment, was one of antagonism. If taking a Socialist point of view, then a Socialist Stockbroker was considered to be largely similar to any other Stockbroker, and to share few of the positive attributes of other Socialists. Appropriateness of the attributes for the conjunction was largely predicted by appropriateness for the "other" constituent category - the one other than the adopted point of view. The same was true for those taking the Stockbroker's point of view - Socialist Stockbrokers were little different from other Socialists for this group of people. As a result, there was very little correlation between the two sets of attribute appropriateness ratings when comparing one point of view with another.

When attribute inheritance was investigated, there were however evidence for some emergent attributes. Table 4 shows the attribute inheritance pattern for all attributes. To help with the interpretation attributes were divided on the basis of the ratings of a new group of subjects into those which were positively evaluated (i.e. good things to be) for the point of view, and those that were negative.

INSERT TABLE 4 ABOUT HERE

Out of 210 attributes across the four pairs of categories, only 2 were judged true of both categories. Of the remainder 65 (all positive) were judged true of one's own point of view, of which only 11 (17%) were inherited by the conjunction. There were 80 attributes that were judged as true of the "other" category, the majority (84%) of which were evaluated negatively, and 55 (69%) of which were inherited by the conjunction. The pattern of antagonistic interpretation of the conjunction was therefore confirmed in

this analysis, with the majority of inherited attributes being negatively evaluated and considered true of the "other" category from the point of view adopted.

There were also a total of 63 attributes that were false of both constituents, of which 22 (35%) were considered true of the conjunction, and therefore emergent. These attributes are shown in Table 5. Some of these were not particularly surprising, tending to be obvious attributes such as "confused" or "inconsistent", which describe the fact that the categories are uncommon as conjunctions.

INSERT TABLE 5 ABOUT HERE

The pair which gave most emergent attributes was the Oxford Graduate-Factory worker pair. There was evidence that the Oxford Graduate point of view attributed membership of the conjunction to laziness, disaffection or mental illness, whereas the Factory Worker attributed it to failure and under-achievement. It might have been expected that cases like Socialist Stockbroker would engender attributes such as *Is a hypocrite*. This attribute was indeed commonly rated as true of the conjunction, but did not turn out to be emergent, because from each point of view it was also seen as being true of the opposing constituent category already!

A second experiment manipulated the gender consistency inherent in the point of view adopted. The experiment involved a further series of 8 pairs of social stereotypes, all of which were linked with gender. One of each pair was traditionally a typical male occupation, while the other was a typical female one. For example one of the pairs was a "car mechanic who reads romantic fiction". Half the subjects were told that this applied to a man, and half that it applied to a woman. Different groups of subjects generated descriptive attributes from different points of view, while others rated their appropriateness - again from a particular point of view. The full design involved twelve different sets of judgments, obtained from twelve different groups of participants. Taking the car mechanic who reads romantic fiction as an example, one group was asked to take the point of view of a male car mechanic (a Gender consistent point of view) and judge the appropriateness of the attributes for describing a male car mechanic. A second group judged the same category (male car mechanic) but took the point of view of a male who reads romantic fiction (a Gender inconsistent point of view). A third and a fourth group judged the alternative category (a male who reads romantic fiction) from the same two points of view respectively. The fifth and sixth groups judged the combined category (a male car mechanic who reads romantic fiction) from the same two points of view again. Finally groups seven to twelve repeated the whole design with the same categories, but with female points of view about females, in place of male points of view about males.

Emergent attributes were analyzed for each point of view and each gender. Examples are shown in Table 6.

INSERT TABLE 6 ABOUT HERE

The patterns in this data are complex. It appears that there are some small differences between gender consistent and gender inconsistent points of view, and much larger differences between the male and female versions of the materials (subjects of both sexes contributed to both halves of the design). The pattern of antagonism was found more commonly when the point of view was a gender consistent one (for example a male fighter pilot, or a female child minder). It was also much more common for the male points of view to be antagonistic than for the female points of view. Female points of

view tended to be more integrational - taking good and bad points from each constituent. Note also in Table 6 how the female points of view about females tended to involve many more positively valued emergent attributes than the equivalent male categories. At a rough count, for the men there were 19 negative attributes and only 8 positive, whereas for the women there were 34 positive attributes and only 3 negative. Male points of view appeared to take a much more negative and antagonistic view of the conjunction than did female points of view. It is interesting (but beyond the scope of this chapter) to speculate on the meaning of this result for British culture and gender stereotypes. It is apparent that male points of view are more antagonistic, and that males are less able to belong to incongruent categories without being seen in a primarily negative way by those who belong in only one of the categories. These results must however be tempered with the important caveat that these are the opinions of people adopting points of view rather than the opinions of people actually in the social categories. It is indeed a remarkable feat of creativity that people are able to perform this task with such apparently clear and systematic results. The ability to adopt the point of view of others is surely at the heart of our empathetic understanding of each other.

Imagination and concept conjunctions

The final study to be reported concerns imaginary objects. The original aim of this small study was to ask people to combine concepts which could not ordinarily be combined, and hence to place the flexibility of their concepts under considerable strain. The procedure was to ask people to imagine apparently contradictory or impossible objects. When they have to do this, they are forced to stretch and bend their concepts to meet the constraints of the task. The procedure may therefore bring to the fore those creative and problem solving strategies that may normally be applied in cases of novel conceptual combination. From the point of view of the theory of concept representation, the procedure can also by understood by analogy with an atom smasher in physics - what bits fly off, and what remains at the core? As concepts are stretched, how do they change?

The study used the nine concept pairs shown in Table 7 and the following instructions:

> *"Try to imagine each object and describe as fully as possible attributes which you would expect it to have, and ways in which it would differ from more typical examples of the same categories. Use drawings if you wish. After each one rate how hard it was to imagine. (Scale 1=easy , 4=hard)"*

The mean rated difficulty of each pair of concepts is also shown in Table 7. One group of 10 subjects received the concepts paired in one order, and another group of 10 were given the reverse order for each pair. One subject failed to complete the task and was excluded from the data analysis.

INSERT TABLE 7 ABOUT HERE

Overall, one order group found the task easier that the other, and there were also significant differences in difficulty between the different pairs. The interaction was not significant, so that it is likely that difference of order reflected subject differences rather than a real difference between the A-B and B-A orders. The hardest pair for both groups was "A food flavoring that is also a kind of Tool".

There are many notable features of these data. One is the degree of variability between participants in the amount of creative ingenuity shown. For the purposes of

conceptual combination research, it is striking how much theory-based problem solving is required to arrive at an elaborated solution. Some people were content to go for a weak surface similarity, an analogy, or even a pun (a Skate as a Fish that is a Vehicle). However those who took on the task whole-heartedly were able to generate ingenious solutions. The Figures show some of the more successful attempts.

INSERT FIGURES ABOUT HERE

The method is particularly revealing of the process of identifying "incompatibilities" between the concepts. Table 8 lists some of the more obvious incompatibilities that were identified in subjects' responses, and to which they tried to provide solutions. Often the solution could go either way. Thus when faced with the problem that Fruit is perishable whereas Furniture is durable, some subjects changed the Fruit concept and imagined a fruit which was highly durable and took a very long time to decay, whereas others changed their Furniture concept, and imagined that this piece of Furniture would need regular replacement as it rotted away. Others solved the problem by allowing the fruit to remain on its vine in the living room - providing a large flower pot for it to grow from.

INSERT TABLE 8 ABOUT HERE

As a result of subjects choosing between these two alternatives, it was common to find different respondents making opposing claims. One person said that the lampshade book would catch fire, while another claimed that it was fire resistant. One pointed out the problem, while the other added an emergent property to deal with it.

Another notable feature of the results is the way that the task encourages people to discover links - an alignment of parts, (see Markman & Gentner, 1993). This was particularly noticeable in the imposition of unusual functions onto objects - the core of a giant fruit was hollowed out into a spiral staircase, the tubes of a bicycle frame were filled with steam which could be released to do the cooking, the pedalling of the bicycle was the energy source for the stove, or the minerals in a rock provided a healthy source of nutritional supplement. The alignment of function and structure provided a creative way in which the two concepts could be "glued" together in a sensible way.

Often, analysing the responses simply in terms of the attributes listed fails to capture the way that the two schema have been integrated - emergent attributes often involve relational attributes, linking parts and functions together. Table 9 shows some of these alignments in each of the category pairs.

INSERT TABLE 9 ABOUT HERE

Emergent attributes were clearly very common in this task. Attributes were classified in an informal way by the author into those which were mainly true of one or the other category, and those which were mainly true only of the combination. On a rough count across all nine pairs of concepts there were approximately 220 attributes mainly true of one or the other constituent concepts, and 170 which were emergent. Table 10 illustrates some of these emergent properties.

INSERT TABLE 10 ABOUT HERE

There was also evidence that subjects tried to find instantiations of general classes in order to help with the problem. For example, Furniture that is a Fruit was instantiated by different subjects in terms of an easy chair/orange, a bench/banana or a pouffe/pumpkin. In this way, people were selecting a basic level class for elaboration (Rosch et al. 1976). Basic level classes have been shown to provide easier processing in a number of tasks, and it may be that the greater facility with which people can process

basic level classes is also helpful in the imaginary object task. In a similar task, Ward (1994) found that when asked to create novel creatures, they tended to adopt particular basic level Earth animals as templates for the generation of novelty.

Finally it is interesting to see the extent to which the criteria for category membership get stretched when the pressure is on - for example when instantiating to basic level classes, people would take whales and dolphins to count as fish (they need to be intelligent to serve as vehicles), or would include pumpkins, tomatoes and even mushrooms as fruits, coral as a rock, and a calculator and an automatic tea-maker as a computer.

Conclusions

Concept conjunctions are a source of insight into creative problem solving particularly when the conjoined concepts are not normally seen as overlapping. In the case of conjunctions of overlapping object categories, a major source of emergent attributes derives from the identification of a familiar object class that falls within the conjunction. Experiments on combinations such as *Pet Fish*, or *Dwellings which are not Buildings*, reveal emergent attributes which are almost certainly based on knowledge of examples of such objects as *Parakeets*, or *Tents*.

People can be categorized in a very wide range of ways, and social stereotypes are a rich domain in which to study processes of conceptual combination. Work on personality by Hampson suggests that incongruent personality traits rarely if ever lead to emergent attributes, although inheritance failure is quite common. Incongruent social stereotypes however do provide emergent features. The research reported here suggests that adoption of a particular point of view encourages an antagonistic (us versus them) approach to conjunctions involving one's own group and a rival. However where the point of view adopted is itself an unlikely category then there is a less antagonistic approach. Furthermore there are gender differences in the degree to which the antagonistic pattern is seen. We don't yet know the reasons for these results, nor exactly what it is about particular viewpoints that makes them more or less antagonistic. The fact that incongruent social categorization leads to emergent personality ascriptions, whereas incongruent personality traits do not lead to emergent behavioural ascriptions is also very interesting (assuming that it is borne out by future research). This result may be taken as indicating a preferred direction of causal attribution -- from traits to behaviour rather than from behaviour to traits. Traits are seen as the causal agents of behaviours (and hence of social/occupational categories). They can therefore be imagined and inferred in order to explain patterns of unusual behaviour. On the other hand unusual behaviours are rarely generated in order to make sense of inconsistent patterns of trait ascriptions.

Where the conjunction of two classes is normally an empty set, then people must rely on creative processes to construct a mental model of imaginary objects that could fulfil at least some of the conjoint constraints implied by the conjunction. This process is revealing of processes that may well be occurring at a less obvious level in more mundane everyday novel combinations. It may also be a source of interesting data about cognitive processes which characterize more creative individuals. There were systematic differences between individuals in their interest and ability in completing the task. The individual differences highlight the fact that the creative combination of concepts is not an automatic process, but involves cognitive effort. Successful creative solutions involve an extensive exploration of the possible mappings between concept representations,

together with imaginative ways of resolving the problematic incongruities that turn up. There was also a degree of playfulness and humor which characterised the most well-developed solutions to the impossible objects task. Training individuals in this kind of task may prove of value in fostering their creativity and enhancing their ability to solve design problems in a novel way.

References

Asch, S.E. (1946). Forming impressions of personality. Journal of Abnormal and Social Psychology, 41, 258-290.

Barsalou, L.W. (1987). The instability of graded structure: implications for the nature of concepts. Chapter in U.Neisser (Ed.), Concepts and conceptual development: Ecological and intellectual bases of categories. Cambridge: Cambridge University Press.

Boden, M. (1991). The creative mind: Myths and mechanisms. London: Abacus.

Hampson, S.E. (1990). Reconciling inconsistent information: Impressions of personality from combinations of traits. European Journal of Personality, 4, 157-172.

Hampton, J.A. (1979). Polymorphous Concepts in Semantic Memory. Journal of Verbal Learning and Verbal Behavior, 18, 441-461.

Hampton, J.A. (1981) An Investigation of the Nature of Abstract Concepts. Memory and Cognition, 9, 149-156.

Hampton, J.A. (1986). Conjunction, Disjunction and Negation of Natural Concepts. Presented to the 27th Annual Meeting of the Psychonomic Society. New Orleans, November.

Hampton, J.A. (1987) Inheritance of attributes in natural concept conjunctions. Memory and Cognition, 15, 55-71.

Hampton, J.A. (1988a) Disjunction of Natural Concepts. Memory & Cognition, 16, 579-591.

Hampton, J.A. (1988b) Overextension of conjunctive concepts: Evidence for a Unitary Model of Concept Typicality and Class Inclusion. Journal of Experimental Psychology: Learning, Memory and Cognition, 14, 12-32.

Hampton, J.A. (1989) Attribute Inheritance under Negation. In G.Dunbar, B.Franks, & T.Myers, (eds.), Papers from the 1989 Edinburgh Round Table on the Mental Lexicon: Edinburgh Working Papers in Cognitive Science, 4, pp.51-60, Centre for Cognitive Science, University of Edinburgh.

Hampton, J.A. (1991). The combination of prototype concepts. In P.Schwanenflugel (Ed.), The psychology of word meanings (pp.91-116). Hillsdale, NJ: Erlbaum.

Hampton, J.A. (1995). Similarity-based categorization: the development of prototype theory. Psychological Belgica, 35, 103-125.

Hampton, J.A. (1996a). Conjunctions of Visually Based Categories: Overextension and Compensation. Journal of Experimental Psychology: Learning, Memory and Cognition, 22, 378-396.

Hampton, J.A. (1996b). Conceptual combination. In K. Lamberts and D. Shanks (Eds.) Knowledge, Concepts and Categories. London: UCL Press (in press).

Hampton, J.A., & Dillane, M. (1993). Taking a point of view on Attribute Inheritance. Paper presented to the 34th Annual Convention of the Psychonomic Society, Washington DC, November.

Hastie, R., Schroeder, C., & Weber, R. (1990). Creating complex social conjunction categories from simple categories. Bulletin of the Psychonomic Society, 28, 242-247.

Johnson-Laird, P.N. (1988). Freedom and constraint in creativity. In R.J.Sternberg (Ed.), The nature of creativity. Cambridge: Cambridge University Press.

Kunda, Z., Miller, D.T., & Clare, T. (1990). Combining social concepts: the role of causal reasoning. Cognitive Science, 14, 551-578.

Markman, A.B., & Gentner, D. (1993). Structural alignment during similarity comparisons. Cognitive Psychology, 25, 431-467.

Murphy, G.L., & Medin, D.L. (1985) The role of theories in conceptual coherence. Psychological Review, 92, 289-316.

Rips, L.J. (1995). The current status of research on concept combination. Mind and Language, 10, 72-104..

Rosch, E., & Mervis, C.B. (1975). Family resemblances: studies in the internal structure of categories. Cognitive Psychology, 7, 573-605.

Rosch, E., Mervis, C.B., Gray, W.D., Johnson, D.M., & Boyes-Braem, P. (1976). Basic objects in natural categories. Cognitive Psychology, 8, 382-439.

Table 1

Attribute Inheritance

Default rule - set union :
Any attribute which is true of A or true of B will be true of the conjunction "A which are also B"

		A which are also B	
Category A	**Category B**	True	False
True	True	*Inheritance*	*Inheritance failure*
True	False	*Inheritance*	*Inheritance failure*
False	True	*Inheritance*	*Inheritance failure*
False	False	*Emergence*	*Correctly false*

Table 2

Emergent attributes from Hampton (1987)

Conjunction	**Emergent Attribute**
Vehicles that are also Machines	Is large
Pets that are also Birds	Is small Is kept in a cage Has claws
Birds that are also Pets	Is small Is kept in a cage Is pretty
Buildings that are also Dwellings	Is tall
Tools that are also Weapons	Is sharp Has a blade for cutting Has a point
Sports that are also Games	Has spectators
Games that are also Sports	Has spectators Is done professionally for money

Table 3
Emergent attributes for negated conjunctions.

Conjunction	**Attribute**	**Frequency**
Dwellings which are not buildings	Are for relaxation out of the home	10%
Household appliances which are not furniture	Are for play	20%
Vehicles which are not machines	Are natural	35%
	Are self-motivating	12.5%
	Are rafts	10%
Birds which are not pets	Have a nose	52.5%

Table 4
Inheritance pattern for attributes of social stereotype categories

	Positively valued		Negatively valued	
	Inherited	Not inherited	Inherited	Not inherited
True of both	2	0	0	0
True of point of view	11	54	0	0
True of "other"	7	6	48	19
True of neither	4	26	18	15

Table 5
Emergent attributes in social stereotype categories

Category A	**Category B**	**Point of View**	**Emergent Attribute**
Conservative	Trade Unionist	Conservative	Traitor
Conservative	Trade Unionist	Trade Unionist	Traitor Confused Strange
Socialist	Stockbroker	Socialist	Champagne Socialist Traitor Unconventional Unrealistic
Socialist	Stockbroker	Stockbroker	Champagne Socialist Not a true socialist Unconventional
Oxford Graduate	Factory Worker	Oxford Graduate	Disaffected Lazy Possible mental breakdown Something wrong with him Unconventional
Oxford Graduate	Factory Worker	Factory Worker	Failure Something wrong with him Unconventional Under-achiever
Rugby Player	Man who knits	Rugby Player	Confused Relaxed
Rugby Player	Man who knits	Man who knits	-----

Table 6
Emergent attributes with Gender consistent and inconsistent stereotypes.

CATEGORIES	POINTS OF VIEW			
	MALE		FEMALE	
	CONSISTENT	INCONSISTENT	CONSISTENT	INCONSISTENT
CAR MECHANIC who READS ROMANTIC FICTION	Dissatisfied Elusive	Dissatisfied Reliable Lonely Soppy	Ambitious Broad-minded Clever	Easygoing Calm Charming Caring Intelligent
TRACTOR DRIVER who is a BALLET DANCER	Passive Unserious	Confused Dirty Eccentric Peculiar	Bold Unconventional Enjoys herself Satisfied	Soft
FIGHTER PILOT who is a CHILD MINDER	--	Untroubled	Contradictory	Fun loving
ROAD DIGGER who does EMBROIDERY	Single Multi-talented Dare to be different Easy	Unusual	Adventurous Challenger Just does a job Healthy	Unstereotypical Unusual Positive
FOOTBALL HOOLIGAN who is a HOUSE HUSBAND/ WIFE	Homosexual Changeable	Vain Changeable	Eager Sporty Unfulfilled Adventurous Football supporter	Antisocial
RUGBY PLAYER who KNITS	--	Brave Funny Eccentric Strange Uncaring of image	--	Organised Well-rounded
REFUSE COLLECTOR who MAKES CAKES	Confused Articulate Simple	Miserable Unsociable Unusual Strange	Simple Broad-minded Determined Equality	Adept Clever Enjoys life Fulfilled Multi-talented Positive Same beneath Broad-minded Determined Fun loving
BOXER who is a NURSE	Repressed Uncompetitive Emotionally split Strange	Dissatisfied Rival	--	--

Table 7
Pairs of concepts used in the Imaginary Object experiment, with mean rated difficulty (1=easy, 4=hard).

	Difficulty	
	A-B	B-A
A piece of FURNITURE which was also a kind of FRUIT	2.6	3.0
A VEHICLE which was also a kind of FISH	1.8	2.6
A FOOD which was also a kind of ROCK	2.7	2.5
A FRUIT which was also a kind of HUMAN DWELLING	1.6	3.1 *
A BIRD which was also a kind of KITCHEN UTENSIL	2.2	3.4 *
A FOOD FLAVORING which was also a kind of TOOL	2.9	3.6
A COMPUTER which was also a kind of TEACUP	2.1	3.2 *
A COOKING STOVE which was also a kind of BICYCLE	2.2	2.9
A LAMPSHADE which was also a kind of BOOK	1.9	2.4

(* indicates a significant difference ($p<.05$) between the order A-B and the order B-A.)

Table 8
Examples of inconsistent or conflicting attributes

CONJUNCTION : A which is B	**A attributes**	**B attributes**
A FRUIT which is a kind of FURNITURE	perishable	durable
	squashy	firm
A VEHICLE which is a kind of FISH	controlled	self-motivated
	for people	under water
	safe	predator
	safe	slippery
A FOOD which is a kind of ROCK	edible	hard
	edible	tasteless
	perishable	permanent
A FRUIT which is a kind of HUMAN DWELLING	edible	hungry inhabitants
	flimsy	provides shelter
	moves around	anchored to foundation
	grows	fixed in size
A BIRD which is a kind of KITCHEN UTENSIL	wild	functional
	delicate	durable
	eats food	for preparing food
	unhygienic	for cooking
	moves	stable
A FOOD FLAVORING which is a kind of TOOL	liquid/powder	solid
	taste	no taste
A COMPUTER which is a kind of TEACUP	heat sensitive	heat resistant
	water sensitive	water resistant
	intelligent	simple
A COOKING STOVE which is a kind of BICYCLE	hot	people sit on it
A LAMPSHADE which is a kind of BOOK	limited surface	long story
	transparent	many pages
	close to bulb	flammable

Table 9
Alignment of properties between categories in Imaginary Objects

CONJUNCTION : A which is B	**Alignable attributes**
A FRUIT which is a kind of FURNITURE	tough skin could be a chair covering soft texture
A VEHICLE which is a kind of FISH	moves along needs fuel - eats other fish
A FOOD which is a kind of ROCK	contain minerals
A FRUIT which is a kind of HUMAN DWELLING	weatherproof exterior hollow interior
A BIRD which is a kind of KITCHEN UTENSIL	sharp beak - used for opening cans eats food - useful to dispose of rubbish
A FOOD FLAVORING which is a kind of TOOL	--
A COMPUTER which is a kind of TEACUP	needs energy - supplied by heat of tea has display - tea leaves show results
A COOKING STOVE which is a kind of BICYCLE	needs power - supplied by pedals
A LAMPSHADE which is a kind of BOOK	writing is on the shade lamp provides light for reading

Table 10
Examples of emergent attributes in Imaginary Objects

FURNITURE - FRUIT
gives out heat
needs renewing
regenerates itself
grows in a flower pot
grows slowly

VEHICLE - FISH
tame and docile
wears a harness
has a sealed cockpit
friendly

FOOD -ROCK
swallowed whole
rubbery texture

FRUIT - HUMAN DWELLING
rope ladder to top
just one room
hollowed out
anchored to the ground
doesn't rot
transparent outer covering

BIRD - KITCHEN UTENSIL
serrated beak
stiff
holds things
cannot fly
eats kitchen rubbish
strong jaw

FOOD FLAVOURING - TOOL
reacts with chemicals

COMPUTER - TEACUP
dispenses tea
powered by heat
tells the time
buttons on the side of the cup

COOKING STOVE - BICYCLE
difficult to ride
steam valves on the handlebars
switch off before mounting

Figure captions

Examples of drawings produced by subjects in the Impossible Objects task.

A piece of Furniture which is also a kind of Fruit

A Vehicle which is also a kind of Fish

A Bird which is also a kind of Kitchen Utensil