TESTING THE WEIGHTED SALIENCE MODEL OF CONCEPTUAL COMBINATION

A Dissertation

by

MERRYL JOY PATTERSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2003

Major Subject: Psychology

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Approved as to style and content by:

Steven M. Smith (Chair of Committee)	Jyotsna Vaid (Member)
Heather Bortfeld (Member)	Robert Hall (Member)
Steven Rholes (Head of Department)	

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ABSTRACT

Testing the Weighted Salience Model of Conceptual Combination. (December 2003)

Merryl Joy Patterson, B.S., Indiana University;

M.S., Texas A&M University

Chair of Advisory Committee: Dr. Steven M. Smith

In two experiments the Weighted Salience Model (WSM) of conceptual combination was examined. Several of the hypotheses set forth in the WSM were evaluated, including the importance of salience of constituent features, differential interpretation strategies based on similarity, an initial reliance on the modifier as opposed to the head, and a context effect of salience reorganization. Results confirmed that the hierarchy of output dominance within constituent features was important in determining features in final combinations. Additionally, similar pairs were defined with property interpretations more frequently than were dissimilar pairs, and dissimilar pairs were defined with relation interpretations more frequently than were similar pairs. Context effects were demonstrated through the finding that target features were found more often in primed than unprimed pairs. The hypothesis of modifier superiority was not confirmed. These findings indicate that the WSM adds to the current understanding of conceptual combination through a reliance on output dominance and the importance of context. Despite these strengths, changes to the WSM may be necessary if future studies fail to support the importance of the modifier over the head noun.

DEDICATION

This dissertation is dedicated to my husband, Justin Patterson. He has been a constant source of support and motivation for me, and I know that without his help, completing this work would have been impossible. I am eternally grateful for his contribution to my life and for his constant encouragement during my graduate education.

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I am also indebted to Rachel Hull, a fellow graduate student has given selflessly of her time and resources. She constantly came to my aid and posted sign up sheets, delivered documents, and helped run subjects so that I could avoid unnecessary commuting.

Thanks as well go to many of the Psychology department staff. Sharon Starr, the graduate advisor, deserves accolades for always making it possible for me to register despite my distance from the University. Lorie Lapaglia, Lori Arnall, Claire Edwards, Amy Ford, and Jennifer Rue have gone above and beyond their job descriptions in their every dealing with me. Throughout my graduate education, I could always count on them for the help I needed and reassuring smiles as well. Their kindness continues to make the Psychology department a better place for myself, and many others, and for this I thank them.

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INTRODUCTION

Conceptual combination is an intriguing process by which two previously unrelated words are integrated to create a new concept. Examples of conceptual combination include the now lexicalized phrases "couch potato" and "brain freeze". Research on conceptual combination is important as it yields information not only about the process of combination, but about the process of language understanding as a whole and the structure of knowledge. Many researchers have investigated this process, (Hampton, 1987; Smith, Osherson, Rips, & Keane, 1988; Cohen & Murphy, 1984; Rips, 1995; Wisniewski, 1996; Gerrig & Murphy, 1992; Gagne & Shoben, 1997; Estes & Glucksberg, 2000a; and Costello & Keane, 2000) but a comprehensive and widely accepted model of conceptual combination has not yet been established.

The present study investigated conceptual combination, beginning with an investigation of the current status of research on conceptual combination. The Weighted Salience Model (WSM), a new model of conceptual combination that attempts to highlight the strengths of the current models, will be presented. Finally, a series of experiments that test the value of the WSM and compare it to other current models will be reported.

This dissertation follows the style and format of *Memory & Cognition*.

Current Models of Conceptual Combination

The Concept Formation Model (Gerrig and Murphy, 1992)

Gerrig and Murphy (1992) were among the first researchers to set out to determine what role context plays in selecting the best meaning for a novel conceptual combination in a particular situation. They stated that examining conceptual combination in isolation produces an artificial understanding of the process at best. The Concept Formation Model states that when attempting to define a novel pair of words, the surrounding context is examined. If the context supports a reasonable relation between the two words (or similar words), then a type of schema is developed. This schema would then facilitate easier comprehension of similar conceptual combinations, because it highlights a permanent relation that is available to the comprehender.

Gerrig and Murphy (1992) presented a series of experiments devised to provide support for the Concept Formation Model. The Concept Formation Model postulates that making one connection between a combination and a referent will ease the process of determining referents for similar combinations in the future because it will develop a schema that becomes a permanent part of the language interpretation process. To test this hypothesis, they developed short stories to provide context rather than examining conceptual combination in isolation. Each story either provided an explicit pairing between a novel conceptual combination and a referent, an implicit pairing, or a neutral pairing. So, for example, after reading a story about a couple who were attempting to determine what type of pet to buy their son at a pet store, participants were probed for the meaning of the pair "dog smile". The explicit condition would state within the story "If he smiles at the dogs we'll get him one of those". The Concept Formation Model would predict that participants would comprehend "dog smile" quickly after reading the explicit condition. The implicit condition would state "If he smiles at the cats we'll get him one of those". The importance of this condition is that after exposure to the implicit condition, participants have actually comprehended the term "cat smile" implicitly. The Concept Formation Model predicts that participants would be able to comprehend "dog smile" as quickly in the implicit condition as they did in the explicit condition.

In several experiments, Gerrig and Murphy (1992) found support for the Concept Formation Model. Participants were presented with a story including either the implicit or explicit sentences above. After reading the story, participants were presented with a sentence that read: "It looks like a dog smile to me… Barbara reached for her credit card." Participants were asked to determine whether the last phrases were true or false. Through this task, the experimenters found that participants were able to comprehend both implicit and explicit conditions equally quickly, as the reaction times to come to a true/false conclusion were equal across conditions. The experimenters also found that participants showed no difference in their ability to verify the correct meanings of the target combination regardless of whether the participants were in the implicit or explicit conditions. These results were taken to support the Concept Formation Model. Of importance, Gerrig and Murphy (1992) suggested that regardless of whether the Concept Formation Model is eventually supported or discredited, their data provide evidence that any model of conceptual combination must be knowledge-driven to be accurate.

The Two Process Model (Wisniewski 1996, 1997, 1998, 2000 and Wisniewski & Love, 1998)

Wisniewski (1996, 1997, 1998, and 2000, and Wisniewski & Love, 1998) has developed the Two Process Account of conceptual combination. The theory deals with two different types of combinations, relation interpretations, and property interpretations, and suggesting that both come about by two different processes working in parallel.

Wisniewski (1997) described relation interpretations as the resultant definitions of conceptual combination that make use of a relation that connects the modifier to the head noun. For instance, when defining *saxophone apple*, the definition *"a small, round item placed in the bell of a saxophone to mute it"* outlines a relation between saxophone and apple, one in which the apple relates to the saxophone by being placed inside it, resulting in an altered tone. Wisniewski (1996) stated that when relation interpretations are formed, the resulting definitions will include both the modifier and head nouns in their entirety; when examining the definition of saxophone apple above, both the saxophone and apple are "visible" in the resultant definition.

On the other hand, property interpretations have been discussed as those definitions that extract a property from the modifier or head noun, and apply it to the other constituent in the combination. (Wisniewski, 1997). When *rifle pistol* is defined as *"a pistol with an especially long barrel"* rifle is being interpreted not as the weapon in its entirety, but as one property of the weapon, that it has a long barrel. When this property is highlighted and applied to the other constituent, the meaning of pistol is kept, but altered by the property "has a long barrel". Thus, Wisniewski (1996) stated that property interpretations can be easily distinguished from relation interpretations in that when examining a property interpretation, only one of the constituents is "visible" in the resultant definition. In this case, pistol is visible, but the definition does not refer to the rifle. Thus, when a definition outlines a relation between two constituents, and maintains the complete identity of both constituents, it is seen as a relation interpretation, and when a definition applies a property of one constituent on to the other, and maintains the complete identity of only once constituent, it is seen as a property interpretation.

The distinction between relation and property interpretations is the key to understanding the two process model. Wisniewski (1997) suggested that each type of interpretation is the result of a separate process. His interpretation of these processes is based on the schema approach (Concept Specialization Model) of Murphy (1988). Wisniewski stated that concepts are stored as schemas, and that during combination, the constituents are subjected to two different processes in parallel. Similarity between the parent concepts determines which process is most likely to be found in evidence in the final combination.

Wisniewski's (1997) theory relies on the idea that the schemas of the constituents contain scenarios which organize possible relations between other constituents. These scenarios contain information about actions normally associated with the constituent, and also contain the roles that highlight how the action is performed. For example, the schema for ski would include a scenario that describes the usual *riding* function of skis. It would also include various roles describing what is usually doing the riding (a person, or skier), where the riding occurs (on snow), and what happens when the skis are ridden on (quick motion), etc. When conceptual combination occurs, people may look for a plausible scenario with which to link the two constituents. Individuals can then produce definitions that highlight the scenario, and maintain both constituents in the definition, that is, to produce relation interpretations. Plausible relations then, occur when each constituent can take on a different role in the same scenario. So, when a person attempts to define *computer ski*, they look for a plausible relation to connect the two, and may fall on the "riding" scenario of skis that includes the relation of *"ridden on"*. An individual can then connect the two constituents by highlighting this relation, applying the role of "rider" to computer, the role of "that which is ridden" to ski, and come up with a relation interpretation of "a computer that is placed on skis to move it through the snow".

Wisniewski (1997, 2000) stated that it is easiest to find plausible scenarios between two constituents that are at least slightly different from one another. This is due to the suggestion that when constituents are highly similar, both schemas contain similar relations and roles, so that it is difficult to apply a relation from one constituent to another without being redundant, or to even find two different roles that can be filled by the constituents. For example, in defining the pair *sled ski*, it is hard to apply the "ridden on" relation from skis to sled, because sled also contains the same relation. In this case, it is difficult to find one role for sled that differs from the role for ski. In other words, how can you be both the rider and the thing that is ridden on? Whereas Wisniewski stated that relation interpretations are possible with similar pairs, he posited that these interpretations are more likely with dissimilar pairs of constituents.

Property interpretations are, according to Wisniewski (1997, 2000) the result of comparison and construction. Comparison is important because it allows for the identification of properties which differ between the constituents, and which then can be highlighted in the combination. Construction allows a connection to be made between constituents that makes sense in terms of their differences, by applying a property of one to another.

Wisniewski proposed that the comparison process that takes place during conceptual combination is that of structural alignment (Markman & Gentner 1991, 1993). This process suggests that pairs of words can be compared along several dimensions: commonalities, alignable differences, non-alignable differences. Commonalities are properties that are shared by both constituents in question, such as the properties of "has strings" and "makes music" for the constituents "guitar" and "harp". Commonalities are prevalent in similar pairs of words. Alignable differences are a different kind of comparison, as they are the differences that are made apparent because of commonalities. For example, the commonalities above for "rifle" and "pistol" are not exactly the same in both constituents. Whereas both rifles and pistols have barrels, this leads to the alignable difference of "has a long barrel" and "has a shorter barrel" for rifle and pistol respectively. These differences are seen as "alignable" in that the slots or roles are similar, but are filled by different values. This connection between commonalities and alignable differences is responsible for the finding that similar pairs are high in both. Dissimilar pairs however, contain many non-alignable differences, those differences that have no connection to commonalities, and are expressed as presence in one constituent and absence in the other (Markman & Gentner 1991, 1993). For example, the words computer and ski might have non-alignable differences of "used for sending email", and "used to travel down mountains". Obviously, skis have no function dealing with email, and computers do not generally provide transportation.

Wisniewski's theory (1997) posits that words are compared for commonalities, alignable differences, and non-alignable differences during the comparison process. In similar pairs, with their preponderance of alignable differences and commonalities, it can be easy to find a dimension that differs between constituents, and then to find where to apply that difference to the other constituent. For example, when a person recognizes that there are differing numbers of strings on guitars as compared to harps, this comparison allows them to imagine what it would be like if guitars had more strings, or harps had fewer.

In addition to the alignments mentioned above, Wisniewski and Middleton (2002) discussed the importance of a special type of non-alignable differences. The researchers suggested that certain non-alignable differences actually point out an alignable spatial relation. These differences simply note the presence of a feature for one constituent, and the absence of that feature on the other constituent. Importantly though, these differences highlight the presence of a similar location where the absent feature could be applied. An example of this type of spatially related non-alignable difference is found in the examples of bucket and bowl. Buckets have handles, and bowls do not, making "have handles" a non-alignable difference. Because however, bowls have shapes that are similar to buckets, bowls actually do have an area where a handle could be affixed. Wisniewski and Middleton (2002) reported a series of experiments in which conceptual combinations by participants favored focusing on this type of non-alignable difference, rather than alignable differences. The experimenters stated that when combinations highlight alignable differences, the aligned feature of one of the constituents is actually deleted, and replaced with the aligned feature of the other constituent. Spatially related non-alignable differences however, simply require the addition of the difference to the related location on the target constituent (see also Wisniewski, 2001).

Wisniewski (1997) put forward the idea that people do not simply apply the exact property that is identified in the comparison process to the constituent in question. Because there is necessarily a difference between the two constituents, some changes must be made when applying the given property. This is where the second process, that of construction, comes in. By examining all of the commonalities and differences that were discovered during the comparison process, the individual has a wealth of information. This information can then be used to make changes to properties of interest, which in turn makes the application of these properties onto new constituents more meaningful and realistic. So, during comparison, when the alignable difference of "barrel length" is highlighted between rifles and pistols, the definition does not necessarily stop at "a pistol with a long barrel," but allows the individual to report features like "can shoot farther" and "has more of a kick". In this case, the construction process changes the representation of the pistol in more ways than just to fill the slot of "length of barrel" with a longer value than usual. The property interpretation yields a whole new weapon, one with features changed by the addition of a rifle barrel. Because the comparison and construction is more likely to be completed in pairs with a lot of commonalities and alignable differences, Wisniewski (2000) stated that property interpretations are more likely in similar pairs of words.

An important feature of Wisniewski's Two Process Model is the suggestion that the processes that yield either relation or property interpretations occur in parallel. Essentially, when confronted with a conceptual combination task, people will attempt both the slot-filling (relation process) and the property interpretation (comparison and construction) process at the same time. Similarity of the modifier and head will affect the likelihood of one process being more successful than the other. Other researchers (Shoben & Gagne, 1997; Gagne & Shoben, 1997) have stated that relation interpretations are preferred over property interpretations, and that property interpretations are therefore a last resort. These researchers suggested that relation interpretations are attempted first, and only when a thematic relation is absent will individuals create property interpretations. Wisniewski and Love (1998) however, failed to support this "last resort hypothesis" and therefore stated that both interpretation types are attempted at the same time (in parallel). For similar pairs, with their wealth of commonalities and alignable differences, the comparison/construction process often "wins out" over scenario creation. For dissimilar pairs, the opposite happens, with scenario creation being more likely to occur.

Thus, the Two Process Model makes several predictions. First, when pairs of words are defined, both property and relation interpretations will occur. Second, dissimilar pairs will yield more relation interpretations, and similar pairs will yield more property interpretations. Third, as the two processes are carried out in parallel, there is no reason to expect that relation interpretations come first, or that they are more preferred.

Sifonis and Ward (2000), described a Pure Alignment Model, which is an adaptation of The Two Process Model (Wisniewski, 1997). In this model, different forms of structural alignment are seen as taking place depending on the level of similarity. In similar pairs, macrostructural alignment is undertaken, in which the modifier and head are aligned. In dissimilar pairs, microstructural alignment is undertaken, in which the modifier is compared to a list of likely fillers for the slots of the head, rather than the head as a whole. It is suggested that with macrostructural alignment, a perceived similarity between the modifier and head is more favorable for the production of property interpretations. With microstructural alignment, perceived similarity between the modifier and a filler of the head is more favorable for the production of relation interpretations. This model offers important insight into what occurs in the case that structural alignment (macro or micro) discovers similarities. It does not specifically mention what occurs in situations where dissimilarity is uncovered.

The CARIN Model (Gagne & Shoben, 1997; Shoben & Gagne, 1997; Gagne, 2000)

The CARIN (Competition Among Relations In Nominals) Model suggests a very different way of looking at conceptual combination. The focus here is on relation interpretations, as the model seeks to explain how relation interpretations occur, and relegates property interpretations to the domain of unlikely occurrences in conceptual combination. Rather than viewing concepts to be combined as schemas with slots to be filled, Gagne and Shoben (1997) stated that concepts store information about relations that are normally associated with them. When conceptual combination occurs then, it is simply seen as connecting two concepts via a plausible relation that is already stored within either or both of the concepts.

Gagne (2000) stated that there are a limited number of relations that can be used when linking concepts. Different researchers have attempted to create comprehensive lists of relations, and have come up with lists of varying lengths, but that are reasonably short (Downing, 1977; Levi, 1978; Shoben, 1991). Examples of a few these relational categories from Shoben (1991) are MADE OF, USED BY, LOCATED ON, and CAUSES. These relations are found when defining pairs of words such as when *pudding metal* is defined as *pudding MADE OF metal*, when *helicopter blanket* is defined as a *blanket USED BY a helicopter as a protective covering*, when *couch skate* is defined as *a skate that is left on (LOCATED ON) a couch*, or when *airplane puddle* is defined as *an airplane crash (AIRPLANE CAUSED A PUDDLE).* The CARIN Model states that these and other relations are stored within the representation of a given concept.

As there are a limited number of relations available to link concepts, Gagne and Shoben (1997), Shoben and Gagne (1997) and Gagne (2000) suggested that as we use language, we begin to see patterns of relations. These patterns are stored within concepts along with the relations themselves, so that we not only have access to all possible relations, but additionally, can recognize which relations are most common for different concepts. This information about past relations then affects the future use of relations by influencing our thought processes about the most likely relations in a given situation.

The CARIN Model (Gagne & Shoben, 1997) stated that information about the most common relations takes on different levels of importance depending on the concept's position in the conceptual combination. The modifier takes precedence over the head noun in determining the likely relation used to link the two. CARIN then, states that the relations that have been frequently associated with a given modifier will be preferred over other relations when conceptual combination is attempted. Additionally, Shoben & Gagne (1997) suggested that the relative strength of a given relation is important in determining whether or not it will be used to link modifiers and heads. Strength is a measurement that compares the frequency of a given relation to all other relations. A relation that is frequently associated with a word will be stronger if all other possible relations are used infrequently. For example, a substance like metal would lend itself to the MADE OF relation. Not only would this relation be frequently associated with the word metal, but it is strongly associated as well, because other relations such as LOCATED ON or CAUSED BY are rarely used.

The CARIN model discusses relation strength and frequency in detail because it suggests a strong preference for relation interpretations as opposed to property interpretations. This difference in predicted importance of relations is a distinction between the CARIN Model and the Two Process Model. CARIN states that the most frequently associated relation for the modifier is most likely to be used to link it with a given head noun, and only when no relations can be found to link the head and the modifier would a property interpretation be attempted. So, the CARIN Model supports the "last resort hypothesis" that the Two Process Model contests.

Gagne demonstrated that presenting primes can alter the reaction time required to complete a forced choice verification task using noun-noun pairs. Participants were presented with primes (in the form of noun-noun combinations) that were related to the following targets, and asked for both the primes and targets whether or not there was a sensible definition for the conceptual combination. The primes were either for a combination that shared the likely linking relation with the target, or that didn't, and had either the head or modifier as a common constituent with the target or no common constituent with the target. (Gagne, 2001; Gagne, 2002). She found that for primes that included the same head noun or modifier as the target, processing time was faster than for primes that did not include a common constituent. In looking at the priming of relations however, she found that the modifier primes decreased the verification time but head primes did not. As CARIN suggests that modifiers store the relations to be considered for conceptual combination, this finding supports the CARIN model. Priming was found for relations only by modifiers. All of the primes and targets in both of these studies incorporated unambiguous stimuli, that is, combinations that had obvious definitions.

Gagne & Shoben, (2002) used ambiguous stimuli and the results were slightly problematic for the CARIN model. In this study, which was essentially the same as those reported above, both modifiers and heads as common constituents were found to effectively prime relations. This finding contradicts the CARIN model because the model predicts that only the modifier is the storehouse of possible relations. Gagne stated that it is possible to update CARIN to account for this finding, by suggesting that modifier profiles are not the only way to influence the selection of a relation to link constituents. Instead of limiting CARIN to this one method as before, Gagne stated that exposure to recent similar combinations might serve as a secondary method for selecting an appropriate relation.

Interactive Property Attribution (Estes & Glucksberg, 2000a and 2000b)

Estes and Glucksberg (2000a & 2000b) also posited the importance of differing contributions of modifiers and heads. In this theory however, it is not the actual relations that are stored within the concepts of interest, but the dimensions and properties that are likely to be important when producing conceptual combinations. The interaction of the modifier and head is seen as a slot and filler relationship, much as in the Selective Modification Model (Smith et al., 1988).

Estes and Glucksberg (2000a) stated that the head and modifier play roles that are equally important. This suggestion is contrary to the idea presented in the CARIN (Gagne & Shoben, 1997) model, which states that the hierarchy of relations outlined by the modifier is more important than that set forth by the head. An additional difference between these two models is that Interactive Property Attribution (Estes & Glucksberg, 2000a) describes different roles for the modifier and the head. The modifier is seen as providing a list of properties that can be used in the combination, whereas the head provides relevant dimensions.

This difference can be highlighted by understanding the representation of the modifier as a loosely associated list of features that are rank ordered by importance. The higher the feature is to the top of the list, the higher its salience. These features can be used as "fillers" in conceptual combination. The head too, can be represented by such a list, but instead of the features being seen as "fillers," the features are the "slots" to be filled. Thus, the relevance of the features within the head can be identified only when compared to the features of the modifier. Relevance is determined by describing how important a feature of the head noun is when examined in comparison to the potential "fillers." So, for the modifier "pudding" in the pair *pudding metal*, two salient features might be "sweet" or "mushy". When attempting conceptual combination on this pair then, one must look at the features of the head noun, and determine how the salient features might fit in. When examining the head noun "metal," we see that there is no obvious slot which the feature "sweet" (from the modifier) might fill. "Taste" or "flavor" is simply not relevant to the head noun "metal". Metal however, is generally hard, and this hardness is important to being classified as metal. The feature "mushy" from the modifier now has a relevant slot to fill. "Mushy" deals with hardness, and hardness is relevant to metal. The Interactive Property Attribution model then, would predict that definitions of this pair of words would be more likely to include references to consistency than to flavor.

Estes and Glucksberg (2000a) use H and L to indicate high and low levels of salience and relevance. Because the modifier is important in determining salience, the first H or L in a pair represents the modifier, and the salience of a given property. The head is represented as the second letter in the pair, and here, H or L refers to high or low levels of relevance. For the example above, pudding metal could be a HH pair, because “mushy” is highly salient for pudding, (the first H) and it is also highly relevant for metal (the second H). Skunk metal, on the other hand, would be considered a HL pair, because whereas a salient feature of skunk is “smelly,” (the H) that feature is not relevant for metal (the L).

In terms of the relative likelihood of different types of interpretations, the Interactive Property Attribution model (Estes & Glucksberg, 2000a and 2000b) once again makes reference to both property and relation interpretations as described by Wisniewski (1996). Estes and Glucksberg (2000a) however, stated that the determining factor between the production of property or relation interpretations is the presence or absence of a dimension where the parent concepts have both high salience and high relevance. The researchers stated that property interpretations will be most prevalent in situations where the modifier has a salient property on a given dimension that is relevant to the head. Relation interpretations then, are most likely when there is no such match between modifier and head. This situation is encountered either when there are no salient dimensions found within the modifier, or when there are salient dimensions in the modifier, but the salient dimensions are not found to be relevant in the head.

Estes and Glucksberg (2000a) stated that not only are salience and relevance important in determining the type of interpretation (as either property or relation), but that these two dimensions are the only important consideration. The researchers deny the importance of similarity in guiding the selection of property or relation interpretations, and report that this is one of the major differences between their model and Wisniewski's (1997, 2000) Dual Process model. Estes and Glucksberg (2000a) further stated that contrary to the Dual Process model, similarity has no effect on property attributions. Instead of perceived similarity guiding the comprehension process, the researchers stated that perceptions of similarity are guided by comprehension. Once a definition is created through conceptual combination, the similarity of the words is perceived differently.

In terms of context, Glucksberg and Estes (2000) demonstrated how the relevance hypothesis of the Interactive Attribution Model can explain some data that were previously difficult to interpret. The experimenters suggested that two types of features are available during conceptual combination. Phrase features are those features that are only found in the definition of the conceptual combination. Noun features are those that are true for the constituents and the conceptual combination. For example, the researchers discussed the combination "peeled apples" and suggested that a phrase feature would be white, whereas a noun feature would be round. White is not a feature normally associated with peeled things or apples, it is only associated with the combined concept " peeled apples" and therefore, it is a phrase feature. Both apples and peeled apples are round, therefore round is a noun phrase. It has been demonstrated by several researchers (including Springer & Murphy, 1992) that people can verify phrase features faster than noun features.

The relevance hypothesis makes sense of this surprising effect of phrase feature superiority. Glucksberg and Estes (2000) stated that when there is no clearly helpful context, that phrase features are likely more relevant to the combined concept than are noun features. Because noun features are true of the constituents, these features do not represent a reason for relying on the phrase. Only phrase features supply the information that is most relevant to the conceptual combination, and therefore the phrase features are the ones that people look to when interpreting a combination. The key here is not that phrase features present "new" information, but that they present "relevant" information. Glucksberg and Estes (2000) demonstrated support for this relevance hypothesis by showing that noun features could be verified more quickly than phrase features when the noun features were made to be more relevant by context. For example, when a story demonstrated peeled apples as being used in a capacity that required "roundness," this noun feature was verified more quickly than the phrase feature "white," because the context made "roundness" more relevant than any color. This experiment provides support for the Interactive Attribution Model because it demonstrates that relevance can effectively change the way a conceptual combination is understood.

The Constraint Theory (Costello & Keane, 2000)

Unlike any of the other models discussed thus far, the Constraint Theory attempts to provide a computer simulation to explain conceptual combination. As their goal, Costello and Keane (2000) seek to develop a theory that accounts for the construction of conceptual combinations, without the influence of context. They also limit their theory to noun-noun combinations.

Costello and Keane (2000) have outlined three constraints that must be satisfied when attempting to produce a conceptual combination. They state that the best interpretations will be created when all three constraints are satisfied. The three constraints are: diagnosticity, plausibility, and informativeness. Diagnosticity is satisfied when the parent concepts are "best defined" by the conceptual combination. Combinations are high in diagnosticity then, when the definition contains properties from the parent concepts that are important to the meanings of the parent concepts. Plausibility refers to the likelihood that a given combination is a reasonable definition of the parent concepts. Combinations are high in plausibility when the definition "makes sense" and seems a likely definition of the parent concepts. Informativeness describes the importance of new information. For a conceptual combination to work, it must somehow supply a listener or speaker with new information that was not possible prior to the creation of the conceptual combinations. This constraint points to the fact that it is unlikely to create a new, compound concept if another concept already exists in the language that fulfills the exact same role. Thus, combinations that are high in informativeness will be those that add something to the lexicon. These three constraints are not treated equally by Costello and Keane (2000) however. They state that diagnosticity and plausibility are more important that informativeness.

In addition to defining these constraints, Costello and Keane (2000) fully describe the type of knowledge base that is accessed when attempting conceptual combination. The researchers suggest that during conceptual combination, people are able to directly access the full contents of their memory, including (but not limited to) prototypes and specific instances of the parent and related concepts. Individuals are also able to access general domain theories and representations of specific events. This access is important when assessing the computer model of conceptual combination that is derived from the Constraint Theory, the "C^3" model.

The Constraint Theory and the C^3 model (Costello and Keane, 2000) states that three sequential steps must be taken when developing a set of likely definitions for a pair of parent concepts. Initially, diagnostic predicates are determined for each of the parent concepts. The set of predicates are then used to form a sample of partial interpretations, each with its own score for diagnosticity. As a next step, the partial interpretations are fleshed out into complete interpretations using the plausibility component. Using the full knowledge base, each complete interpretation is analyzed for how well it fulfills both the diagnosticity and plausibility constraints. Lastly, each complete definition is evaluated for its level of informativeness, and the overall acceptability of each definition is determined.

To cut down on the amount of time required for all of these steps, Costello and Keane (2000) stated that these three steps are conducted beginning with the predicates that have the highest level of diagnosticity. The model then moves down through predicates at each level of diagnosticity. At each level, when the final step of determining acceptability is reached, the model requires that all possible definitions that fall below the current level of acceptability will be deleted. The model continues cycling through all three steps until, because of diagnosticity or plausibility, all further definitions can be ignored because they are lower in acceptability than the current definition. At this point, the model concludes its search for a definition. The Constraint Theory then, predicts that definitions that are produced through conceptual combination will be those that make use of diagnostic predicates, make sense in the knowledge base, and provide a reasonable amount of new information. Definitions that give too much new information, or give too little new information will be excluded from final consideration.

When compared with human data, the simulation was found to do a good job in the rating of definitions. Costello and Keane (2000) described some areas where the model fell short as well. The C^3 model was unable to account for context effects found in human data. It also failed to come up with certain common definitions found in the human production data. The experimenters acknowledge that these problems are shortcomings, but suggested that these problems are excusable considering the limited knowledge base supplied to the computer.

Other Implications for Conceptual Combination

Other researchers have examined conceptual combination and it is important to review their contributions to this area of inquiry. Despite the fact that these experiments have not produced complete models of conceptual combination, they do provide pieces of the puzzle. Any new model of conceptual combination will have to account for these findings, as well as those supported by a particular theoretical framework.

In a series of four experiments, Kunda, Miller and Claire (1990) provide evidence for causal reasoning in conceptual combination. The researchers asked participants to describe certain individuals, so the conceptual combinations were attempted on social concepts, as opposed to simple concepts. By asking people to combine usually unrelated social concepts such as “Harvard-educated Carpenter”, “Communist Ex-Marine”, and “Blind Marathon Runner”, the experimenters were able to make several observations.

Kunda et al. (1990) found a preponderance of causal reasoning in participants’ definitions of the combined social categories. They suggested that when confronted with an unusual pairing, people must question how such a combination is possible. In answering the questions they develop, individuals use world knowledge to come up with a narrative that accounts for the alliance between two previously unrelated social groups. These narratives are causal in that they allow participants to explain what "caused" the outcome that was outlined by the question they developed. In addition, the experimenters found that participants could use causal implications to change one or both constituents, rather than simply link the constituents through a relational narrative reference. When these modifications occurred, they resulted in definitions that demonstrate something like the construal described by Wisniewski (1997). An example of this type of construal is found when "Harvard-Educated Carpenter" is defined as "A manager of a furniture manufacturing firm".

An important consideration for Kunda et al. (1990) was the amount of surprise generated by the pairing of social categories. The researchers found a positive correlation between ratings of surprise upon hearing a pair of social concepts and evidence of causal reasoning in the resultant definitions. They therefore stated that the more surprising a combination is between two social categories, the more likely participants will need to consult world knowledge and use causal antecedents to explain the pairing.

Despite this clear prediction about the importance of surprise on causal reasoning, Kunda et al. (1990) stated that it is very difficult to predict the ultimate definitions resulting from the combination of social categories. They point out that the resultant definitions are necessarily tied to the types of questions that are asked in response to the surprise that is felt upon sensing that the pairs are unrelated. In some of their test cases, it was clear that only some questions were being posed, though others were possible. The experimenters provide the example of "Harvard-Educated Carpenter," for which the resultant definitions seemed to be in response to the question "How could a Harvard-educated person become a carpenter?" rather than the other possible question of "How could a carpenter become Harvard-educated?". Definitions for other pairs indicated preferences for other types of questions. Without a clear understanding of which questions will be asked when surprising pairs are encountered, Kunda et al. (1990) argue that it is difficult to predict what definitions will result, though other theorists (Smith et al., 1988) stated that this is possible.

Another important message from the work of Kunda et al. (1990) is the finding that neither constituent in social combinations dominates the resultant definitions completely. The researchers found evidence for three different methods of resolving surprise. The attributes from one constituent can be *inherited* by the other, the attributes can be *averaged* over both parent concepts, or emergent attributes can result. Kunda et al. (1990) found evidence of inheritance and averaging for all pairs. They also found that emergence was prevalent. Despite a very stringent definition of emergence (at least 3 participants had to list an attribute of the pair that was never seen in the attribute lists for the constituent concepts) every social combination had at least two emergent attributes. The researchers took these findings to indicate that there is no clear domination of one constituent over the other. Even in situations where very strong stereotypes exist, the stereotypical views were modified by the other constituent.

In a similar series of studies, Hastie, Schroeder, and Weber (1990) had participants examine combined social concepts. The researchers first asked participants to develop attribute lists for the parent concepts, and then for the combinations. In a second study, the researchers had participants rate attributes on a series of continua for the parent concepts and then the combinations. Both studies demonstrated a high level of emergence, defined in the first study as attributes listed for the pairing but not the parent concepts, and in the second as ratings of the pairings that were outside of the range set by the ratings of the parents.

Hastie et al. (1990) stated that in order to explain the preponderance of emergence, some kind of two stage model will need to be developed. In the first stage, participants will attempt to create a coherent explanation for the parent concepts through some sort of averaging or slot filling (a la Smith et al., 1988). During these attempts, if there is a discrepancy between the suggested default values or some other problem that makes combination by slot filling impossible, then the processes of the second stage will take over. Stage two then, would be the construction of a more complex solution, which could simply be to identify an example from memory, or to use rules available from stored memory examples to combine the parent concepts.

Moving Toward a New Model of Conceptual Combination

All of these models give us a framework for understanding the process of conceptual combination. In the next section, I will present a new model of conceptual combination, the Weighted Salience Model. In discussing it, I will highlight several areas that are important in a comprehensive model of conceptual combination, and examine what predictions are made by current models.

Creating a More Comprehensive Model

In examining the current research on conceptual combination, there are some major points that must be addressed. The importance of the modifier versus the head, interpretation type, alignment, similarity, memory, and context are issues that must be included in a comprehensive model. The current models though, discuss some of these attributes and omit others. If one model could be presented that has predictions in all of these areas, it would be stronger than any model that discusses a few of these issues in isolation. The Weighted Salience Model incorporates the most important issues surrounding the problem of conceptual combination into one cohesive model.

An important feature of the Weighted Salience Model is that it posits an evaluation of possible solutions to the problem of conceptual combination before a final solution is selected. The Constraint Model (Costello & Keane, 2000) highlights the importance of comparing possible definitions on the basis of plausibility and informativeness. These two constraints determine the value of definitions provided in response to conceptual combination. The constraints are therefore necessary parts of the Weighted Salience Model, and determine the likelihood that a specific definition will be accepted or rejected.

The Importance of Salience

The Weighted Salience Model incorporates the idea of output dominance into a description of the process of conceptual combination. Barsalou (1983, 1987) discusses the graded structure of categories, and has found that features listed for categories can be organized in several ways. One such way is by output dominance. Output dominance is the ordering of exemplars from most commonly produced to least frequently produced. Exemplars with high output dominance are generally those that are highly salient to a particular category. For instance, when participants are asked to list exemplars of the category "furniture," the exemplars that are most frequently produced are "bed" and "desk". Exemplars that are rarely produced are "piano bench" and "microwave cart". Exemplars with high output dominance are generally those that are salient to the category.

The Weighted Salience Model makes use of the graded structure of concepts. It is well known that certain features are more commonly listed for certain concepts. In addition to simple features, concepts also contain a graded structure of possible relations (as in the CARIN Model, Gagne (2000)). This graded structure is important not only for relation interpretations as Gagne (2000) would suggest, but for property interpretations as well. This is an idea supported by the Interactive Property Attribution Model (Estes, & Glucksberg, 2000a) and the Constraint Theory (Costello & Keane, 2001). The Weighted Salience Model proposes that when conceptual combination takes place, the graded structure is consulted such that properties and relations with high output dominance take precedence in the final combination. For example, the word "spear" has many properties and relations in its graded structure. The relations "can be thrown" (elicits the "for" relation), and "used by Indians" (elicits the "used by" relation) are higher in output dominance than the relation "carry in car" (elicits the "located" relation). Likewise, the properties "sharp" and "long" are higher in output dominance than the properties "hard" and "silver". The WSM then, predicts that when "spear" is used as a constituent in conceptual combination, that there will be more definitions highlighting the "for" and "used by" relations, and the properties "sharp" and "long" than definitions highlighting the relations and properties that are lower in output dominance.

Importance of the Parent Concepts and Alignment

The Weighted Salience Model states that the graded structure of the modifier is initially most important. The CARIN Model (Gagne & Shoben, 1997) stated that the salience of the relations in the modifier are more important than in the head. and the WSM extends this prediction to include the salience of properties as well. An alignment process takes place such that the most salient features (both relations and properties) of the modifier and head are compared. If the features of the modifier and head are similar (or if the parent concepts have a large number of commonalities and alignable differences), the modifier will be examined for the most salient attribute (the one with the highest output dominance). If the modifier and head are dissimilar (or if the parent concepts have a large number of non-alignable differences), the modifier will be examined for the stored relation that has the highest salience. This first choice item is called an "alignment proposed element". An attempt will then be made to develop a definition that highlights the attribute or relation in question. In similar pairs, because the alignment proposed element is an attribute, property interpretations are most likely. In dissimilar pairs, the alignment proposed element should be a relation, so relation interpretations are most likely. This explains the data from Wisniewski (1996) and Wisniewski and Love (1998), who found that relation interpretations are more likely in dissimilar pairs, whereas property interpretations are increased in similar pairs.

If however, the alignment proposed element from the modifier results in definitions that are not plausible, selection will proceed to a secondary alignment proposed element. This item will be of the same type (feature or relation) as the primary alignment proposed element, and is simply next highest in output dominance. If the items with the highest levels of salience for the modifier are all discarded, an alignment confuted element will be selected. This will be an item of the type not suggested by the alignment (relations for similar pairs, attributes for dissimilar pairs). All of the highest alignment confuted elements will be examined. At any point, if a salient is identified that can be incorporated into a definition that is both informative and plausible, the definition will be produced, and processing will stop.

If none of the elements (alignment proposed or alignment confuted) are found to be appropriate, the entire process can be undertaken with items from the head instead of the modifier. Once again, alignment will determine the type of item to first be attempted, and attempts will then be made to incorporate this type of item until the highly salient items have been exhausted. Then, the alignment confuted elements of the head will be examined. The steps are followed until a satisfactory definition (in terms of plausibility and informativeness) is found. This explains why Estes and Glucksberg (2000a) found different levels of property and relation interpretations within pairs of the same perceived similarity. The Estes and Glucksberg (2000a) study focused only on salient properties, not relations. The salience and relevance of these properties were evaluated, and allowed parent concepts to be paired in different organizations. Clearly, the highly salient items considered in the work of Estes and Glucksberg were predominantly properties, so in their experimental pairs, "highly salient" meant that the concept had a highly salient property. Essentially, their finding that the HH pairs are more likely than the HL and LH pairs to yield property interpretations can be explained by the WSM as a situation in which only the HH pairs have a highly salient property in the modifier that allows a plausible linkage to the head. The HL pairs had a highly salient property in the modifier, but one that could not plausibly connect to the head.

The WSM would suggest this type of pair would require further processing, possibly moving to the use of a relation that would predispose this pair to a relation interpretation. Finally, in LH pairs, the most relevant feature of the head did not have a corresponding salient property in the modifier. Again, in this situation, the WSM would predict a switch in focus, to a perusal of the relational structure of the modifier, which could lead to relation interpretations. It is important to note that according to the WSM, participants do not have to use relation interpretations for dissimilar pairs and property interpretations for similar pairs, so the finding that there was such variability among pairs that shared common similarity ratings is not a problem. According to the WSM, among pairs that share the same level of similarity, the graded structure of each parent concept will still cause differences in interpretation type. The Weighted Salience Model holds that the salience and relevance that are hallmarks of the Interactive Property Attribution Model are important. Similarity does not limit a pair to one type of interpretation, it simply suggests what type of items are first to be examined.

More support for the suggested importance of graded structure comes from Costello and Keane (2001). These researchers demonstrate that diagnosticity is important in both comprehension and production. Note that Costello and Keane (2001) state that diagnostic features are those that are important to the constituent in question – this is very similar to my definition of salient features. They found that when varying alignability and diagnosticity, that definitions highlighting diagnosticity were preferred over those that did not. The WSM then, in relying on salience predicts the same effects found by Costello and Keane (2001), that most definitions produced will incorporate diagnostic or salient features.

At any point when the model processes lead to a possible feature or relation that could be used in a plausible definition, a final step is undertaken. This step, called renovation, ensures that the final definition is plausible and clear in a similar fashion to the construction process in The Two Process Model, and the "clean up" process in the Concept Specialization Model. During renovation, the salient item can be construed to make it fit better into the desired definition.

An example of the Weighted Salience Model can be found when tracing the pair "car milk". Because car and milk are dissimilar, the alignment proposed elements will be relations rather than attributes. The relations with the highest salience levels from the modifier "car" would be used in the first attempts at combination. A possible alignment proposed element in this situation is a relation based on the "used for" relation, such as "used for transportation" and "used for carrying people". These relations might be removed from consideration because "milk used for transportation" and "milk that carries people" are obviously not satisfactory definitions, in that they are not plausible or informative. In addition, features of milk make these definitions impossible. As milk is a liquid, it is not capable of carrying people. The model would then move to attributes, or alignment confuted elements, such as "has four wheels" and "is large." These attributes might be discarded because both "milk with four wheels" and "large milk" are nonsensical definitions as well. Finally, the model would move to the alignment proposed elements of the head, relations such as “used for” in “used to drink”, “located” as in “can be located in a cup”. Focusing on the location relation, a person might posit that “car milk” is “milk located in a car.” The renovation process would hone this definition to be more plausible, and could lead to a definition like “Milk that is left in a car and spoils.”

Context Effects: Salience Reorganization and Context Over Alignment

The Weighted Salience Model predicts that context can alter the conceptual combination process in two ways. First, in salience reorganization, the context may alter the salience of any given property or relation in the head or modifier. Second, with the context over alignment process, if the context provides an example that outlines a certain interpretation type, pairs encountered that share some similar elements to the example will demonstrate attempts to mimic that interpretation type despite what alignment would suggest. In this situation, the template from context will be substituted for the alignment process, such that instead of alignment proposed elements receiving preferential treatment, context proposed elements will be examined first, and the rest of the process will proceed as usual. These two context effects, salience reorganization and context over alignment can cause their effects separately or in conjunction.

An example of salience reorganization is found when participants are asked to define the pair “helicopter blanket.” Salience reorganization predicts that the process of defining will be different depending on whether or not a context is provided. In a situation where there is no context specified, there are certain items (attributes and relations) that are highly salient for helicopter such as carries passengers, flies, and goes fast. There are also items that are highly salient for blanket, such as covers things, is warm, and is soft.

However, if a context is supplied, different features may become more salient. If a sentence describing someone who needs to protect an expensive investment precedes a direction to combine "helicopter blanket," a new feature of helicopter might be "is expensive", and of blanket might be "protective cover". These newly salient items may be incorporated into a final definition if they create plausible and informative responses.

The process of salience reorganization is tied into Barsalou's (1983, 1985) suggestion of a distinction between context-dependent and context-independent information within concepts. Barsalou states that context-independent information is always incorporated into the understanding of a concept. Context-dependent information is only incorporated into the understanding of a concept if a relevant context is provided. For example, the concept of "house" may always include the properties "home" and "safe." These properties then, are context-independent. When listing properties for "house," "frustrating" may not commonly be listed, but might be elicited more frequently when the context "trying to build" is provided. In this example, "frustrating" is context-dependent information, that is only incorporated into the concept "house" when the relevant feature "trying to build" is present. Salience reorganization then, can take place when relevant contexts allow the inclusion of context-dependent information into the parent concepts in question. Additionally, salience reorganization might also take place when a context causes a person to re-think a concept without adding new features. In this case, is possible for context-independent features to be reorganized through context simply by rearranging features normally associated with the concept.

The context over alignment effect differs from salience reorganization in that it does not require any change in the concepts themselves. Context over alignment is demonstrated when a previously encountered interpretation guides the choice of interpretation type in the current conceptual combination. The context over alignment effect was demonstrated in Wisniewski and Love (1998). By priming with pairs that were most readily defined by property interpretations, the researchers found more neutral pairs being defined by property interpretations. For example, the pair "zebra tablecloth" was used as a property prime because it can readily be defined using a property interpretation of "a striped tablecloth". The pair "holiday tablecloth" was used as a relation prime because its most plausible definition uses a relation interpretation "a tablecloth used during the holidays." When participants were presented with the prime "zebra tablecloth" (along with the 9 other property interpretation primes) they defined test items such as "spear chisel" using property interpretations like "a chisel that is long" rather than relation interpretations like "a tool used for sharpening the point of a spear". In addition to priming of this type, presenting actual definitions of other conceptual combinations prior to a conceptual combination should result in context over alignment effects.

Though the processes of the WSM may sound time consuming, in practice, the processes can take place exceedingly quickly. The model allows for the elimination of a large number of potential features by only allowing the most salient features into the equation. With only two or three top features for consideration, the process of considering and eliminating inadequate features takes place rapidly. In addition, it is important to remember that the WSM predicts that many pairs can be defined by looking only at one or two possibilities. In such cases, many of the steps of model will never even be taken. Once again, this predicts speed of processing. In the worst case scenario, many comparisons will need to be made to find an adequate solution for the conceptual combination, but this delay is acceptable. During conceptual combination tasks, certain pairs are harder to define than others. The WSM explains this difficulty by suggesting that the hardest pairs to define are those that require moving through each of the steps, from alignment proposed element, to refuted, from modifier to head.

The Weighted Salience Model incorporates all of the aspects required of a model of conceptual combination. It discusses the relative importance of the modifier versus the head, type of interpretation (relation or property), the importance of alignment and similarity, and context effects. Next, I present a series of experiments designed to test some of the important predictions of the Weighted Salience Model.

Using production data, I examined the content of conceptual combination definitions to test several hypotheses presented in the WSM. In Experiment 1, I examined the method of interpretation to see if there were more relation interpretations for dissimilar pairs than for similar pairs, and more property interpretations for similar pairs. I further tested to see if there were more salient features from the modifier than from the head of word pairs. I used reaction time data to test the prediction that the modifier is the first constituent examined for likely elements for inclusion in the final combination. Additionally, I used reaction time data to examine whether combinations containing alignment proposed elements were defined more quickly than those combinations relying on other elements.

In Experiment 2, I tested the importance of salience reorganization using a priming methodology that allowed me to examine whether or not specific features were more likely to be used in the final combination if the features were primed. Finally, I used reaction time data to test whether or not primed features allowed for a faster processing time.

PRETEST 1: SIMILARITY RATING

This pretest was used to develop a list of word tetrads for study. An initial similarity rating task was undertaken that provided similarity rating for 90 pairs of words, but due to the way the pairs were structured, they were found to be inappropriate for further study. The discarded list of 90 pairs of words was taken from the stimuli used by Wisniewski (1996) and Gagne (2000). Both researchers created word pairs by randomly pairing each word in the list with two other words. Thus, each word was used as a head noun for one pair and a modifier noun for the second pair.

Using the randomly paired original stimuli as a model to avoid, it was determined that the best method to guard against a difficult pairing situation was to create word tetrads. Word tetrads are groups of four words that can be organized to produce two similar word pairs, and two dissimilar word pairs. In using the tetrad system, the elimination of one pair due to insufficient similarity or dissimilarity would only require the elimination of three other word pairs, rather than the chain reaction elimination effect found in the first similarity rating task.

Method

Participants

The participants were 39 Texas A&M undergraduates from the psychology subject pool. In return for their participation, students were given course credit in an introductory psychology class. All participants were native English speakers.

Stimuli

The stimuli were selected from the original stimulus set that was tested in the first similarity rating task (see Appendices A and B). The entire set of stimuli for this pretest is presented in Appendix C. Word tetrads were formed by reviewing the results from the first similarity rating task. The pairs rated as most similar were examined and placed in tetrads such that highly dissimilar pairings occurred when the two similar word pairs were rearranged. For example, the three most similar pairs were *robin canary*, *lettuce cabbage*, and *organ piano*. I predicted that pairing the words *robin canary* with *lettuce cabbage* might result in pairs that would be rated more similarly than pairing *robin canary* with *organ piano* because the first tetrad consisted of living things, whereas the second crossed over an ontological boundary. Thus, the tetrad *robin canary* / *organ piano* was selected for further study. The only exception to this selection plan was made for any pairs that incorporated the word "stool". In a pretest of the feature listing task, it was determined that stool was defined by participants in two very different ways, and for this reason, it was dropped from the similarity rating task.

The decision to start with similar pairs rather than dissimilar pairs was made because in the first pretest it was clear that participants were more comfortable rating pairs as very dissimilar as opposed to very similar. In fact, whereas all 20 of the most dissimilar pairs were rated as –81 or lower, the most similar pair was rated as +80.3. This tendency to rate dissimilar pairs as closer to the endpoint led the experimenter to posit that it would be easier to create dissimilar pairs from scratch rather than similar ones. In addition to placing the most similar pairs into word tetrads, four additional word pairs were placed into tetrads.

These were *paper antiques, mountain magazine, town treatment, and servant scandal.* These pairs, though rated as dissimilar, were included because they were pairs from Gagne (2000). All of the other pairs were from Wisniewski (1996), because only stimuli from Wisniewski's stimuli set had been rated as most similar. The inclusion of four of Gagne's pairs was an attempt to incorporate some of her stimuli once again. In the case of these word pairs, tetrads were produced in hopes of creating similar pairs when the words were rearranged.

The final stimuli set consisted of 17 word tetrads, which were arranged into 68 word pairs (34 similar and 34 dissimilar) and can be found in Appendix C. The word pairs were presented in the order in which they are listed in the Appendix as well as the reverse order, such that each head noun became the modifier and vice versa. This manipulation was done between subjects, to avoid any priming effects that could be produced by seeing each word pair twice.

Procedure

The word pairs were presented to participants via a computer program. The computer presented the stimuli to the participant, and asked each one to rate the degree of similarity of each pair. Participants were given as much time as they needed to complete this task.

The computer program presented the pairs in a random order, with each participant rating 68 pairs, either the original presentation order (listed in Appendix C) or the head/modifier reversal order. For example, the 20 participants in Condition 1 were asked to rate the similarity of the pair *robin canary*, whereas the 19 participants in Condition 2 were asked to rate the similarity of the reversed pair, *canary robin*. In this way, participants only saw each pair once.

The on-screen instructions asked the subjects to read each pair and to rate how similar or different each pair was on a sliding scale which was below each pair. The participants were able to indicate their similarity selection on the scale by clicking on it with the mouse before clicking a "continue" button that was below the scale. The scale (which had the corresponding numerical values hidden) was from -100 to +100 where -100 =completely dissimilar, and 100=completely similar. The word "dissimilar" appeared on the far left of the scale, and the word "similar" appeared on the far right. The participants were given examples as follows: "You may see a pair like this: *pink red*. Because these two words are very similar, you might click near the right end of the scale. However, if you saw a pair like: *stadium toe*, you might click more to the left side of the scale, because these two words are not similar."

Results

The similarity ratings for this pretest allowed the selection of word pairs for further study. Word tetrads were examined for their suitability for further study by examining them along several dimensions. First, selected tetrads must not demonstrate significant or marginal order effects across condition. This requirement meant that word pairs must demonstrate essentially the same level of rated similarity regardless of which word was presented as the head noun, and which was presented as the modifier. Additionally, the optimal structure for a tetrad was for two of the pairs to be rated in the top 1/3 most similar pairs, and the other two pairs to be rated in the top 1/3 most dissimilar pairs. This strict requirement though, eliminated too many pairs, and so a lenient criterion was employed such that three of the four pairs must meet the strict requirement, whereas the fourth pair was in the middle of the similarity distribution.

Selected Pairs

For the purposes of selecting tetrads for further study, the distribution of similarity ratings was broken into thirds. The highest 1/3 of scores (with mean ratings of 66.1 and higher) belonged to pairs considered most similar, the lowest 1/3 of scores (with mean ratings of –86.6 and lower) belonged to pairs considered most dissimilar. To be selected for further study, tetrads had to either meet the strict or lenient criteria listed above. Preference was given to pairs in which satisfied the strict criterion

Three tetrads were selected for further study because each one met the strict criterion. These tetrads were: *lettuce cabbage/pistol rifle, fork spoon/bus truck*, and *coffee tea/spear sword*. Their resultant word pairs and their ratings are listed in Appendix D. Six tetrads were selected for further study because each one met the lenient criterion. These tetrads were: *saxophone trumpet/apple pear*, *drill screwdriver/mosquito fly, tie scarf/radish onion, coat shirt/knife chisel, cup bowl/cow horse*, and *bed couch/shark piranha*. Again, their resultant word pairs and their ratings are listed in Appendix D.

The similarity rating distribution then resulted in the selection of nine tetrads and 36 pairs that could be used for further study. This number of word pairs was deemed necessary because additional testing regarding lists of features for the independent words might require more deletions from this word list. It was assumed that from the 36 word pairs, there would be at least 16 that would meet the requirements of the feature listing task.

PRETEST 2: FEATURE LISTING

The WSM predicts that the properties and relations that will predominate in the definitions produced during conceptual combination will be those that were most salient in the parent concepts. To test this part of the WSM, it was necessary to develop a feature database for each word to be incorporated in this study. This pretest was designed to produce such a database.

Method

Participants

The participants were 45 Texas A&M undergraduates from the psychology subject pool. In return for their participation, subjects were given course credit in an introductory psychology class. All participants were native English speakers.

Stimuli

The stimuli were the list of 36 words generated from the group of word tetrads selected in Pretest Two. All of the words appearing in the nine tetrads (presented in Appendix D) were presented to participants one at a time.

Procedure

The 36 individual words were shown to participants in a pencil and paper task. The words were typed in a random order for condition one, and a second condition presented the words in the reverse order. Each word was placed on a page with several other words, with enough room between each item to list at least six features for each word.

Participants were told that they would be presented with several words, and that they should list features or attributes for each one. Participants were given 50 minutes to complete the task. The instructions were as follows:

> This experiment is an attribute listing task. For each word you see, you should list all of the attributes or features that something would need to be considered a good example of the word. If you see the word *cloud*, some features may be: *white, fluffy, high in the air, gives rain, changes shapes*, and *soft*.
>
> Please look at each word, and use the space beneath each one to write all of the important attributes that you can think of. Remember to **write only features that normally describe the word**, not those that would only make sense to you. For example, if you see the word *summer*, you **should not** give *"when I always get sick"* or *"when I have my birthday"* as attributes. More appropriate choices would be: *hot, no school,* and *a season*. Please come up with **at least six attributes** for each word, but feel free to include more if you can. Make sure that you **do not skip any words** as you work.
>
> Please take your time when giving answers, as this is a timed task and you will not be allowed to leave if you finish early. However, if you do finish before the allotted time, please raise your hand to let the experimenter know.

Results

Each feature was entered into a database under the word that it defined. Features were collated within the database to ensure that synonyms were noted, but even features that were only listed by one subject were included. The resulting database of 9,552 features was then referred to in determining which word pairs should be included in the final portions of this research.

Feature Requirements

The WSM makes its predictions based on the salience or output dominance of properties and relations in each of the parent concepts. High output dominance features are the ones expected to be found in the final combinations of parent concepts, unless another feature or relation has been primed. Because the following series of experiments were designed to compare unprimed versus primed conceptual combination situations, only certain parent concepts were expected to be useful for the experimental paradigm. For the unprimed conditions, parent concepts were needed that had several highly dominant properties and relations. The primed conditions however, required word pairs that had a large number of medium high dominance features that could be ripe for priming. To this end, a series of requirements were developed that would insure that the words selected could serve equally well in both the primed and unprimed conditions.

As stated previously, 45 participants contributed feature lists for the present experiment. The distinction then, between high, medium and low output dominance was determined as a function of the percentage of participants who listed a given feature for a particular word. To be considered a high dominance feature, a given feature had to be listed by at least 30% of the participants, demonstrating an output dominance of 14 or higher. A feature was considered to have medium high dominance if it was listed by between 11 and 29% of the participants, yielding an output dominance range from 5 to 13. To be rated as a medium low dominance feature, the feature was listed by between 6 and 10% of participants, with a related output dominance of 3 to 4, and features listed by fewer than 6%

of participants, with an output dominance of 2 and below were considered low dominance features.

For inclusion in the conceptual combination portions of these studies, a word tetrad had to meet the following requirements: 1) Each word in the tetrad should have at least two high dominance features. 2) Preference for inclusion would be given to tetrads with words that have more than 2 high dominance features each. 3) Each word in the tetrad should have at least four medium high dominance features. 4) Preference for inclusion would be given to tetrads with words that have more than five medium high dominance features.

Selected Tetrads

On the basis of the requirements listed above, four tetrads were selected that were to be used for the rest of the studies included in this paper. The tetrads and the number of high dominance features and medium high dominance features listed for each are listed below. Tetrad #1: lettuce-5 high / 8 medium high; cabbage-3/12; pistol-4/10; and rifle-4/10. Tetrad #2: saxophone-5/8; trumpet-5/7; apple-4/10; and pear-5/8. Tetrad #3: coffee-8/7; tea-5/13; spear-5/10; and sword-4/12. Tetrad #4: bed-5/7; couch-5/9; shark-4/14; and piranha-5/12.

The tetrads that were eliminated, and the reasons for their elimination were as follows. Whereas the tetrad drill/screwdriver/mosquito/fly met the output dominance requirements, there were two clearly different meanings for both drill and fly. This tetrad was eliminated to reduce the confusion inherent with multiple meanings. The tetrad fork/spoon/bus/truck was eliminated because the features listed for truck were almost exclusively brand names for truck. The tetrad tie/scarf/radish/onion was eliminated because there were two strong meanings for tie, and there were not enough high dominance features to meet the inclusion requirements. The tetrad cup/bowl/cow/horse was eliminated because bowl did not meet the dominance requirements. Lastly, the tetrad coat/shirt/knife/chisel was eliminated because these words had lower high dominance features than the four that were selected.

With the four tetrads selected, the final list of parent concepts was created. Again, these pairs were to be tested in both the order presented and the reverse order, such that each modifier became a head noun, and each head noun became a modifier. The sixteen word pairs that were selected for use in the final experiments were broken down into similar pairs and dissimilar pairs. The eight similar pairs were: *lettuce cabbage, pistol rifle, saxophone trumpet, apple pear, coffee tea, spear sword, bed couch,* and *shark piranha*. The eight dissimilar pairs were: *lettuce pistol, rifle cabbage, saxophone apple, pear trumpet, coffee spear, sword tea, bed shark,* and *piranha couch*.

EXPERIMENT 1: UNPRIMED CONCEPTUAL COMBINATION

This experiment was designed to test some of the major predictions of the WSM. The WSM predicts a specific progression of combination attempts that will be made for each pair of parent concepts. Similarity of the parent concept is predicted as being important because the WSM states that similar parent concepts will be combined using the highest dominance properties, whereas dissimilar pairs will be combined using the highest dominance relations from the parent concept. This prediction was tested through the present experiment by comparing the number of property interpretations and relation interpretations in the combinations of similar and dissimilar pairs, and by assessing the extent to which those properties and relations were the highly dominant ones for the parent concepts.

The WSM will gain support if dissimilar pairs are found to be defined using relation interpretations more than similar pairs. Additionally, the serial methods predicted by the WSM will garner support if reaction times are found to be longer for pairs that are defined using either lower dominance relations or properties, or properties or relations from the head rather than the modifier. The WSM predicts that high dominance properties and relations will be examined before lower dominance properties and relations. It also predicts that the properties and relations that will first be examined will be those from the modifier. This reaction time distinction was expected to be more pronounced in dissimilar pairs as compared to similar pairs, not because of a prediction of the WSM, but because similar pair will likely have similar features for both the modifier and the head. Therefore, it is expected that it will be more difficult to link a difference in reaction time to similar pairs where the feature lists are very similar for both parent concepts.

Method

Participants

The participants were 59 Texas A&M undergraduates from the psychology subject pool. In return for their participation, participants were given course credit in an introductory psychology class. All participants were native English speakers. Participants were all tested in groups in the same room of the Student Computing Center at Texas A&M.

Stimuli

The stimuli for the present experiment were the eight similar and eight dissimilar pairs of words selected in Pretest 2. All of the pairs were presented in two ways, such that pairs were seen in both an initial order and its reverse. To create the initial presentation form, the word pairs were displayed exactly as they appeared in Pretest 2. To create the reverse form, the head noun from the initial order was presented as the modifier noun, and the modifier from the initial order was presented as the head noun. This manipulation was done to insure that across subjects, all words were used as both modifiers and heads in the same combinations.

Procedure

The word pairs were presented to participants via a web-based computer program. The computer presented the sixteen word pairs in a random order to participants. Each participant was then asked to develop a definition of what the words meant when used together. Participants were given one hour to complete this task.

The two conditions of this computer-driven experiment were the two different presentation orders of the parent concepts, either original modifier and head order, or the reverse. Participants were unaware of the two different conditions.

The on-screen instructions were as follows:

> In the following experiment, you will be asked to complete a task that involves defining pairs of words. For each pair, which we call a "combination," you should come up with one definition. Each definition should describe what the two words mean when used together, rather than what each word means when used separately. For example, if you are given the words "sky monster", you could define this combination as a "thunderstorm," a "monster that lives in the sky," or a "very loud helicopter," but you should not give a simple definition of "sky" like: "the upper atmosphere of the earth" or for "monster" like: "an evil imaginary creature."
>
> As you define the combinations, please think of the meaning that you think best describes the pair, even if you think that it is unlikely that the words really mean anything when they are paired together.
>
> Be sure to write each definition in the field provided. Please do not begin typing until you have settled on a definition.
>
> After you've written each definition, you will move on to another screen and be asked to describe your definition further. A field will be provided for you to list some attributes of the thing you have defined. These attributes will be used to clarify the meaning of your definitions. When coming up with attributes, think of features that something would need to be considered a good example of the definition. For example, if you have defined "sky monster" as "a thunderstorm," you might list attributes like "is very loud," "can scare kids," and "produces rain."
>
> Please work on the pairs in the order in which they are presented, and refrain from typing until you are sure you have a definition you like. Please do not skip any of the pairs. YOU MAY NOT USE THE BACK BUTTON DURING THIS EXPERIMENT, so please do not move on until you feel satisfied with your response.

> On each of the screens, use the mouse to click the continue button when you are finished. On each screen you will be provided with refresher instructions. Feel free to refer to them if you need help.

The computer program would then present the participants with the sixteen word pairs in a random presentation order. The first screen participants saw was a refresher instruction screen with a reminder that they were to write a definition that defined the pair of words together. Once participants clicked the "continue" button, they were shown a word pair. It was at this point that the computer started calculating reaction time, to avoid a situation where differing instruction reading times could affect reaction times. Reaction time was measured by javascript which recorded responses to the nearest millisecond. Below the word pair was a text box, with a cursor ready for text input. Participants simply typed in their definition using the keyboard, and then clicked "continue".

The next screen contained refresher instructions about the feature listing task. Below the instructions was the word pair in question, and then the statement "you defined this pair as:" along with a display of the definition the participant had provided on the previous screen. A text box was provided below these prompts for participants to list their clarifying features. Again, participants typed in features using the keyboard, and then clicked "continue", at which point they were presented with another combination instruction screen. This continued until all pairs had been defined.

If at any point, a participant attempted to click the "continue" button without entering any text for either a definition or feature list, a screen appeared with a reminder to enter appropriate text. Participants were then redirected to the initial page so they could complete the task.

In addition to collecting the definitions and features, the computer program obtained partial and total reaction times for each definition provided. With each keystroke, a new reaction time was reported, and after the entire definition was completed (as indicated by a click of the "continue" button) a total reaction time was collected.

Results

Similarity and Method of Combination

To determine the method of combination used by participants, the definitions provided by participants were examined. Using the coding scheme from Wisniewski (1996), definitions were classified either as property interpretations, relation interpretations, hybrids, or other. Property interpretations were coded when the definition highlighted the projection of a property from the modifier or head on to the other constituent. For example, when a participant defined *shark piranha* as "an extremely large piranha". In this case, the participant was applying the property "large" from shark on to the normal definition of a piranha (a small fish with sharp teeth). Relation interpretations were coded when the definition highlighted a relation between the modifier and head nouns. For example, defining *saxophone apple* as "a small round object used to mute the saxophone" is essentially describing a situation where an apple is placed inside a saxophone – highlighting a relation between the two. Hybridization was coded when pairs were defined as a combination of the two parent concepts. An example is when tea coffee is defined as "a mixture of coffee and tea". Definitions were coded as "other" when they couldn't be placed in to any of the other three categories. Despite coding for all four methods, for the purpose of analysis, both property and hybridization interpretations were considered property interpretations. This method was established by Wisniewski and Love (1998), who suggest that hybridization is an extreme form of property interpretation. The mean number of times each of the four combination methods were used can be found in Table 1, and the compounded values can be found in Table 2.

Table 1
Mean Number (and Standard Deviation) of Definitions That Were Classified as Property, Relation, Hybridization and Other for Similar and Dissimilar Pairs

Type of Pair	Method of Combination	Number of Definitions
Similar		
	Property	3.10 (1.82)
	Relation	1.00 (.64)
	Hybridization	1.86 (1.42)
	Other	2.03 (2.24)
Dissimilar		
	Property	3.37 (1.66)
	Relation	2.34 (1.78)
	Hybridization	0 (0)
	Other	2.29 (1.80)

Table 2
Mean Number (and Standard Deviation) of Definitions That Were Classified as Property and Relation for Similar and Dissimilar Pairs

Type of Pair	Method of Combination	Number of Definitions
Similar		
	Property	4.97 (2.16)
	Relation	1.00 (.64)
Dissimilar		
	Property	3.37 (1.66)
	Relation	2.34 (1.78)

The WSM predicts that similar pairs will be defined using property interpretations more often than relation interpretations, and that dissimilar pairs will be defined using relation interpretations more frequently than similar pairs.

As the WSM only makes predictions about the likelihood of the usage of property and relation interpretations, only these types of interpretations were examined. The values for property and relation interpretations were examined with a repeated measures ANOVA. There was a significant main effect of interpretation method, [$F(1,58)=91.20$, $p<.001$]. In addition, there was a significant interaction between similarity and method of interpretation, [$F(1,58)=44.46$, $p<.01$]. There was no significant main effect of similarity. This indicates that there is a link between similarity and method of combination as predicted by the WSM. There were more relation interpretation for dissimilar pairs than for similar pairs, and there were more property interpretations for similar pairs than for dissimilar pairs. This trend remained in evidence despite the fact that overall, there were more property interpretations.

Content Analysis of Definitions

Presence of High Output Dominance Features

The WSM predicts that the hierarchy of output dominance within parent concepts will serve as a guide when conceptual combination is undertaken. Specifically, the WSM suggests that the reliance on high output dominance features will result in definitions highlighting features from the parent concepts that are high in output dominance. To test this prediction, the content of definitions produced by the participants were examined for the presence of high output dominance features. Pairs were coded as either having high output dominance properties and relations, or having no high output dominance features and relations. Features of both the head and modifier were included in this analysis. The mean number of pairs for which participants had included high OD features or failed to include high OD features can be found in Table 3. For each participant, the total number of pairs was 16, so the maximum mean for either of these values was 16.

Table 3
Mean Number (and Standard Deviation) of Definitions That Included High Output Dominance Features (n=59)

High Output Dominance Features	Number of Definitions
Present	11.25 (2.14)
Absent	4.75 (2.14)

The means in Table 3 were examined by way of paired T Tests. In support of the predictions of the WSM, the difference between the number of definitions that included high OD features and the number of definitions that included no high OD features was significant [$t(58) = 11.69$, $p<.001$]. Clearly, high OD features are important in the conceptual combination. Pairs were combined without the use of high OD features less than 30% of the time, whereas pairs were combined using high OD features more than 70% of the time. This result suggests that the salience of features is important when attempting conceptual combination, and supports the ideas of the WSM.

Importance of Modifier as Compared to Head

Another prediction of the WSM is that the modifier will contribute its properties and relations to the final combination more often than the head. It is likely that this distinction will be more obvious in dissimilar pairs. In similar pairs, with their wealth of common features, there may be little or no difference between the relative contributions of the modifier and head. This is because the properties and relations in similar pairs will likely be virtually the same due to the similarity of both nouns. To test these predictions, participants' definitions were coded for the presence or absence of properties and relations from both the modifiers and the heads. The number of times each participant used properties or relations from either the modifier or head was then calculated across similarity, and also for similar and dissimilar pairs separately. The means for the number of times properties and relations were used in each of these conditions can be found in Table 4.

Table 4
Mean Number (and Standard Deviation) of Definitions That Included Properties and Relations for Similar and Dissimilar Pairs (n=59)

Type of Pair	Presence of High Output Dominance Features	Number of Definitions
Both Similar and Dissimilar		
	From Modifier	8.93 (2.73)
	From Head	10.30 (3.00)
Similar		
	From Modifier	6.20 (1.82)
	From Head	6.30 (2.06)
Dissimilar		
	From Modifier	2.73 (1.54)
	From Head	4.00 (1.77)

In stark contrast to the predictions of the WSM, more definitions included properties and relations from the head than the modifier [$t(58)=3.38$, $p<.001$]. If similarity was taken into account along with the relative contributions from the modifier and the head, this trend was still robust for dissimilar pairs [$t(58)=4.07$, $p<.001$]. Similar pairs however, as predicted, showed no significant difference in the relative contributions from the head and modifier.

Reaction Times: Modifier versus Head

The WSM predicts a serial approach to conceptual combination. It suggests that upon the presentation of a novel pair of concepts, a person will first examine the modifier for reasonable properties or relations that can be used in the conceptual combination. The WSM then, predicts clear differences in reaction times. Pairs defined with high output dominance features from the modifier should have shorter reaction times than those that are defined with features from the head. In addition, pairs defined with high output dominance features from the modifier should have shorter reaction times than those that lack features from either the modifier or head.

To test these predictions, participants' definitions were examined for the presence of high output dominance features. Mean reaction times were calculated for all pairs which were defined using high output dominance features from the head, modifier or neither. Participants with mean response times of less than 4000 msec and greater than 60,000 msec were removed from the analysis, as data exploration demonstrated a large break in the reaction time data distribution near these values. As it was apparent that the range of reaction times was excessive (due to the cognitive complexity of the task at hand), an attempt was made to delete extreme values, while maintaining the majority of the data. Data exploration determined that the majority of the data points were in between these values. Additionally, when the minimum and maximum values were examined, it was found that the mean of all the minimum values and the mean of all maximum values were below 4000 msec on the bottom of the distribution, and above 60,000 msec on the top of the distribution. Therefore, this new range was adopted to remove outlier values equally across all reaction time experiments. In the present experiment, the use of this new range required the deletion of 3.4% of the data. The complete data set can be found in Appendix E.

Table 5 presents the mean reaction times for pairs which were defined using high output dominance features from the head, modifier or neither. These means are collapsed across similarity, as the WSM does not make any predictions of difference in reaction time due to similarity.

Table 5
Mean Reaction Time In Milliseconds (and Standard Deviation) of Definitions That Included High Output Dominance Properties and Relations from the Head, Modifier, or Neither (n=57)

Presence of High Output Dominance Features	Mean Reaction Time
From Modifier	16437.71 (9826.13)
From Head	17814.68 (11578.17)
From Neither	18756.96 (10088.02)

Mean reaction times were examined using two paired T tests. Both tests demonstrated reliable results. The first T test compared the reaction times of pairs using properties or relations from the modifier to the reaction times of pairs using properties or relations from the head [$t(56)=-2.07$, $p<.04$]. The second T test compared the reaction times of pairs using properties or relations from the modifier to the reaction times of pairs using no properties or relations from the head or modifier [$t(56)=-2.78$, $p<.007$]. Thus, the reaction times presented above follow the pattern predicted by the WSM. Pairs that are defined with salient features of the modifier are defined more quickly than pairs that are defined with salient features of the head. Additionally, pairs that are defined with salient features of the modifier are defined more quickly than those pairs that are defined without any salient features at all.

Reaction Times: Alignment Proposed Elements

The WSM states that the alignment process determines likely candidates for inclusion in conceptual combination. Similar pairs are expected to predispose participants to use properties from the modifier, whereas dissimilar pairs are expected to suggest the use of relations from the modifier. These "alignment proposed elements" or APE's, then, should be associated with short reaction times, because APE's would be the first examined when attempting to develop novel conceptual combinations. Because the WSM predicts that the process of combination is serial, "alignment confuted elements" from the head should always be the last features considered. Thus, these "alignment confuted elements" should be associated with longer reaction times.

The WSM would predict a progression from alignment proposed elements from the modifier first, to alignment confuted elements from the modifier, to alignment proposed elements from the head, to alignment confuted elements from the head. Due to the wide range of reaction times however, it was expected that the smaller differences might fail to reach statistical significance. Because of this, the only comparison tested was between the alignment proposed elements from the modifier and the alignment confuted elements from the head, as this comparison should produce the largest differences in reaction times.

To test this prediction of the WSM, the reaction times were calculated for all pairs defined with alignment proposed elements from the modifier, and also for the alignment confuted elements from the head. Because alignment varies with similarity, the pairs in question were those similar pairs defined using properties from the modifier, and relations from the head. Dissimilar pairs that were defined using relations from the modifier and properties from the head were also examined. Again, the range of reaction times was truncated to values between 4000 msec and 60,000 msec. This resulted in the deletion of 8.2% of the data. The complete data set can be found in Appendix G. The mean reaction times for the included pairs can be found in Table 6.

Table 6
Mean Reaction Time In Milliseconds (and Standard Deviation) of Definitions That Included Alignment Proposed Elements from the Modifiers, and Alignment Confuted Elements from the Head

Similarity	Presence of High Output Dominance Features	n	Mean Reaction Time
Similar			
	PropertiesFrom Modifier (APEs-Modifier)	41	15644.13 (9555.49)
	Relations From Head (ACEs - Head)	41	15543.35 (12699.34)
Dissimilar			
	Relations From Modifier (APEs - Modifier)	37	19685.90 (15811.30)
	Properties From Head (ACEs – Head)	37	20578.82 (14029.43)

The means in Table 6 were analyzed using paired T tests. No significant differences were found between the reaction times of pairs that included the alignment proposed elements from the modifiers as compared with pairs that included the alignment confuted elements from the head. These results are in opposition with the predictions of the WSM. Of interest however, is the fact that for dissimilar pairs, the results, while not approaching statistical significance, show a pattern in the expected direction, whereas the similar pairs show the reverse pattern. Alternatively, the possibility remains that the predictions of the WSM are actually correct. The range, though truncated was still large, and this led to enormous standard deviations. Additionally, the relatively small sample size may have limited the power of the present experiment. If this is the case, the findings here may be due to a type II error. Further tests will be necessary to determine whether the predictions of the WSM regarding the serial progression through features of the parent concepts will be supported or refuted.

EXPERIMENT 2: PRIMED CONCEPTUAL COMBINATION

In addition to the basic ideas of the WSM, it predicts that context will affect the conceptual combination process. One method by which conceptual combination is expected to be altered by context is through what the WSM calls "salience reorganization." Salience reorganization suggests that when context provides a feature or relation that is important for a parent concept, that feature will become more salient than before. In this way, a previously medium, or low dominance feature would increase in dominance such that it would be more likely to be included in a conceptual combination. To test the accuracy of this prediction, a priming task was added to the conceptual combination methodology of the previous experiment. It was predicted that the primed features would be used more frequently in the priming experiment than in the previous experiment when they were not primed.

Method

Participants

The participants were 63 Texas A&M undergraduates from the psychology subject pool. In return for their participation, participants were given course credit in an introductory psychology class. All participants were native English speakers. As in Experiment 1, participants were all tested in groups in the same room of the Student Computing Center at Texas A&M. No attempt was made to recruit participants via the web, or to allow participants to take self-guided versions of the present experiment.

Stimuli

The stimuli were the same sixteen word pairs that were used in Experiment 1. In addition, each modifier had an associated prime that would suggest a certain interpretation of the modifier in question. These primes were developed through an analysis of the typical definitions produced by participants in Experiment 1, as well as an analysis of the feature database produced in pretest three.

In creating primes for each noun used in the present experiment, several requirements had to be met. First, no prime could have been listed as a high dominance feature by participants in the feature listing task. Second, words were preferred for selection as primes if participants had not produced these words in the definitions of the unprimed conceptual combination task. Third, words were not selected as primes if more than 10% of participants listed the words as either definitions or features in the unprimed conceptual combination task. Fourth, no preference was given to relations over properties or vice versa – the WSM predicts that a change in salience will predict a change in conceptual combination regardless of the similarity of the pair or whether the prime is a feature or relation. Fifth, the same prime could be used for different words, but ONLY if that duplicated prime would not appear twice in the same condition (order). Using these constraints, one prime was created for each possible modifier of a word pair. This yielded the production of 32 different primes. The primed features as well as the actual priming stimuli for each pair are listed in Appendix E.

Procedure

The word pairs were presented to participants using the same computer program as was used in Experiment 1. The only difference applied to the primes that were presented in the present experiment. Instead of simply defining pairs, before each "definition screen" a separate "priming screen" presented participants with the priming sentences listing in Appendix E. On the "priming screens" the prime was presented with a "continue" button below it. After this screen, the participants were given the refresher instruction screen, and then the definition and feature listing screens for the primed pair. In this way, priming was immediate for each pair, the only delay being the amount of time the participant took to read the refresher instructions for the definition screen. The computer program collected the data in the exact same way as for Experiment 1.

The instructions for the present experiment were the same as for Experiment 1 but with the addition of the following statement: "You will also see some short stories throughout the experiment. When you get to a story screen, please read the story carefully and then click the continue button when you feel you have understood it." This addition was made just between the fifth paragraph and the final paragraph of the instructions as presented for Experiment 1.

Results

To examine the effects of priming in the present experiment, several variables were coded. Each pair was examined for the presence of the primed feature in the final combination. If the primed feature was present for any given pair, it was then counted and added to a dependent variable that contained a running total of the number of times primed features were included by a given participant.

Effects of Priming

To determine how feature inclusion was affected by priming, the definitions provided by participants were compared between the present experiment and Experiment 1. The two experiments then, served as two different conditions in this analysis. Experiment 1 was considered the not primed condition, and Experiment 2 was considered the primed condition. Each participant's definitions were examined for the presence of the primed features. Variables were created to indicate whether or not a participant included a primed feature in his final definition. Each time a participant included a primed feature in a definition, a counting variable was increased, so that the number of times each participant had used a primed feature when defining any of the sixteen pairs could be assessed.

Table 7 shows the mean values of this counting variable for both the not primed and primed conditions. The range of possible values for this variable was from zero to sixteen. Here, the higher the value of the counting variable, the more times a participant defined their pairs by including a primed feature. The participants' mean scores were compared by way of an ANOVA. The effect of priming was significant [$\underline{F}(1,121)=81.54$, $\underline{p}<.0001$]. As predicted, there were more primed features found in pairs defined by participants in Experiment 2 than in Experiment 1. Priming features then, was an effective way to cause those features to be used in the final definitions of participants.

Table 7
Number of Primed Features

Priming	n	mean
Not Primed	59	.31
Primed	63	3.08

Priming and Reaction Times

The WSM states that priming effects are caused by salience reorganization. Essentially, when a property or relation is primed, that feature temporarily moves up in the hierarchy of output dominance, and becomes a more likely choice for inclusion in the conceptual combination. The WSM predicts that because conceptual combination is undertaken in a serial manner, definitions that include high output dominance features will be defined faster than those that do not. It follows then, that definitions that include primed features will be defined faster than those that do not, as the primed features should be more dominant than even the most highly dominant features from the normal hierarchy.

To test this prediction, reaction times for pairs that were defined using the primed feature were compared to reaction times for pairs that were not defined using the primed feature. These calculations were only undertaken for participants from the second experiment, as participants from the first experiment used the primed features too infrequently to be considered. As with the other reaction time tasks, the range was trimmed to include only those values between 4000 msec and 60,000 msec. This limitation required the deletion of 11.9% of the data. The complete data set can be examined in Appendix H. The mean reaction times for both similar and dissimilar pairs are found in Table 8.

Table 8
Mean Reaction Time (and Standard Deviation) of Definitions That Included Primed Features Versus Unprimed Features

Similarity	Presence of Primed Features	n	Mean Reaction Time
Similar			
	Primed Feature Present	42	12134.46 (11124.56)
	Primed Feature Absent	42	15268.55 (10811.77)
Dissimilar			
	Primed Feature Present	38	18738.31(12721.05)
	Primed Feature Absent	38	18715.11 (8781.27)
Both			
	Primed Feature Present	53	13975.40 (9141.44)
	Primed Feature Absent	53	17142.87 (9259.75)

Paired T tests were run for each of the means in the pairs in Table 8. As predicted, pairs that included primed features in their definitions took less time to define. This finding was robust for similar pairs alone [$t(41)=2.11$, $p<.05$], and all pairs lumped together [$t(52)=2.02$, $p<.05$], but not for dissimilar pairs alone. These data then, serve to support the predictions of the WSM. When a particular meaning has been primed, using that meaning of the concept in question decreases the required processing time for pairs in general, as well as similar pairs. Dissimilar pairs seem to show a different pattern, however, this may be due to the outlier removal technique. The analysis of the dissimilar pairs yielded fewer usable data points than either of the other two analyses. In the uncut data presented in Appendix H, the dissimilar pairs demonstrate a trend (though statistically not significant) consistent with the other findings in this section.

DISCUSSION

The results of the present experiments present a mixed impression of the usefulness of the WSM. Several of the key features of the model were supported, whereas others were refuted. These results can be taken as evidence that the WSM has promise, but that it may need to be altered to allow it to accurately capture the subtleties of conceptual combination that were uncovered here.

Similarity and Method of Combination

The Weighted Salience Model states that the definitions of noun-noun combinations will show more relation interpretations for dissimilar pairs, and more property interpretations for similar pairs. Additionally, it suggests that property interpretations are prevalent, and that this method of interpretation is not simply used as a last resort. The present experiments support this prediction of the WSM. Property interpretations were indeed prevalent, and were the most common method of combination for similar pairs. Dissimilar pairs were defined with relation interpretations more frequently than were similar pairs.

Of interest was the finding that in the present experiments, dissimilar pairs were actually defined using property interpretation more than relation interpretation. Bock and Clifton (2000) provide a possible explanation for this finding. They suggested that property interpretations are preferred in a variety of situations. First, the researchers state that conceptual combinations attempted on natural kinds predispose people to attempt property interpretations. Of my 16 pairs tested, 12 contain at least one constituent that is a natural kind. Of my 8 dissimilar pairs, 7 were constructed using at least one constituent that is a natural kind. This heavy reliance on natural kinds may have skewed my data toward higher levels of property interpretation overall.

Bock and Clifton (2000) further stated that when a constituent has a "super salient feature," one that is exceedingly diagnostic and salient (such as "stripes" for tiger), that property interpretations are preferred. They state that when such a feature is present, an exhaustive alignment and construction process can be avoided by simply relying on the "super salient feature". This prediction (which was supported by their data) is in line with the predictions of the WSM, and might also account for the data in the present experiments. The preponderance of property interpretations may have been due to the fact that all parent concepts in the present experiments were selected on the basis of meeting the requirement of having several super salient features.

The last factor that Bock and Clifton (2000) considered to influence the likelihood of property interpretations is similarity. They agree with the predictions of the WSM and state that similar pairs will more likely be defined with property interpretation. As already mentioned, the present data support this position.

Both the WSM and the Two Process Model (Wisniewski, 1996) predict that similarity plays a role in determining the likely interpretation type used in defining conceptual combinations. The Interactive Property Attribution Model (Estes & Glucksberg, 2000a) however, predicts no such importance of similarity. Rather, this model suggests that it is the interaction between a salient property of the modifier and a relevant dimension of the head. The CARIN Model (Gagne, 2000) suggested that property interpretations are simply used as a last resort, and as such, relation interpretations are always favored over property interpretations. Similarity, according to the CARIN Model then, only has the effect of making interpretation more difficult. Despite this, it has no important effect on interpretation type because property interpretations are unlikely regardless of the similarity of the parent concepts. The present data then, support the WSM and the Two Process Model, while refuting the Interactive Property Attribution and the CARIN Models.

Presence of High Output Dominance Features

The WSM makes several predictions about features that should be found in the definitions of noun-noun combinations. The hypothesis that conceptual combination takes place by way of a serial process that examines alignment proposed elements and then moves to alignment confuted elements would suggest two particular findings. First, it suggests that both properties and relations considered salient should be found in final combinations. This was borne out by the data. Clearly, people use properties and relations with high output dominance in their production of definitions. Additionally, the WSM states that most definitions produced during conceptual combination should contain high output dominance features (regardless of type). The data support this hypothesis as well. The large majority (70%) of definitions included at least one high output dominance feature. Thus, these findings support the WSM and its description of the conceptual combination process.

The CARIN Model (Gagne & Shoben, 1997) suggested that frequently encountered stored relations will be incorporated into definitions of conceptual combinations. This model then, predicts a preponderance of relations to the exclusion of properties in the final combinations. The CARIN would not predict that highly salient properties are included in definitions with any frequency. The findings presented here then, fail to support the CARIN model.

Importance of Modifier as Compared to Head

Content Analysis

Because the Weighted Salience Model suggests a serial processing of features to be considered for inclusion in conceptual combinations, a possible prediction of the model is that high output dominance features of the modifier will be preferred over those in the head if the modifier features are acceptable. This prediction would be supported by evidence that definitions show high output dominance features from the modifier more frequently than they show high output dominance features from the head.

This prediction was not supported by the present data. Definitions were actually shown to contain more features from the head concept than from the modifier. This finding was found to be statistically significant for dissimilar pairs, but similar pairs showed no preference for one constituent over the other. There are several possibilities for these findings.

First, it could be that the model does progress as suggested, with a progression from the modifier to the head when examining possible features for inclusion, but that the pairs selected here tended to lack reasonable highly salient features from the modifier. If this were the case, it could simply be that processing continued past the modifier, and that head features were chosen. This explanation allows for maintaining the WSM in its current state, but would need support from the reaction time data, showing that pairs defined using features from the head took longer to define than pairs using features from the modifier. Foreshadowing the discussion of reaction times, the data here demonstrated this pattern exactly. Reaction times were significantly shorter for pairs defined using modifier features, longer for pairs defined using head features, and longest for pairs defined using no highly salient features. Thus, it is possible that the WSM does take place serially, as predicted, but that for most pairs, the head noun had a better feature for combining than the modifiers.

Another interpretation of the current data is to assume that the WSM is correct in positing serial processing of high output dominance features, but that the criteria for considering features to be highly salient may have been too strict. To be considered a high dominance feature, a given feature had to be listed by at least 30% of the participants, demonstrating an output dominance of 14 or higher. A feature was considered to have medium high dominance if it was listed by between 11 and 29% of the participants, yielding an output dominance range from 5 to 13. In coding the data, it was apparent that many pairs were defined using features that had medium high dominance. Had these features been included in the consideration of salient features, the results may have been different. The possibility that the results were skewed due to an inappropriate operational definition of "highly salient" could be examined later using the current data, by altering the operational definition of highly salient to include additional features.

One additional explanation for the finding that more pairs included features from the head comes is that when conceptual combination is undertaken, the head is important as well. Certainly, any property of the modifier that is mapped into a conceptual combination makes use of the head concept. For instance, when "piranha couch" is defined as "a couch with sharp springs poking out that makes it hard to sit on," the feature "sharp" from the modifier is clearly being applied, but so is "sit on" from the head. While this example could still be produced through the explanation provided by the WSM, when it is analyzed in the present experiments, in is counted as a property interpretation with features from the modifier and the head. When relation interpretations are highlighted, a different picture of modifier versus head features develops. For example, when "coffee spear" is defined as "long stick used to stir coffee," "long" clearly comes from the head, and no features are present from the modifier.

This distinction could account for the different profiles of similar and dissimilar pairs. While this was not predicted initially by the WSM, it is clear that the WSM predicts different processes are at work for similar as compared to dissimilar pairs. The finding that similar pairs use features from the head and modifier equally, whereas dissimilar pairs rely on features from the head more frequently supports this prediction of the WSM. In similar pairs, where a property is being mapped from modifier to head, features from both are likely to be found in the definitions, resulting in the virtually identical numbers for the modifiers and heads found in the current research. In dissimilar pairs, when relation interpretations are frequently used, only the head features may be appearing, resulting in the higher reliance on features from the head found here.

It is important to note that the WSM does not state that features from the head will be used infrequently. It simply states that during the alignment process, the modifier will first be examined for appropriate features to use during combination. It is likely (and necessary) that these features will be placed in correspondence with features from the head once the renovation process is undertaken. It will be important in future research to tease apart the two processes of alignment and renovation so that a determination can be made as to whether the alignment process proceeds as suggested by the WSM.

Another possibility is that the WSM is incorrect. It is possible instead, that features are accessed in parallel, such that both the head and modifier are examined at the same time, or that the head is examined first. These two alternative hypotheses would require an alteration of the WSM. Further testing will allow a better understanding of the actual processes used when examining the head and modifiers.

None of the current models provide data on the question of the dominance of salient properties from the modifier over the head in final combinations. The CARIN Model states that a highly frequent relation stored in the modifier will guide the final combination. Despite this, the data supporting the CARIN Model simply show that it is easier to interpret pairs when there is a dominant relation for the modifier, and that pairs are more likely judged as sense rather than nonsense in this condition. (Gagne & Shoben, 1997; and Gagne, 2000). In studies that have participants define combinations, data were presented only to support the idea that property mapping was a rarity, even in conditions that primed for it. There were no data reporting the frequency of finding specific relations or properties in the definitions produced by participants (Gagne, 2000). Despite this lack, it is clear that the CARIN Model would predict a high proportion of definitions to incorporate the stored relation that is most highly frequent for the modifier. The WSM would make this same prediction for dissimilar pairs, but would predict lower reliance on stored relations in similar pairs, where the process would first favor attributes from the modifier over stored relations. The current finding that stored relations as well as specific attributes are found in final combinations lends support to the WSM whereas countering the CARIN Model.

Neither the Two Process Model (Wisniewski, 1996) nor the Interactive Property Attribution Model predicts an importance of the modifier over the head. The Interactive Property Attribution Model (Estes & Glucksberg, 2000a) states that each parent concept has a different role, but that one will not exert a force over the other in terms of properties found in the final combination. The current results here support both the Two Process Model and the Interactive Property Attribution model in that there is no clear modifier superiority. As mentioned earlier, the WSM suggests that the failure to demonstrate modifier superiority may come from the renovation process, whereby features of the head are placed into correspondence with the selected features from the modifier. Further testing will help determine whether or not there is a reliance on the modifier features as suggested by the WSM, or if the Wisniewski or Estes and Glucksberg models are more representative of the conceptual combination process.

Reaction Time Data – Modifier versus Head

Reaction time analysis can be useful in examining the hypotheses of the Weighted Salience Model. Because the model predicts serial processing with an initial reliance on features from the modifier, the WSM predicts that reaction times should be longer for any definitions that highlight features from the head. The means presented in Table 5 follow the trend predicted by the WSM. Pairs defined using the modifier were defined the fastest, with those defined using features from the head being slower and those using no highly salient features being the slowest still.

This pattern of results suggests that the WSM is correct in predicting serial processing that moves from the modifier first, and then to the head. It also provides further support for a key tenet of the WSM, that high output dominance features are focused on when developing conceptual combinations. This finding is particularly important in that this type of reaction time testing is unusual. Generally, researchers in this area have used reaction time tasks to examine forced choice tasks (Gagne, 2000; Gagne & Murphy, 1996; Gagne & Shoben, 2002; and Gerrig & Bortfeld, 1999), which resulted in smaller ranges of reaction times. Despite the unique demand characteristics of the current instructions and task, the methodology developed here demonstrated important effects. Participants were instructed to think about each pair they saw, and to start typing only after they had arrived at a definition they were pleased with. Developing a definition in its entirety requires much more processing time than making a simple decision. Though this method resulted in an enormous range of reaction times, it was still sensitive enough to demonstrate the predicted pattern of results. Importantly, this suggests that there may be a place in future research for this method of obtaining reaction times.

Reaction Time Data – Alignment Proposed Elements

In addition to the general predictions about the modifier and the head, the Weighted Salience Model predicts that alignment proposed elements (APEs) will be preferred over alignment confuted elements (ACEs). It would therefore predict another specific pattern of reaction times in terms of the content of the definitions. In this case, there are four different types of possible pairs. "Proposed Elements – modifier" pairs will be pairs that are defined using APEs of the modifier. "Confuted Elements – modifier" pairs will be pairs that demonstrate the use of ACEs of the modifier. "Proposed Elements – head" will be pairs that highlight APEs from the head. Finally, "Confuted Elements – head" will have the presence of ACEs from the head in the final combinations. The shortest reaction times should be found for those pairs that are defined using any APEs of the modifier, the "Proposed Elements – modifier" pairs. Slightly longer times should be found for "Confuted Elements – modifier" pairs, because processing for these pairs would have first exhausted the APEs of the modifier. Longer times still would be expected for "Proposed Elements - head" pairs, because the processing for these pairs would have progressed through all of the features of the modifier. Finally, the longest times reaction times should be found for "Confuted Elements – head" pairs. These pairs would have required processing of all the modifier features, as well as the APE's of the head.

This analysis was expected to be difficult because it is expected that similar pairs might share many of the same features. Therefore, only the comparison that was expected to produce the largest differences in reaction times was analyzed, the comparison between APEs of the modifier and ACEs of the head. This comparison was made twice, once for similar pairs, and once for dissimilar pairs. Though all of the results failed to achieve statistical significance, the similar pairs did demonstrate a trend in the expected direction. For dissimilar pairs though, the trend was reversed, with the pairs containing ACEs showing shorter reaction times than pairs that contained APEs.

These data are hard to explain using the WSM. Even if the failure to achieve significance is attributed to the large range of reaction time data, the difference between the similar and dissimilar pairs is surprising. The WSM would predict that the trend for the similar pairs should be found in the dissimilar pairs as well. As this result can't be explained by possible problems in methodology, it requires serious consideration.

The prediction of the WSM that the modifier is more important than the head was developed because of the strong evidence produced in attempts to support the CARIN model. According to the CARIN (Gagne & Shoben, 1997) approach, every word has stored within it thematic relations that can be used to form a link with another word during conceptual combination. These relations can vary from being commonly encountered to rarely encountered. Therefore, within any word, a given relation can be either highly frequent (referenced as "H") or relatively infrequent (referenced as "L"). When looking at a pair of words then, there are several possible arrangements dealing with the perceived frequency of stored relations. In an "HH" pair, the stored thematic relation that is most frequent for the modifier is also most frequent for the head. For example in the pair, "cheese gravel" both share the relation "made of" as a highly available one. In an "HL" pair, the stored thematic relation that is most frequent for the modifier is low in frequency for the head. For example, "cheese gas," where the "made of" relation is high for cheese, but low for gas. Lastly, an "LH" pair would show the opposite arrangement, where the relation that is most frequent for the modifier is not often encountered for the head. An example is the pair "cheese magazine," where the relation "about" (as in magazine about "X") is common for magazine, but low for cheese.

Gagne and Shoben (1997) created pairs of words that were either of the form "HH," "HL," or "LH," to determine the relative importance of the modifier and head in providing a thematic relation for the final combination. Using a reaction time task, the researchers presented participants with a series of sentences that held a pair of one of the three types discussed. Participants were asked to rate each pair in question in terms of whether or not it made sense. Reaction times were recorded, and it was hypothesized that if the modifier's relations were most important, HH and HL pairs would be equally easy to interpret. LH pairs however, would suffer from more difficult interpretations because the most plausible relation was one that was not commonly associated with the modifier. Gagne and Shoben (1997) found that the reaction times were the same for the HH and HL pairs, but that the LH pairs took significantly longer to interpret. The similarity of reaction times for HH and HL pairs demonstrate the importance of the combinatorial history of the modifier. The lack of importance of the head's combinatorial history is shown by the result that HL pairs did not take longer to interpret.

As the CARIN was used as a jumping off point for this prediction of the WSM, perhaps it can explain the surprising results found here. The words selected for inclusion in this examination of the WSM were not combined with other words on the basis of shared relations. Therefore, the variability between HH, HL, and LH pairs was not controlled for. When participants were defining pairs, perhaps they found it easier to link some pairs as opposed to others because the pairs were HH or HL as opposed to LH. This effect may have overshadowed any differences that could have been found between pairs that used APEs versus ACEs. In the future, a test should be attempted which controls the links between pairs, to avoid this additional variability. Until such a test is completed, it will be impossible to determine whether or not the WSM's prediction of reliance on APEs before ACEs is correct.

Salience Reorganization: the Effects of Priming

The Weighted Salience Model posits that context can affect conceptual combination through the process of salience reorganization. Salience reorganization is the effect predicted when the context causes a change in salience for properties of the parent concepts. If a context is presented that causes a property typically low in output dominance to have a higher output dominance, the items deemed most salient by the new output dominance will be accessible during conceptual combination, for as long as the priming maintains its effectiveness.

The idea of salience reorganization is supported through the present experiments. The target features were found in the definitions more often when the features were primed. This clearly demonstrates the importance of context in conceptual combination. While other researchers have demonstrated that priming is effective when combinations are used as primes (Gagne & Shoben, 2002; Wisniewski & Love, 1998), the present experiments provide evidence that simply highlighting a particular meaning of a constituent to be used in conceptual combination is effective. Participants exposed to alternative meanings of words that were then used as modifiers in a conceptual combination task reacted by incorporating features that were otherwise ignored into their definitions.

Priming and Reaction Times

The WSM suggests that salience reorganization works by altering the profile of features in the output dominance hierarchy of a constituent. It was expected that this difference would be testable through the reaction times of participants. Primed features should benefit from higher output dominance once salience reorganization takes place. If this is the case, and the WSM is correct in predicting that highly salient items are examined first, pairs using primed features should have shorter reaction times than those that do not use primed features. When similarity was not taken into account, pairs defined using the primed features were defined more quickly than pairs defined without the benefit of a primed feature. This finding supports the predictions of the WSM. Of interest though, was the finding that similar pairs were defined more quickly when defined with a primed feature, but that this same pattern of results was not statistically significant in dissimilar pairs. Several possibilities exist that might account for this result.

One way to account for the lack of a significant finding for dissimilar pairs is to posit that the trimmed range of reaction times deleted too many dissimilar pairs to reach significance. When trimmed to the required range, data from only 38 participants were available for analysis. Data from several more participants were available for analysis for the other two comparisons. Support for this idea comes from the finding that the untrimmed means for the dissimilar pairs demonstrated the predicted trend (though it was not significant) whereas the trimmed means are almost identical to each other. Another attempt at this experiment might alleviate this problem if more participants were tested.

A second possibility is that dissimilar pairs were less susceptible to priming in the present experiment due to a task demand characteristic. Even prior to trimming the range of results, more participants included primed features for similar pairs than for dissimilar pairs. An examination of the primes demonstrated that there were more property primes than relation primes. Perhaps, as the WSM suggests, dissimilar pairs are less likely to use properties to link the concepts during the defining process. If this is so, the property primes may have been less effective when used for dissimilar pairs, and more effective when used for similar pairs. Thus, the primes were used less frequently for dissimilar pairs, and this decrease in sample size limited the likelihood that the results would be significant. If this is the reason for the pattern of results that were found, the lack of a difference in reaction times for the dissimilar pairs would not pose a problem for the WSM.

A last possibility is that there are different processes at work for similar pairs as compared to dissimilar pairs. Perhaps when similar pairs are being defined, participants search for something that will allow the new definition to differ from the definitions of either parent concept. Because most features in the modifier will also be present in the head, this task is difficult when no context is supplied. When however, a priming context is provided, this task becomes easier, and so participants would be more likely to "latch on" to primed features when defining similar pairs. In dissimilar pairs, with their wealth of opposing features, participants may be able to find unique ways to link the concepts without relying on a prime. As the WSM already predicts several differences in the way similar and dissimilar pairs are processed, the possibility that similar and dissimilar pairs might react differently to primes is acceptable. However, to strengthen the WSM, if this difference accounts for the distinction between similar and dissimilar pairs, the model would need an amendment explaining the relative likelihood for relying on primes between similar and dissimilar pairs.

One way to determine which of these alternatives is correct might be obtained in future research without reaction time data. The idea that the output dominance hierarchy could be altered through priming could also be tested by having participants attempt a feature listing task. One group of participants could list features for a group of words without any priming, and the second could list features after being exposed to primes similar to the ones used here. The WSM would predict that the primed feature would be higher in output dominance lists for the participants in the primed group as opposed to the unprimed group.

CONCLUSION

The present experiments are only the beginning of a thorough evaluation of the WSM. Many more experiments will be necessary to conclusively determine the value of the model. The current methods have allowed me to suggest that certain hypotheses of the WSM are of value.

The idea that there is a reliance on the output dominance hierarchy of the parent concepts was supported, and demonstrates the importance of salient features in defining conceptual combinations. This idea has been alluded to in the past by other researchers (Costello & Keane, 2001), but the present experiments provide the first concrete evidence that output dominance alone is an important qualifier for inclusion in conceptual combination.

The suggestion of a serial processing method was also supported by this research. Processing of definitions took longer for pairs that were defined with highly salient features from the head as compared to the modifier. Additionally, pairs lacking any highly salient features took the longest to define. This suggests that processing occurs in the order that the WSM predicts, modifier first, and head second, with a reliance on highly salient features unless none are found to be appropriate.

The importance of similarity was another aspect of the WSM that garnered support through the present experiments. Relation interpretations occurred more frequently in dissimilar pairs than in similar pairs. Property interpretations occurred more frequently in similar pairs than in dissimilar pairs.

Lastly, a predicted effect of context, salience reorganization, was supported. Priming particular features of a constituent served to increase the likelihood of the inclusion of those particular features in the definitions of the combined constituents. Priming also has the effect of reducing the amount of time required to come up with definitions. It appears that the output dominance hierarchy of parent concepts can be altered through priming, and that the alteration affects subsequent attempts at conceptual combination.

The hypothesis of the WSM that was not clearly supported by this research was the idea of the superiority of APEs over ACEs. The present results cannot confirm an initial reliance on APEs from the modifier, and a secondary reliance on ACEs from the head. Further experimentation will determine whether or not this hypothesis can be supported, or whether it should be abandoned.

In conclusion, the WSM has served as a beneficial model to drive research on conceptual combination. It has confirmed the importance of output dominance, similarity and context in the conceptual combination process. There are still many more questions that must be answered with future research, but the using the WSM as a guide will likely serve as a useful jumping off point for a comprehensive model of conceptual combination.

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APPENDIX A

Initial Similarity Rating: Similar and Dissimilar Pairs for Testing from Wisniewski (1996) and Gagne (2000)

Similar Pairs

Wisniewski (1996)

- coat shirt
- organ piano
- pistol rifle
- apartment hotel
- magazine newspaper
- whiskey beer
- bus truck
- stool chair
- fork spoon
- knife chisel
- apple pear
- lettuce cabbage
- mouse squirrel
- mosquito fly
- shark piranha
- robin canary
- tie scarf
- saxophone trumpet
- spear sword
- igloo tent
- book pamphlet
- coffee tea
- motorcycle bicycle
- bed couch
- cup bowl
- drill screwdriver
- pineapple coconut
- radish onion
- cow horse
- ant termite
- clam oyster
- goose duck

No stimuli needed to be dropped from this stimuli list. It was used in its entirety.

Gagne (2000)

- financial headache – dropped (financial = adverb)
- plastic toy – dropped (plastic = adjective)
- paper antiques
- urban light – dropped (urban = adjective)
- office plant
- home language

- mountain bird
- student equipment
- water money
- chocolate utensils
- wood treatment
- family town
- cooking remedy - dropped (cooking = adjective and verb)
- college magazine
- gas crisis
- servant scandal
- headache light – added to provide a match for dissimilar pairs

Dissimilar Pairs

Wisniewski (1996)

- magazine shirt
- apartment piano
- coat rifle
- stool hotel
- whiskey newspaper
- pistol beer
- knife truck
- bus chair
- igloo spoon
- cup chisel
- lettuce pear
- cow cabbage
- radish squirrel
- clam fly
- pineapple piranha
- ant canary
- fork scarf
- tie trumpet
- coffee sword
- spear tent
- drill pamphlet
- bed tea
- book bicycle
- saxophone couch
- organ bowl
- motorcycle screwdriver
- shark coconut
- mouse onion
- goose horse
- robin termite
- mosquito oyster
- apple duck

No stimuli needed to be dropped from this list. It was used in its entirety.

Gagne (2000)

- college headache
- musical town – dropped (musical = first definition is adjective)
- office antiques
- chocolate plant
- gas cloud
- wood money
- cooking treatment – dropped (cooking = verb and adjective)
- servant language
- family utensils
- floral toy - dropped (floral = first definition is adjective)
- water bird
- paper equipment
- home light
- financial remedy – dropped (financial = adverb)
- plastic crisis – dropped (plastic = adjective)
- mountain magazine
- town treatment – added to provide a match for similar pairs
- crisis town – added to provide a match for similar pairs

APPENDIX B

Initial Similarity Ratings for the 20 Most Similar and 20 Most Dissimilar Pairs

Similar Pairs

Pair	Mean Rating
robin canary	80.31
lettuce cabbage	80.31
organ piano	80.10
clam oyster	76.77
stool chair	76.31
pistol rifle	75.18
goose duck	73.69
magazine newspaper	71.44
saxophone trumpet	71.15
apple pear	69.92
whiskey beer	69.87
drill screwdriver	69.74
fork sppon	69.44
mosquito fly	69.38
bus truck	67.95
coffee tea	65.54
tie scarf	64.62
radish onion	64.00
spear sword	62.97
pineapple coconut	60.97

Disimilar Pairs

Pair	Mean Rating
whiskey newspaper	-90.15
coffee sword	-90.03
mountain magazine	-89.87
fork scarf	-89.74
organ bowl	-89.18
igloo spoon	-89.08

saxophone couch	-87.54
mouse onion	-87.05
tie trumpet	-86.21
town treatment	-85.15
knife truck	-85.10
apartment piano	-84.18
stool hotel	-84.03
cup chisel	-83.33
apple duck	-82.54
paper antiques	-82.44
drill pamphlet	-82.41
radish squirrel	-82.08
motorcycle screwdriver	-82.05
pineapple piranha	-81.79

APPENDIX C

Stimuli Set for Pretest One: Word Tetrads and Tested Pairs

Word Tetrads

- robin canary / organ piano
- lettuce cabbage / pistol rifle
- clam oyster / magazine newspaper
- goose duck / whiskey beer
- saxophone trumpet / apple pear
- drill screwdriver / mosquito fly
- fork spoon / bus truck
- coffee tea / spear sword
- tie scarf / radish onion
- pineapple coconut / motorcycle bicycle
- book pamphlet / ant termite
- coat shirt / knife chisel
- cup bowl / cow horse
- bed couch / shark piranha
- apartment hotel / mouse squirrel
- paper antiques / mountain magazine
- town treatment / servant scandal

Similar Pairs to Test

- robin canary
- organ piano
- lettuce cabbage
- pistol rifle
- clam oyster
- magazine newspaper
- goose duck
- whiskey beer
- saxophone trumpet
- apple pear

- drill screwdriver
- mosquito fly
- fork spoon
- bus truck
- coffee tea
- spear sword
- tie scarf
- radish onion
- pineapple coconut
- motorcycle bicycle
- book pamphlet
- ant termite
- coat shirt
- knife chisel
- cup bowl
- cow horse
- bed couch
- shark piranha
- apartment hotel
- mouse squirrel
- paper magazine
- mountain antiques
- town scandal
- servant treatment

Dissimilar Pairs to Test

- robin organ
- canary piano
- lettuce pistol
- cabbage rifle
- clam magazine
- oyster newspaper
- goose whiskey
- duck beer
- saxophone apple
- trumpet pear
- drill mosquito

- screwdriver fly
- fork bus
- spoon truck
- coffee spear
- tea sword
- tie radish
- scarf onion
- pineapple motorcycle
- coconut bicycle
- book ant
- pamphlet termite
- coat knife
- shirt chisel
- cup cow
- bowl horse
- bed shark
- couch piranha
- apartment mouse
- hotel squirrel
- paper antiques
- mountain magazine
- town treatment
- servant scandal

APPENDIX D

Pretest One: Similarity Ratings for Selected Tetrads

lettuce cabbage / pistol rifle
- lettuce cabbage = 88.79 (sim)
- pistol rifle = 84.46 (sim)
- lettuce pistol = -94.90 (dis)
- cabbage rifle = -90.26 (dis)

fork spoon / bus truck
- fork spoon = 76.15 (sim)
- bus truck = 68.51 (sim)
- fork bus = -94.15 (dis)
- spoon truck = -86.62 (dis)

coffee tea / spear sword
- spear sword = 75.23 (sim)
- coffee tea = 68.08 (sim)
- coffee spear = -90.95 (dis)
- tea sword = -90.33 (dis)

saxophone trumpet / apple pear
- saxophone trumpet = 75.03 (sim)
- apple pear = 70.64 (sim)
- saxophone apple = -91.54 (dis)
- trumpet pear = -85.21 (middle – almost dis)

drill screwdriver / mosquito fly
- mosquito fly = 78.92 (sim)
- drill screwdriver = 72.69 (sim)
- screwdriver fly = -92.82 (dis)
- drill mosquito = -69.49 (middle)

tie scarf / radish onion
- tie scarf = 75.44 (sim)
- radish onion = 65.85 (middle – almost sim)
- tie radish = -91.72 (dis)
- scarf onion = -88.95 (dis)

coat shirt / knife chisel

- coat shirt = 66.08 (sim)
- knife chisel = 47.79 (middle)
- coat knife = -91.46 (dis)
- shirt chisel = -89.41 (dis)

cup bowl / cow horse

- cup bowl = 71.74 (sim)
- cow horse = 48.95 (middle)
- bowl horse = -91.77 (dis)
- cup cow = -91.33 (dis)

bed couch / shark piranha

- bed couch = 67.31 (sim)
- shark piranha = 63.36 (middle – almost sim)
- bed shark = -91.85 (dis)
- couch piranha = -87.33 (dis)

APPENDIX E

Experiment Two: Priming Stimuli

ORDER ONE

Similar

- lettuce cabbage
    - PRIME lettuce = on a sandwich
        - Sarah loved lettuce. She always put lettuce on her sandwiches and enjoyed eating them.
- pistol rifle
    - PRIME pistol = police carry
        - Jeff was a police officer. He always made sure he was carrying his pistol before he left for a day of work.
- saxophone trumpet
    - PRIME saxophone = blues
        - Wendy bought a saxophone because she loved the "blues".
- apple pear
    - PRIME apple = round
        - Brad examined the shape of his apple. He was happy to find that it was perfectly round.
- coffee tea
    - PRIME coffee = starbucks
        - Alice really wanted some coffee, so she headed to a Starbucks to get some.
- spear sword
    - PRIME spear = wood
        - Dave took a look at his new spear. The handle was made out of a really nice type of wood.
- bed couch
    - PRIME bed = sheets
        - Steve found just the right sheets to cover his bed.
- shark piranha
    - PRIME shark = gray
        - Ella looked at the sharks. She noticed that all of them seemed to be similar shades of gray.

Dissimilar

- lettuce pistol
    - PRIME lettuce = rabbits
        - Billy had to feed his rabbits. He found some lettuce and gave it to them.
- rifle cabbage
    - PRIME rifle = heavy
        - Anne attempted to pick up the rifle, and was surprised to find that it was so heavy.
- saxophone apple
    - PRIME saxophone = large
        - Joe pointed at the saxophone. "I like it because it is so large" he said.
- pear trumpet
    - PRIME pear = need to ripen
        - Karen took the pears home, but she knew that she'd have to find someplace to let them ripen.
- coffee spear
    - PRIME coffee = morning
        - Alex's first thought every morning was of coffee. "Mornings are for coffee" he said.
- sword tea
    - PRIME sword = battle
        - Marty grabbed the sword and prepared for battle.
- bed shark
    - PRIME bed = night time
        - Sally looked at the dark sky. It was night time, and all she could think about was her bed.
- piranha couch
    - PRIME piranha = rare/unusual
        - When Emily saw the piranha, she thought about how rare they were. "It is unusual to ever get to see a piranha" she thought.

ORDER TWO

Similar

- cabbage lettuce
    - PRIME cabbage = boiled
        - Sarah took the cabbage out and put it in some water to boil.
- rifle pistol
    - PRIME rifle = wood / wooden handle
        - Jeff took a look at his new rifle. The handle was made out of a really nice type of wood.
- trumpet saxophone
    - PRIME trumpet = used to play marches
        - Wendy listed to the sound of the trumpet playing the march.
- pear apple
    - PRIME pear = soft
        - Brad picked out the best pear. "It has to be soft" he said.
- tea coffee
    - PRIME tea = comes in a bag
        - Alice picked up the tea bag. She really liked that tea was packaged in this way.
- sword spear
    - PRIME sword = used by knights
        - Dave watched the knights. Each one carried a sword.
- couch bed
    - PRIME couch = watch TV
        - Steve always enjoyed watching TV. His favorite spot was on the couch.
- piranha shark
    - PRIME piranha = lives in the amazon
        - Ella visited the Amazon River and asked her guide "will we see a piranha today?"

Dissimilar

- pistol lettuce
  - PRIME pistol = loud
    - Billy put down the pistol. "That was really loud!" he said.
- cabbage rifle
  - PRIME cabbage = smelly
    - Anne wrinkled her nose. "That cabbage is so smelly!" she yelled.
- apple saxophone
  - PRIME apple = give it to teacher
    - Joe took the apple from his mom. He was proud to be able to give it to his teacher.
- trumpet pear
  - PRIME trumpet = played when the sun comes up
    - The sun was coming up. Karen heard the trumpet being played.
- spear coffee
  - PRIME spear = pointy
    - Alex looked at the spear. It was very pointy!
- tea sword
  - PRIME tea = weak
    - Marty tasted the tea and found it to be weak, just the way he liked it.
- shark bed
  - PRIME shark = gray
    - Sally looked at the sharks. She noticed that all of them seemed to be similar shades of gray
- couch piranha
  - PRIME couch = big
    - Emily thought that the most important thing about a couch was that it be the right size. "The bigger the better!" she said.

APPENDIX F

Complete Data Set for Table 5

Mean Reaction Time In Milliseconds (and Standard Deviation) of Definitions That Included High Output Dominance Properties and Relations from the Head, Modifier, or Neither (n=59)

Presence of High Output Dominance Features	Mean Reaction Time	Minimum Reaction Time	Maximum Reaction Time
From Modifier	17046.23 (11663.50)	3888.80	64889.50
From Head	17456.99 (11556.44)	3812.10	54362.60
From Neither	18659.39 (10089.21)	4662.90	44828.58

APPENDIX G

Complete Data Set for Table 6

Mean Reaction Time In Milliseconds (and Standard Deviation) of Definitions That Included Alignment proposed elements from the Modifiers, and Alignment confuted elements from the Head

Similarity	Presence of High Output Dominance Features	n	Mean Reaction Time
Similar			
	PropertiesFrom Modifier	45	16064.88 (10421.32)
	Relations From Head	45	18011.65 (20166.39)
Dissimilar			
	Relations From Modifier	40	24396.93 (29413.86)
	Properties From Head	40	21741.23 (16434.25)

APPENDIX H

Complete Data Set for Table 8

Mean Reaction Time (and Standard Deviation) of Definitions That Included Primed Features Versus Unprimed Features

Similarity	Presence of Primed Features	n	Mean Reaction Time
Similar			
	Primed Feature Present	50	13953.53 (18220.13)
	Primed Feature Absent	50	15484.65 (10811.77)
Dissimilar			
	Primed Feature Present	42	17296.57 (12898.65)
	Primed Feature Absent	42	19355.23 (11054.47)
Both			
	Primed Feature Present	59	15448.32 (15291.34)
	Primed Feature Absent	59	17010.82 (9669.11)

VITA

Merryl Joy Patterson

1438 Hargis Creek Trail
Austin, TX 78717
(512) 238-0046 *missi@head-gear.com*

Personal
A.K.A. Merryl Joy Wilkenfeld

Educational Background
B.S. in Psychology (May, 1993) from Indiana University, Bloomington, Indiana
M.S. in Psychology (May, 1995) from Texas A&M University, College Station, Texas

Current Position
Adjunct Faculty Member, Austin Community College 1999-present
Teaching: Undergraduate courses in Child Development, Human Growth & Development, Human Sexuality, and Introductory Psychology.

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