CS 182 Spring 2004. Assignment 4 Solution.

Psycholinguistics Experiments, Categories and Prototypes

The solutions here are model answers only. There are a number of equally good answers to these questions.

Problem 1. Choose a category that includes at least 5 kinds of prototypes.

a. Give a brief description of the internal structure of your chosen category. Does it have a central case (or cases)? If so, what properties hold for the central case?

b. Briefly describe 5 prototypes or prototype effects relevant to your category, and show how each gives rise to the type of reasoning indicated.

Here's a sample answer from a student:

> The category I have chosen is that of war. A war in which there is fighting between two sides, death and destruction of property, and the eventual declaration of winners and losers would be the central case. War is generally considered to be armed conflict after a declaration of intent to commit hostility. For this reason, certain actions, such as the surprise attack on Pearl Harbor are considered outside the realm of the normal, since the Japanese declared war at almost the same time they attacked the United States.

> A **typical case** of a category is one that exhibits a set of properties that are considered germane to the category. As I have already mentioned, a typical war consists of armed conflict with casualties on both sides, and both World War I and II could be considered examples of typical wars.

> An **ideal case** in one that is used as a standard of comparison for other cases, having the characteristics that make something particularly good. An ideal war might be thought of as a war in which one side (the side you are on, which was aggrieved and in the right) quickly and thoroughly defeated the other side, with a minimum of bloodshed. Many people would argue that no war could be ideal, but many ideal cases aren't extant.

> A **salient example** is an example of a category that is well known and often displays characteristics not always consistent with the category, but is still associated with that category and thus can mislead people. People use these examples to make 'probability judgments'. One salient example of war is that of The Vietnam War, in which one country (the US) became involved in a conflict within another nation and was embroiled for much longer than originally intended. This example was used before the declaration of war on Iraq, as people were afraid that we would not be able to win the war and would be forced to commit many more troops than was originally intended. As the quick fall of Baghdad indicated, this was not the case, although we may still be stuck in the humanitarian cleanup afterwards, which we ironically took no part in after Vietnam.

> A category can have **graded membership** when certain members of the category are considered less typical and less appropriate as members. One example is the cold war, which to many people doesn't qualify as a real war, because there was little exchange of fire and destruction of property. Enough people do consider it a war for it to be called one, however, based on the intense rivalry between the USSR and the US and the number of times we almost escalated into real fighting.

> A **paragon exemplar** is a particularly excellent example of a category. It is a single instance that resonates as having the ideal characteristics of the category and is often used for comparison against other instances of the category. An **anti-paragon exemplar** is a particularly bad example that still represents the category but is linked to the more unpleasant aspects of it. Many people consider Vietnam an anti-paragon exemplar because of the way it divided our country and because of the lack of justification of our involvement. It is well known that wars aren't always fought for good causes, but people couldn't understand why Vietnam was being fought at all.

Here's one more sample answer from another student:

> The category "literature" appears to comprise a few central cases: the novel, poetry, and drama (tragedy and comedy). These are probably fairly uncontentious, and falling into one of these cases is both necessary and sufficient for being literature. However, what is contentious is the "falling into": whether, in fact, a particular work qualifies as poetry, or rises to the standards of a novel.
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> This category evinces the following prototype effects:
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> (1) **Typical case**: We don't generally have to reason about whether or not (e.g.) Shakespeare's works are literature; inferences here are automatic. A dispute over the literature status of Hamlet would not be possible—without a radical shift in the meaning of the word.
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> (2) **Paragon/exemplars**: At least some of the "central cases" of literature seem to have a few exemplars: War and Peace and Moby-Dick exemplify the novel; Hamlet, drama; "The Raven," poetry. When making a judgment about whether or not a particular work qualifies as literature, we often look to paragons like these for comparison.
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> (3) **Social stereotype**: The concept of literature stereotypically revolves around works authored, by and large, by dead Europeans and Americans. There is also a stereotype against the inclusion of certain written works: song lyrics, for example, are generally assumed not to have poetic merit; likewise science-fiction novels are presumed to fall short of the honorific "literature." These judgments are of course not immune from error, though they make good heuristics.
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> (4) **Graded membership**: Whereas Oliver Twist and "Shall I Compare Thee to a Summer's Day?" rank as full members of the concept "literature," The Lord of the Rings and "I Know Why the Caged Bird Sings" earn only lesser status. (Sir) Paul McCartney's collection of Beatles' lyrics and Stephen King's books are at best marginal members of the category.
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> (5) **Central cases**: As mentioned earlier, there appear to be at least three central cases of literature: poetry, drama, and the novel. Ancillary or "radial" cases include the short story; poetry with neither rhyme nor meter ("free verse"); holy books like the Bible, the Koran, and the Upanishads; essays; letters; etc. Some have even suggested that philosophy is best considered as simply another form of literature.
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> It might be noted that essays and novels as literary works did not appear until after the Middle Ages, the latter in fact appearing with the rise of the middle class. These examples suggest that the category of literature has fluid boundaries which have been extended in the past and may be again in the future. (It is also interesting to note that novels have insinuated themselves into the role of a central case of literature to a much greater extent than essays, despite their correspondingly late appearance.)

Problem 2. Using color as a model, pick a different domain of embodied concepts and speculate about how it may arise from the neural system.

    a.   What are the basic-level categories in your chosen domain?

    b.   What gives rise to this domain and the category structure within it? What interacting factors are involved? Try to be specific about the biological underpinnings of the domain. What kind of additional biological evidence would be necessary to support the claim that your chosen domain is embodied?

    c.   Based on your analysis, what kind of crosslinguistic variation would you expect for this domain? Feel free to cite linguistic examples if you know of them.

Here's a sample answer from a student:

> A) Using TEMPERATURE as an example, the basic level categories are HOT, COLD, WARM and COOL. Other words like LUKEWARM or BOILING only apply to specific contexts and circumstances. HOT, COLD, WARM and COOL can each be visualized using a single mental

representation. They also have their own motor programs and are the most common words we use in neutral communication. Our knowledge of TEMPERATURE is organized at these levels and we use them to gauge the temperature of other examples.

B) Our experiences with temperature and our sensory abilities shape the structure of the TEMPERATURE domain. We have experiences that are grouped into the four basic level categories for temperature (things that are hot, cold, cool or warm). Deviations from these basic categories give rise to more specific words like FREEZING or MILD. Our sensory receptors are also important for judging temperature. We have sensory receptors on our skin and tongue that respond solely to HOT, COLD, WARM or COOL things. The biological basis for this domain is similar to the basis of color in our bodies (photoreceptors, color opponent cells, etc.). If we could show that we do NOT have receptors for temperatures beyond our basic levels and typical language use (extremely hot or extremely cold) that would support the idea that this concept is embodied, because what we don't directly experience we won't have many words to describe. But this would be a cruel experiment.

C) I would expect that cultures who live in warmer areas would have more basic level categories on the warmer side of the spectrum. Similarly, cultures that live in cold areas would have more basic level categories for COLD. This is similar to the Alaskan eskimo language that has over 20 different terms for the word SNOW.

Here's one more sample answer from a student:

I have decided to analyze the domain of flavor. This is different from "taste" which is the direct processing of the information from the receptors on the tongue. Flavor is more complex, and one flavor can include many different tastes. Also, flavor is a result of integration of information of both taste and smell. I will suggest that the neurobiology of taste determines the basic categories of flavor.

a. There are five basic categories for flavor: sweet, salty, sour, bitter, and umami. These directly correspond to the five distinct receptors on the human tongue.

b. The sensation of taste is detected by five different receptors in the human tongue. These taste receptors are characterized in terms of their molecular structure. Receptor for salty has a sodium ion channel, and the taste of sour is associated with hydrogen ion channels. Receptors for bitter, sweet, and umami are G-protein coupled receptors, and there are several different kinds of them. These five different receptors give rise to the five distinct basic flavors. The prototypes are the result of the nervous system reacting more intensely to activation of one of the receptors. One of the most important factors that interact with the information from the tongue is the information from the olfactory system. The exact pathways for taste are not much studied, but it is assumed they eventually end up in the somatosensory area of the cortex. In order to confirm the hypothesis, studies would have to show the stages of processing the information and the influence of the olfactory system.

c. Human beings are capable of distinguishing many kinds of flavors. This should be particularly the case in cultures that use many spices in food, for example. However, the basic flavors should be the same for each culture, and they should consist of no more than the proposed five basic categories. On the other side, it is possible that some cultures do not recognize all five basic tastes. For example, in English speaking part of the world, there are only four basic flavors (sweet, salty, sour, and bitter). The fifth one is called umami, which is a Japanese word for "delicious."

Problem 3.

Part 1. Repeating the Martin et al. experiment using fMRI

a. Does this experiment test our hypothesis? What kind of results will confirm (or at least not disprove) our hypothesis?

This experiment basically tests our hypothesis. Out of our four sets of comparisons, (1) subtracting activation due to noise patterns from activation due to animals and tools, and (2) subtracting activation due to nonsense objects from activation due to animals and tools are for control only. We want to see at least some remaining activations in both sets (that is, after subtracting the activation due to visual processing, we should get activation that corresond roughly processing categories).

The two remaining sets of comparisons are the crucial ones. (3) subtracting activation due to animals from activation due to tools should leave us with brain areas that are used selectively for processing tools. We should see activation in the pre-motor area (and the middle temporal gyrus). (4) subtract activation due to tools from activation due to animals should leave us with activations that are strictly due to processing animals. We should see activation in the medial occipital lobe.

b. What are possible flaws of our experiment setup? How can you improve it?

There are a number of factors to control for. Many students pointed out that some animals / tools may be more readily identified than the others, and line drawings may be confusing to the test subjects.

Given that these factors are controlled, there is still one major issue with our setup, which is the temporal resolution of fMRI. fMRI measures oxygenated blood flow, and there can be up to a 2-second delay between the activation in the brain and seeing the activation pattern in the fMRI scan. The minimum time required between stimulus presentation and fMRI snapshot is 500ms, which means that if we take the fMRI snapshot 150ms after the stimulus is presented, we are going to get garbage.

Moreover, our fixation cross is displayed only for 500ms, which means the levels of activation from different stimuli that we capture using fMRI scans can be clobbered. To make sure this unwanted inteference go away, we should display the fixation cross for 1500 – 2000ms.

Part 2. Behavioral experiment with a picture-word matching task

a. Does this experiment test our hypothesis? What kind of results will confirm (or at least not disprove) our hypothesis?

Again, this experiment basically tests our hypothesis. We should expect the fastest response when the word matches the picture, and slightly slower responses when the word does not match the picture, but they are from different categories. Most importantly, when the word does not match the picture, but they are from the same category, the response should be slowest.

b. What are possible flaws of our experiment setup? How can you improve it?

The most obvious flaw in our experiment setup is the frequency of the animals and tools we chose. Whereas dogs and horses are prototypical animals, aardvark and capbara are quite uncommon. The same is true for our selection of tools stimuli. Not controlling for frequency will skew our reaction time results. For example, with our set of picture-word pairs, a non-match between a capybara and wolverine (or an embosser and a chainsaw) might be slow just because they are uncommon animals (or tools), and we cannot use this result to justify the claim that there is interference effect from using the same brain areas for processing.

One obvious way to fix this problem is to choose a different set of animals and tools that are balanced in frequency (as ranked by an independent set of test subjects), and make sure that the picture-word pairs are controlled for any differences in frequency.