Local Incommensurability and Communicablity[1]

Xiang Chen

Virginia Polytechnic Institute and State University

One of the most controversial ideas in recent philosophy of science is the incommensurability of scientific theories. For Kuhn, the claim that two theories are incommensurable is the claim that there is no common language within which both theories could be fully expressed (Kuhn 1977, p. 301). In others words, two theories are incommensurable if and only if they are articulated in languages that are not mutually translatable or communicable without loss. This type of incommensurability, according to Kuhn, is the result of changes in worldview. The proponents of different paradigms practice their researches in different worlds (Kuhn 1970, p. 150). They may have different classifications of objects in the world due to their different cultures. For example, the astronomers who belonged to Ptolemy's paradigm grouped the sun, moon, and Mars into the same set, while the astronomers who belonged to Copernicus's paradigm classified them into three different categories. These different classifications result, Kuhn claims, from the differences in the similarity or dissimilarity relations that hold in the respective world between objects (Kuhn 1970, pp. 200-1). The similarity between the sun and Mars in Ptolemy's paradigm is replaced by a dissimilarity relation in Copernicus's paradigm, and the dissimilarity between Earth and Mars in the former becomes similarity in the latter. Following these arguments, it is clear that Kuhn intends to present the thesis of incommensurability at a psychological or cognitive level in the sense that he regards the different similarity or dissimilarity relations produced in the processes of learning as the primary causes of failures in full communication or incommensurability.

The thesis of incommensurability has been a subject of widespread critique since it was introduced in the 1960's. People regard this thesis as a threat against the rationalist tradition in the philosophy of science, because they are concerned over one possible implication of the thesis of incommensurability that certain competing theories cannot be compared in a rational manner, or, cannot be compared at all. In his responses to the critiques, Kuhn tries to soften his position by denying the incomparability implication of his incommensurability thesis. What Kuhn actually does is to introduce a modest version of incommensurability: the notion of "local incommensurability". Kuhn says:

PSA 1990, Volume 1, pp. 67-76

> Most of the terms common to the two theories function the same way in both; their meanings, whatever those may be, are preserved; their translation is simply homophonic. Only for a small subgroup of (usually interdefined) terms and for sentences containing them do problems of translatability arise. (Kuhn 1983, pp. 670-1).

Since only a small group of concepts changes during a scientific revolution, Kuhn claims that incommensurable theories can still be compared rationally at a global level. "The terms that preserve their meanings across a theory change provide a sufficient basis for the discussion of differences and for comparisons relevant to theory choice" (Kuhn 1983, p. 671). By introducing the distinction between local incommensurability and global commensurability, Kuhn hopes that he can avoid the incomparability implication at global level and satisfy the rationalist tradition, while he can insist on incomparability or incommunicability at the local level and preserve the validity of the incommensurability thesis.

But the distinction between local incommensurability and global commensurability is somehow arbitrary. Since each concept is not entirely isolated within a theory, it is rather implausible to assume that some concepts change fundamentally while others remain the same. Therefore, in order to have a consistent answer, Kuhn should either weaken his claim on global commensurability, conceding the difficulties of full expressions of theories at global level, or weaken his claim on local incommensurability, accepting the possibility of successful communication at the local level.

The primary purpose of this paper is to argue that even at local level incommensurability may not necessarily bring about incommunicability. In order to support this claim, we need to clarify the notion of local incommensurability, especially the cognitive processes which generate local incommensurability. In the following sections, I will first introduce a theory on graded structures for categories developed in recent cognitive psychology, which concerns the cognitive processes generate local incommensurability. Secondly, I will explicate the relation between graded structures and incommensurability in some historical cases. Finally, I will discuss the relationship between local incommensurability and communicability, in the light shed by the psychological theory and historical cases.

1. Graded Structures of Categories

According to the classical theory of categorization, every category should have definitions specifying necessary and sufficient criteria for its membership. All category members should equally satisfy these criteria and thereby be logically equivalent. But this classical theory was challenged by the works of Rosch and her collaborators during the 1970's (Rosch and Mervis 1975; Rosch 1978). By conducting a series of experiments, Rosch and her collaborators demonstrated the existence of an internal structure in categories. Instead of being equivalent, the members of a category vary in how good an example they are of their category. Some members are especially good or typical examples; the very best are called "prototypes". Other members are only moderately typical, and even atypical. The prototype of the category of "chair", for instance, is the four-legged straightbacked kind often seen in a dinning room. Modernistic single-pedestal armchairs are less typical of the category, and barstools are absolutely atypical. These different degrees in representativeness constitute the "graded structure" of the category.[2]

Further studies in categorization also indicate that, not only do categories posse a grade structure, but also people with different backgrounds may have different graded structures for the same category. People who have different cultural backgrounds

https://doi.org/10.1086/psaprocbienmeetp.1990.1.192693 Published online by Cambridge University Press

often have different opinions about how typical a certain object is of its category (Barsalou and Sewell 1984). In the category of bird, for example, American college students generally agree that robins and eagles are very typical, pigeons are moderately typical, and ostriches are atypical, while Chinese students generally agree that swans and peacocks are typical, ostriches are moderately typical, and bats are atypical.

The existences of different graded structures for a category may be connected to the existences of different worldviews, as described by Kuhn. According to Kuhn, people who belong to different paradigms or different cultures have different worldviews due to holding different similarity or dissimilarity relations between objects. Similarly, according to the psychological theories of graded structures, the differences between two graded structures for a category consist in the different ideas both about what the ideal example or prototype of the category is and about what kind of similarity or dissimilarity relates the members of the category to the ideal example. From the American point of view, for instance, robins are typical of birds because they are similar to the ideal example or prototype of the category and ostriches are atypical because they are dissimilar to the same ideal. And from the Chinese point of view, swans are typical and bats are atypical because they are similar or dissimilar to a different prototype of the category of birds. Also, from the point of view of Ptolemy's astronomy, the sun is typical and the Earth is atypical of the category of "planet" because the former is similar but the latter is dissimilar to the prototype of the category defined by the theoretical tradition. And from the point of view of Copernican's astronomy, the Earth is typical and the sun is atypical because they are similar or dissimilar to a different prototype of "planet" defined by another theoretical tradition. Following Kuhn's logic, if people hold different graded structures for a category, they will have different classifications and even different worldviews on certain objects, and thereby fail to communicate with each other without loss. Therefore, it is inevitable that if two groups of people hold different graded structures on a category then an incommensurability between them on the category will happen. This is a kind of local incommensurability: an incommensurability about a single category, or, a single concept.

The close connection between graded structures and incommensurability indicates that the theory of graded structures in cognitive psychology may be able to shed light on the incommensurability thesis in philosophy of science. Considering its possible contributions to the incommensurability thesis, two discoveries in the psychological theories of graded structures are particular interesting: First, the studies of the cognitive processes which generate graded structures; Second, the experiments about the possibility that people understand the graded structures drawn from different points of view.

According to Barsalou, the generation of a graded structure for a category involves two basic factors. The first factor is a stereotype of culture that people have according to the given point of view they are taking or the given theoretical tradition they are belonging to. The second factor is a knowledge base for the category that may contain tremendous amounts of information about the category. The first step in generating graded structures is to construct the ideal example or prototype of the category. Information of the prototype is drawn directly from the knowledge base, but, very importantly, only a small fraction of the information in the knowledge base is used to formulate a prototype in a specific situation. It is the stereotype adopted that determines which information in a category's knowledge base becomes incorporated into the category's prototype in particular situation. After the prototype is formed, the second step in generating graded structures is to determine the similarity or dissimilarity of other members to the current prototype of the category. Members highly similar to the prototype are typical, whereas less similar members are less typical and dissimilar members are atypical (Barsalou and Sewell 1984).

Comparing the cognitive process of generating graded structures described by Barsalou and the cognitive process of generating different worldviews described by Kuhn, we find that the former involves the interactions between stereotype and knowledge base but the latter has a single determinant - cultural background or theoretical tradition. To put it in other words, in Kuhn's model, the generation of different worldviews is straightforward: different cultures produce different worldviews. But in Barsalou's model, the generation of different graded structures is a lot more complicated. Considering the interactions between stereotype and knowledge base, especially the assumption that only a small fraction of information in the knowledge base is needed for constructing a prototype, it is likely that there is no one-to-one correspondence between stereotypes and graded structures. We will see in the last section that this complicated relationship between stereotypes and graded structures has a very important implication for the thesis of incommensurability.

Another interesting study conducted in recent cognitive psychology is on the question whether people from one population can take another's point of view. More specifically, this is the question whether people with certain point of view can understand the graded structures drawn from a different point of view. Barsalou and Sewell tried to answer these questions through a series of experiments. The subjects of these experiments were three different groups of people: university faculty, undergraduates, and graduate students. Each group, because of their different cultural backgrounds, has different graded structures in a series of categories. In the experiments, subjects were asked to construct graded structures for several categories both from their own point of view and from another group's point of view. If the graded structures constructed by, say, faculty who are taking the undergraduates' point of view, are similar to those constructed by the undergraduates themselves, then this is an indication that people can understand each other even with different points of view. The results of these experiments are surprising. The graded structures generated by undergraduates from the faculty's point of view are identical to those generated by faculty taking their own point of view. In addition, the graded structures generated by faculty taking the undergraduate point of view are very close to those generated by undergraduates taking their own point of view. All groups of subjects are extremely accurate in taking other points of view, although most of them did not believe that they could do so before the experiments (Barsalou and Sewell 1984).[3]

The results of these experiments are very significant for the discussion of the communicability between two incommensurable theories or concepts. These experiments indicate that, although there may be local incommensurability in a particular concept or category because of differences in graded structures, people with different cultural backgrounds may still be able to communicate with each other effectively and to present other's point of view accurately. This is certainly not a conclusion consistent with Kuhn's theory, in which local incommensurability is supposed to create obstacles to communication and understanding between people belonging to different theoretical traditions.

2. Historical Cases

The first historical case that I am going to discuss is the controversy between Biot and Fresnel on the explanation of the polarization of light. This controversy happened during the second decade of the nineteenth century.

In their explanations of polarization, both Biot and Fresnel accounted for the phenomenon in terms of the asymmetric property of rays. But they have different ideal examples, or prototypes, of the category of "ray".

https://doi.org/10.1086/psaprocbienmeetp.1990.1.192693 Published online by Cambridge University Press

For Biot, the prototype of the category of "ray" is not a single ray but a collection of rays. Each ray has an inherent asymmetry which is a vector and always at right angles of the direction of the ray. One cannot speak of the polarization of a single ray, because a single ray has its permanent asymmetry and is always just as asymmetric as it can ever be. Actually, polarization is the collective effect of the asymmetric property of a group of rays. If the asymmetries of rays in a given beam of light point randomly in many directions, then the beam is unpolarized. If all rays in a given beam have the same asymmetry, then the beam is just polarized (Buchwald 1988, p.xv).

Unlike Biot, Fresnel regards a single ray rather than a collection of rays as the prototype of the category of "ray". According to Fresnel, rays of light are only mathematical abstractions. They are the directions joining the center of the wave to the front itself. The feature of asymmetry exists at a given point of the front in every wave of light. And the phenomenon of polarization is just the result of this asymmetry at a given point of wavefront. Since to each point in the wavefront there corresponds only one ray, one can link a single ray to the asymmetry at any point and say that a ray is polarized (Buchwald 1988, p. xvi).

From different prototypes of the category of "ray", Biot and Fresnel end up with conflicting explanations of polarization. But in their debates on the subject, they do not realize the fundamental differences between their understandings of the category of "ray". When Biot criticizes Fresnel, he interprets the term "ray" in Fresnel's text as a collection of rays. Similarly, Fresnel understands the concept of ray in Biot's text as an individual ray. Consequently, neither Biot nor Fresnel pinpoints the major issue and understand the other correctly (Buchwald 1988, pp. 245-50). This failure in communication between Biot and Fresnel is closely related to their different graded structures of the category of "ray", which include different prototypes of the category and different similarity or dissimilarity relations between the members of the category.

The second historical case that can be used to clarify the relation between graded structures and incommensurability is the controversy between Brewster and Herschel on the absorption of light. The debate happened at the beginning of 1830's.

The main question in this debate is whether the wave theory of light is able to explain the absorption of light. According to Brewster, if one wants to explain absorption of light in terms of wave theory, he must first prove that the phenomena of absorption also exist in the field of sound, since there exists an analogy between waves of light and waves of sound. But to imagine the absorption of sound by the medium transmitting it is just incomprehensible, Brewster argues. "We might readily understand how a medium could transmit sounds of a high pitch, and refuse to transmit sounds of a low pitch; but it is incomprehensible how any medium could transmit two sounds of nearly adjacent pitches, and yet obstruct a sound of an intermediate pitch" (Brewster 1833). By showing that analogies to the absorption of light are impossible in acoustical phenomena, Brewster concludes that the absorption of light is incompatible with the wave theory.

In his response to Brewster's challenge, Herschel conducts a thought experiment to show that the phenomena of absorption can also exist in the acoustical field and thereby that the wave theory is able to explain the absorption of light. Herschel assumes that the medium transmitting sound consists of a series of special chambers. Inside each chamber, there are two separate pipes, which have the same starting and ending point but different lengths. The length of one pipe is shorter than the other by half the wave-length of a particular note. If a note with this particular wave-length were sounded at the entrance of the chamber, its vibrations would be first divided to go

along two separate pipes, and would then meet again at the exit of the chamber and cancel each other out because of their different phases. If several such chambers were arranged in succession, Herschel claims, it can easily be imagined that a series of notes would be absorbed by the medium, just like the absorption of light (Herschel 1833).

In this debate, it is clear that both Brewster and Herschel have different ideas about the structure of an acoustical medium. In Brewster's argument, the prototype of an acoustical medium is a homogenous configuration. An acoustical medium is regarded by Brewster as consisting of elements that have similar acoustical structures. With this homogenous structure, a medium can not transmit two sounds of nearly adjacent pitches and yet obstruct a sound of an intermediate pitch. Therefore, an analogy to absorption in light can not be found in the acoustical field. But in Herschel's thought experiment, the prototype of an acoustical medium is a heterogeneous configuration, which may have some special chambers that have different acoustical structures. Only with these special and heterogeneous chambers can Herschel construct an acoustical analogy to absorption of light.

But unlike the controversy between Biot and Fresnel described above, the debate between Brewster and Herschel finally ends with a consensus. After Herschel presents his thought experiment at the British Association meeting in 1833, Brewster immediately said that Herschel successfully removed his difficulties with regard to the wave explanation of absorption, and admitted that the absorption of light was theoretically reconcilable with the wave theory. Although Brewster later continues to attack the wave theory, he is careful to avoid reopening the debate on absorption (James 1983, p. 352). The consensus between Brewster and Herschel in this issue indicates that they successfully communicate with each other in the debate. Even though they have different prototypes and different graded structures of an important category, they are able to understand each other and finally obtain a consensus. Therefore, the debate between Brewster and Herschel on absorption is an example in which different prototypes, or different graded structures, of a category does not generate incommensurability.

3. Graded Structures and Local Incommensurability

In the controversy between Biot and Fresnel described above, we find that different graded structures, or, using Kuhn's notions, different similarity and dissimilarity relations between objects, generate an incommensurability between rivals. This historical case is therefore consistent with Kuhn's theory of incommensurability. In the debate between Brewster and Herschel, we find the existences of different graded structures, or, different similarity and dissimilarity relations, but we do not find incommensurability between the rivals. It seems that this historical case constitutes a counter-example to Kuhn's theory of incommensurability.

As we indicated before, Kuhn's account of the generation of incommensurability is relatively simple. Different cultural backgrounds are identified as the only cause for the generations of different graded structures and incommensurability. For Kuhn, there is one-to-one correspondence between cultural traditions and graded structures. The appearance of different graded structures indicates that people have different cultural traditions and that there inevitably exists incommensurability among them. But the experiments and historical cases described above suggest that the relationship among cultural backgrounds, graded structures, and incommensurability may be a lot more complicated. There may not be a one-to-one correspondence between cultural backgrounds and graded structures, and different graded structures may not necessarily lead to incommensurability. Clearly, we need to reconsider the processes of generating graded structures and the relationship between graded structures and incommensurability.

https://doi.org/10.1086/psaprocbienmeetp.1990.1.192693 Published online by Cambridge University Press

In Barsalou's theory, the generation of graded structures involves one more factor: the knowledge base of the category. The introduction of knowledge bases makes the process of graded structure generation complicated. The knowledge base for a given category primarily includes the information about average values on dimensions that structures the category as well as properties or correlations of properties that occur for category members.[4] For example, the knowledge base for the category of birds at least includes information about the average size for birds and the correlated properties of having feathers and laying eggs for birds. The content of knowledge base is relatively independent of the particular stereotype or cultural background that people accept. The function of the stereotype or cultural background is to activate a small fraction of information in the knowledge base and to incorporate this information into the prototype of the category. Hence, although two persons endorse different stereotypes or have different cultural backgrounds, it is theoretically possible that their knowledge bases for a given category have a certain degree of overlap and the information to be incorporated into the prototype of the category is activated partly within the overlapping section. In this situation, different graded structures do not lead to incommensurability, because the overlap in their knowledge bases ensures the possibility of successful communication. But if there is no overlap between two knowledge bases, or the information to be incorporated into the prototype is not drawn from the overlapping section, then different graded structures may results in communication failures and incommensurabilities just as what Kuhn has described.

Barsalou's account of the relationship between stereotypes, knowledge bases, and graded structures is supported by the historical cases described above. In the controversy between Biot and Fresnel, their knowledge bases of the category of "ray" diverge dramatically. They have entirely different ideas about such crucial topics as the nature of a ray, the property of asymmetry, and the relation between ray and beam of light. The overlapping section in their knowledge bases contains only such peripheral information as the linear propagation principle that defines the direction of ray's motion. Certainly, the information for the prototype of the category is not drawn from this overlapping section. It explains why Biot and Fresnel fail to understand each other and why there is an incommensurability between them. But in the debate between Brewster and Herschel, their knowledge bases of the category of "acoustical medium" have a large overlap. Although they have different ideas about the particular structures of the basic unit in the medium, they share the same ideas about the physical nature, the geometrical size, and, most importantly, the principle governing the relation between these units and the vibration representing sound. The information that is incorporated into their different prototypes of the category is partly drawn from this shared section in their knowledge bases. This shared information ensures that Brewster and Herschel are able to successfully communicate with each other and avoid incommensurability.

By clarifying the process of graded structure generation, Barsalou's model has several interesting implications for the thesis of incommensurability.

The first interesting implication is about the cause of local incommensurability. The process of graded structure generation described by Barsalou, which is also supported by historical cases, suggests that different graded structures do not necessarily bring about incommensurability. To use Kuhn's language, different worldviews, different classifications of the world, or different similarity and dissimilarity relations between objects, do not necessarily generate local incommensurability between two concepts. Instead, problems in full expression between two concepts are caused by the separation between the two knowledge bases for the relevant category, or by the way of retrieving information from the knowledge bases to form the prototypes of the

https://doi.org/10.1086/psaprocbienmeetp.1990.1.192693 Published online by Cambridge University Press

category. Although stereotypes or cultural backgrounds directly determine which information is incorporated into the prototypes of the category, they do not directly influence the distance between two knowledge bases. The relation between two knowledge bases is in a great degree determined by the nature of the category itself. Hence, it is just too simply to say that incommensurability is the result of different languages or different cultures.

On the account sketched here, another interesting implication is that local incommensurability becomes a matter of degree. In practice, the different knowledge bases of a given category held by people with different cultural backgrounds are seldom separated completely. The overlap between two knowledge bases ensures the possibility that people can successfully communicate with each other although they have different cultural backgrounds. But the actual degree of successful communication depends upon the extent to which information for the prototypes is drawn from the overlap in the knowledge bases for the category. If all information for the prototypes is drawn from the overlapping section, these two prototypes which exemplify two concepts are mutually translatable or communicable without loss. If part of the information is drawn from the overlapping section, these prototypes and their corresponding concepts are partly translatable, and partial local incommensurability exists. And, clearly, the more information is drawn from the overlapping section, the higher degree of communicability between the different prototypes and the corresponding concepts and lower degree of incommensurability is.

These two implications improve our understanding of incommensurability. First, our new account of incommensurability can accommodate the cases that Kuhn fails to explain. Both the experiments conducted by Barsalou and Sewell, in which people are able to take others' point of view accurately, and the historical debate between Brewster and Herschel are incomprehensible in terms of Kuhn's theory. Only when we consider the interactions between knowledge bases and cultural backgrounds and regard incommensurability as a matter of degree can these anomalies be digested. Moreover, recognizing local incommensurability as a matter of degree can also eliminate an internal inconsistency within the thesis of incommensurability. As we indicated earlier, it is implausible for Kuhn, on the one hand, to claim that incommensurable theories at the global level can be compared rationally, and, one the other hand, to insist on absolute incommensurability at local level. In order to eliminate this inconsistency, one reasonable solution is to accept the possibility of successful communication at the local level by regarding local incommensurability as a matter of degree. Finally, by examining the cognitive processes that generate incommensurability, we demonstrate the close connection between the thesis of incommensurability and the psychological theories about graded structures in categories. This connection makes it possible that our discussions of incommensurability can be freed from *a priori* elements and eventually be based upon empirical or experimental results.

These implications about the causes and features of incommensurability are not discussed by Kuhn in his theory of local incommensurability. But these implications are in principle consistent with Kuhn's incommensurability thesis. Most of Kuhn's conclusions about local incommensurability are built upon an ideal situation in which the meaning of a concept changes completely during a scientific revolution, so that no common content can be found between the new and the old concept. Therefore, Kuhn claims that the changes of a concept's meaning in a scientific revolution necessarily bring about local incommensurability, and does not regard local incommensurability as a matter of degree. But in the history of science, the ideal situation assumed by Kuhn is rare. In most cases, scientific revolutions do not change a concept completely. A category may have a new prototype in the new theoretical framework, but this

https://doi.org/10.1086/psaprocbienmeetp.1990.1.192693 Published online by Cambridge University Press

new prototype may still connect with the old one in the old theoretical framework. Barsalou's theory of graded structures can really shed light on the issue of incommensurability in those less extreme and more common situations. Our analyses of the relationship among cultural backgrounds, knowledge bases, and incommensurability, and our suggestion that local incommensurability is a matter of degree should be regraded as improvement rather than a denial of Kuhn's thesis of incommensurability.

Notes

[1]Earlier version of this paper was prepared for Professor Peter Barker's seminar on "Psychology of Science" in 1989. I am grateful to Professor Barker for his comments and criticisms.

[2]Strictly speaking, the notion "graded structure" here does not refer to cognitive structure. It simply refers to behavioral structure, namely, to how people order exemplars in categories according to typicality. See Barsalou (1987, p. 102).

[3]It should be noted that these results only show that, on the average, different populations can take each other's point of view very accurately. But they do not indicate how well a given individual can take the point of view of another individual.

[4]This is particularly true for common taxonomic categories. For goal-derived categories, their knowledge bases may include different kinds of information. See Barsalou and Sewell (1984).

References

Barsalou, L. (1987), "The Instability of Graded Structure: Implication for the Nature of Concepts," in *Concept and Conceptual Development: Ecological and Intellectual Factors in Categorization*, U. Neisser (ed.). Cambridge: Cambridge University Press, pp. 101-140.

_____. and Sewell, D. (1984), *Constructing Representations of Categories from Different Points of View*. Emory Cognition Project Report #2, Atlanta, GA: Emory University.

Brewster, D. (1833), "Observations on the Absorption of Specific Rays, in Reference to the Undulatory Theory of Light", *Philosophical Magazine* 2: 360-3.

Buchwald, J. (1988), *The Rise of the Wave Theory of Light*. Chicago: The University of Chicago Press.

Herschel, J. (1833), "On the Absorption of Light by Coloured Media, Viewed in Connection with the Undulatory Theory", *Philosophical Magazine* 3: 401-15.

Hoyningen-Huene, P. (1988), "Incommensurability in Kuhn". Unpublished paper.

James, F. (1983), "The Debate on the Nature of the Absorption of Light, 1830-1835: A Core-Set Analysis", *History of Science* 21: 335-367.

Kuhn, T. (1970), *The Structure of Scientific Revolution*. Chicago: The University of Chicago Press.

_____. (1977), "Theory-Changes as Structure-Change: Comments on the Sneed Formalism," in *Historical and Philosophical Dimensions of Logic, Methodology and Philosophy of Science*, R. Butts and J. Hintikka (eds.). Dordrecht: D. Reidel, pp. 289-309.

_____. (1983), "Commensurability, Comparability, Communicability," in *PSA 1982*, Vol. 2, P. Asquith and T. Nickles (eds.). East Lansing: Philosophy of Science Association, pp. 669-688.

Rosch, E. (1978), "Principles of Categorization", in *Cognition and Categorization*, E. Rosch and B. Lloyd (eds.). Hillsdale, NJ: Erlbaum, pp. 27-48.

_____. and Mervis, C. (1975), "Family Resemblances: Studies in the Internal Structure of Categories," *Cognitive Psychology* 7: 573-605.