A multidimensional analysis of the epistemic origins of nursing theories, models, and frameworks

Jason W. Becksteada,*, Laura Grace Becksteadb

aUniversity of South Florida, College of Nursing, 12901 Bruce B. Downs Boulevard, MDC 22, Tampa, FL 33612-4766, USA
bUniversity of Tampa, USA

Received 9 September 2004; accepted 30 September 2004

Abstract

The purpose of this article is to introduce our notion of epistemic space and to demonstrate its utility for understanding the origins and trajectories of nursing theory in the 20th century using multidimensional scaling (MDS). A literature review was conducted on primary and secondary sources written by and about 20 nurse theorists to investigate whether or not they cited 129 different scholars in the fields of anthropology, biology, nursing, philosophy, psychology, and sociology. Seventy-four scholars were identified as having been cited by at least two nurse theorists (319 citations total). Proximity scores, quantifying the similarity among nurse theorists based on proportions of shared citations, were calculated and analyzed using MDS. The emergent model of epistemic space that accommodated these similarities among nurse theorists revealed the systematic influence of scholars from various fields, notably psychology, biology, and philosophy. We believe that this schema and resulting taxonomy will prove useful for furthering our understanding of the relationships among nursing theories and theories in other fields of science.

Keywords: Nursing theory; Multidimensional scaling; Epistemic space

1. Introduction

1.1. Epistemic space

The progress of science is the work of creative minds. However, every creative mind that contributes to scientific advance works within two limitations. It is limited by ignorance, for each discovery waits upon that other that gave way to it. Discovery and its acceptance are also limited by the habits of thought that pertain to the culture of any region or period; slow change is the rule. Given that advances in science build upon discoveries that have been widely accepted or sufficiently established, we can envision scientific knowledge as having a progressive, or positive trajectory, moving from a position of less knowledge to one of more. Different fields of science, or bodies of scientific knowledge, may be said to have originated at different points in history and to be growing at different rates, affected by advances in relevant technology and cultural mores. These developments take place in what we label as epistemic space. Epistemic space is the unlimited expanse...
in which all knowledge is located. Individual bits of knowledge and the defined relationships among them constitute the system of inquiry known as science. We assume that the amalgamation of scientific knowledge occurs within such space.

According to Kuhn (1977), the term metaparadigm may be used to refer to the set of highly abstract concepts that identify the phenomena of interest to a scientific field or discipline. The metaparadigm is the most abstract component in Fawcett’s (2000) structural hierarchy of nursing knowledge containing the global concepts of interest to the discipline and their relationships. Metaparadigms summarize the intellectual and social missions of a discipline and place a boundary on its subject matter (Kim, 1989). As such, the metaparadigm guiding research in a discipline distinguishes that discipline from others. The metaparadigm of nursing identifies for the nurse researcher the study of “the wholeness or health of humans, recognizing that humans are in continuous interaction with their environments” (Donaldson and Crowley, 1978). The metaparadigm of medicine, in contrast, identifies for the physician researcher the study of the causes, diagnosis, and treatment of diseases (Fawcett, 1993). Next we turn to the juxtaposition of these two metaparadigms in epistemic space.

Our perspective, or weltanschaung, of nursing and medical knowledge begins with Descartes’ dualism of mind and body which provides a means for defining the metric of our epistemic space. Believing as he did that the body’s behavior can be in no way guided by purpose, Descartes was naturally eager to show that there exists a sharp distinction between body and mind. He split the world into two types of being, volitional thought and physical or spatial matter. Since his time, the specialties of science have emerged consistent with this distinction. Epistemic space may be represented using a multidimensional coordinate system in which science exists and expands outward from an origin (corresponding to relatively established knowledge) in various directions encompassing new theoretical developments. Consider two perpendicular axes representing the trajectories of scientific knowledge development. The first, $\Psi$, corresponds to the sciences of the mind (e.g., psychology, sociology, anthropology, etc.) being spontaneous and teleological. The second, $\beta$, represents the sciences of the body (e.g., biology, chemistry, physics, etc.) being wholly mechanical. Using such a metric, all scientific knowledge in nursing and medicine may be positioned in epistemic space by assigning general coordinates that reflect the relative influences of established knowledge from the sciences of psychology, biology, etc., as reflected in their metaparadigms. We consider the health sciences, namely nursing and medicine, as comprising the application and adaptation of established scientific knowledge (i.e., knowledge that is relatively close to the origin of our epistemic space) to the promotion, improvement, and maintenance of human health and well-being. Thus, our placement of nursing and medicine in epistemic space (see Fig. 1) is consistent with their metaparadigms; nursing being more concerned with, and more influenced by, established knowledge derived from work in the social sciences, arguably offering more teleologic explanations, while medicine is more concerned with, and influenced by, the mechanistic explanations afforded in biology and chemistry.

1.2. Purpose

The purpose of this article is to introduce our notion of epistemic space and to demonstrate its utility for understanding the origins and trajectories of nursing theory in the 20th century using multidimensional scaling (MDS). Whether a particular assemblage of nursing knowledge qualifies as a philosophy, theory, conceptual model, or an organizing framework, has been debated by various scholars (e.g., Fawcett, 1993, 2000; Meleis, 1997; Reed, 1995; Whall, 1996). The subtleties of such discussions are by no means trivial, however, for our purposes we will use the term “nurse theorist” to refer to those individuals who have substantively affected the developments of nursing as a science during the 20th century, and the term “theory” in reference to the body of their published work that has lead to such developments.

1.3. Nursing theory and epistemic space

In comparison to other sciences, nursing is in the early stages of scientific development (Bishop, 2002).
Examination of the published works by various nurse theorists reveals that many of them have built upon the established knowledge amassed in the mind–body sciences, consistent with our notion of nursing’s coordinates in epistemic space. Different foundational ideas, both conceptual and philosophical, have predisposed nurse theorists to describe and explain the phenomena of concern to the discipline in diverse ways (Kim, 1999). Our concern is with such foundational ideas. We propose that by analyzing patterns in the citation of scholars it is possible to discern, with a reasonable degree of objectivity, similarities in the epistemic origins of nurse theorists’ foundational ideas. In other words, it is possible to position nurse theorists in epistemic space on the basis of the established knowledge that influenced their critical thinking and research endeavors. This approach to comparing nurse theorists is taxonomic rather than typologic. These two methods of classification are distinguished succinctly by Hair and Black (1998): a taxonomy is an empirically derived classification, while a typology is a conceptually based one. To conduct this analysis, we employed a quantitative technique known as MDS. This technique is briefly explained below.

1.4. Multidimensional scaling

MDS comprises a family of geometric models for representation of data in two or more dimensions and a corresponding set of methods for fitting such models to actual data. The goals of MDS are (a) to find a low (e.g., two or three) dimensional space in which points in the space represent the objects being studied and such that the distances between the points in the space match, as well as possible, the original similarities (or differences) between the objects and (b) to represent the space and the relationships among objects as a geometric model or picture. This second goal distinguishes MDS from factor-analytic methods (Shepard, 1972). Factor-analytic methods generally require a solution of greater dimensionality than do MDS methods (Napier, 1972). The MDS approach used in the current study is nonmetric in the sense that the data are nominal (a theorist cited, or did not cite a scholar). Typical (i.e., linear) factor analysis models have been criticized when applied to dichotomous data due to the non-positive definite nature of such covariance matrices, and non-linear factor analysis models for determining dimensionality are unavailable or limited by sample size (see Meara et al., 2000 for discussion).

The basic function of MDS may be illustrated by using travel times between a group of cities in order to reconstruct a map of their geographic locations. For example, Greenacre and Underhill (1982) used flying times between major airports. In this case, a single attribute, travel time, served to quantify the proximity or similarity between objects (i.e., cities). More interesting applications have involved the use of multiple, and less objective, attributes to quantify the proximities among rare Scotch whiskies (Lapointe and Legendre, 1994) and among Renaissance painters (Davenport and Studdert-Kennedy, 1972). The adequacy of the resulting “map” may be expressed using a general measure of stress in the system, i.e., the lack of fit between the actual proximities and those that result from the analysis. The stress measure is the square root of the normalized residual sums of squares and ranges from 0.00 to 1.00, with smaller values indicating less stress and a better solution (Kruskal and Wish, 1978).

MDS was originated in the 1930s when Young and Householder (1938) showed how starting with a matrix of distances between points in Euclidean space, coordinates for the points could be found such that distances are preserved. It was later popularized by Torgerson (1958), who applied it to the problem of psychological scaling. Since then it has been used in nursing research (see Houfek, 1992; Wilson and Retsas, 1997) and numerous other disciplines: biometrics—Lawson and Ogg (1989), counseling psychology—Fitzgerald and Hubert (1987), ecology—Tong (1989), ergonomics—Coury (1987), forestry—Smith and Iles (1988), lexicography—Tijssen and Van Rann (1989), tourism—Fenton and Pearce (1988), and brain connectivity—Goodhill et al. (1995). Given the inherently Cartesian nature of our notion of epistemic space, it seemed reasonable to us to employ MDS in an attempt to objectively position nurse theorists in multidimensional space.

2. Method

We began by compiling a list of 129 scholars in the fields of anthropology, biology, nursing, philosophy, psychology, and sociology from popular text books in each field. This list operationally defined “established knowledge” for the purpose of our analysis. Next, a literature review was conducted on primary and secondary sources (see Appendix A) written by and about the 20 nurse theorists listed in Table 1. Although not exhaustive, this list represents the major contributors to nursing scholarship during the 20th century based on our review. One hundred and sixteen of our scholars were cited by at least one of the theorists studied here. A data matrix was constructed with nurse theorists as columns and scholars as rows. If a nurse theorist cited a particular scholar, a “1” was placed in the corresponding cell of the matrix, otherwise the cell was coded “0”. (Due to space constraints, the data matrix is not reprinted here; however, it is available
from the first author.) This approach does not distinguish whether a nurse theorist cited a scholar to support, or contradict her theory; such was not our intent. Rather, this approach serves as a proxy indicating whether or not a nurse theorist was influenced (for good or ill) by the writings of a particular scholar, at least to the extent that she felt compelled to cite his or her work. It could be argued that this approach has some limitations. Scholars might be cited for reasons such as availability rather than because of their intrinsic merit. Theorists may have read and may have been influenced by scholars they did not cite (and it may also happen that some cited works they had not read!). While recognizing these limitations, this form of citation analysis does have the virtue of providing an objective measure similarity in such a context (Everett and Pecotich, 1993).

The data matrix was used to calculate a matrix of proximity scores between all pairs of nurse theorists. Proximity scores reflect the degree of similarity or dissimilarity among a set of objects being compared on a set of characteristics (Beckstead, 2002). There are numerous proximity coefficients for various types of data (see Cox and Cox, 2001, for review). For the purpose of quantifying the proximity between nurse theorists based on similarities in their patterns of cited scholars, we used Russell and Rao’s similarity index. For any two nurse theorists, this index was defined as the number of shared citations over the total number of scholars qualifying for our analysis (see below). This measure was chosen from among several appropriate for binary data because it does not count conjoint absences as reflecting similarity (i.e., two theorists are not considered similar because they omitted the same scholars) and because conceptually it represents the similarity between theorists in terms of the proportion of operationally defined established knowledge that they share. Scholars cited by only one nurse theorist, do not contribute to these proximity scores; their inclusion essentially constitutes “noise” and degrades the reliability of resulting proximity scores (Hair and Black, 1998). To be included in the analysis a given scholar had to have been cited by at least two nurse theorists. Proximity scores were thus based on 319 citings of 74 scholars: three from anthropology, seven from biology, 15 from nursing, eight from philosophy, 35 from psychology, and six from sociology.

2.1. Data analysis

The proximity matrix was analyzed using Alternating Least squares SCALing (ALSCAL) developed by Takane et al. (1977). ALSCAL is an extremely flexible
The three-dimensional solution produced a stress discerning any systematic pattern in the coordinate values.

It is not unusual for a higher-dimensional configuration to be more readily interpretable than a lower-dimensional configuration given the relationship among configurations of different dimensionality. MDS is more complex with MDS than for other methods (see Kruskal and Wish, 1978, p. 92, for further discussion).

## Table 2
Correlations among coordinates for nurse theorists on the scaling dimensions and the proportion of scholars cited from various disciplines

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Dimension 1</th>
<th>Dimension 2</th>
<th>Dimension 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropology</td>
<td>−0.181</td>
<td>−0.256</td>
<td>−0.117</td>
</tr>
<tr>
<td>Biology</td>
<td>−0.434</td>
<td>0.733</td>
<td>−0.141</td>
</tr>
<tr>
<td>General systems theory</td>
<td>−0.441</td>
<td>0.691</td>
<td>−0.207</td>
</tr>
<tr>
<td>Nursing</td>
<td>−0.114</td>
<td>−0.413</td>
<td>0.098</td>
</tr>
<tr>
<td>Philosophy (all)</td>
<td>−0.134</td>
<td>0.098</td>
<td>0.788</td>
</tr>
<tr>
<td>Philosophy (existential)</td>
<td>−0.058</td>
<td>0.066</td>
<td>0.751</td>
</tr>
<tr>
<td>Psychology (all)</td>
<td>0.779</td>
<td>0.097</td>
<td>−0.097</td>
</tr>
<tr>
<td>Psychology (personality)</td>
<td>0.916</td>
<td>−0.226</td>
<td>−0.255</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.232</td>
<td>−0.335</td>
<td>−0.521</td>
</tr>
</tbody>
</table>

**Note**: Italicized values indicate the discipline(s) dominating each dimension.

*There were seven biologists cited, three of these were noted existentialists.

**Eight scholars of philosophy were cited, three of these were noted existentialists.

*There were 35 psychologists cited, 12 of these were personality theorists.

3. Results

MDS was successfully applied to the proximity matrix relating nurse theorists based on similarities in patterns of the scholars they cited. Initially, we examined a two-dimensional solution given the nature of epistemic space proposed in Fig. 1. This solution produced a stress index \( R^2 = 0.757 \); however, we could not discern any systematic pattern in the coordinate values.

The three-dimensional solution produced a stress index \( R^2 = 0.826 \), and afforded a meaningful interpretation of the dimensions in epistemic space as described below. The resulting coordinates are presented in Table 1.

In an attempt to provide substantive interpretation of the three dimensions resulting from the scaling of nurse theorists, point-biserial correlations between coordinates on each dimension and whether or not a scholar was cited by nursing theorists were calculated. Common citations by theorists located at similar coordinates provide a criterion for determining the meaning of each dimension. This analysis proved cumbersome to interpret given the large number of scholars cited. Instead, we first grouped scholars according to their discipline and then examined the correlations between the proportions of each nurse theorist’s citations from the fields of anthropology, biology, nursing, philosophy, psychology, and sociology, and the theorist’s coordinates on each dimension (see Table 2). This approach is a form of property vector fitting (see Jones and Koehly, 1993) and is useful for interpreting MDS solutions and deciding how many dimensions to retain. These correlations suggest that as coordinates on Dimension 1 increase so do the proportions of scholars cited from the field of psychology \( r = 0.779 \). As noted above, there were more scholars cited from this field than any of the others examined here. The most often cited were Abraham Maslow, Carl Rogers, and Gordon Allport; all noted for their work in the area of personality theory (see Feist, 1985; Hergenhahn, 1980). Hence, we decided to examine more closely the proportion of personality psychologists cited by each nurse theorist in relation to their coordinates on Dimension 1 and found this relationship to be quite strong \( r = 0.916 \). Values on Dimension 2 appear to correspond to the proportion of biologists cited \( r = 0.733 \). Three of the seven biologists cited were referenced for their work in general systems theory; again we decided to examine more closely a subset of scholars. Coordinates on Dimension 2 were also related to the proportion of these general systems theorists cited \( r = 0.691 \). Dimension 3 seems most related to the proportion of scholars cited from philosophy \( r = 0.788 \). Closer examination of these
Unlike Hall and Orlando, her profile of citations was dominated by anthropologists and sociologists. The tight configuration of theorists in the central position (near coordinates 0, 0, 0) cited more scholars from a wider range of disciplines than did those located in the periphery of the space.

It occurred to us that coordinate values based on patterns in citations might be associated with temporal relationships among the nurse theorists. That is, are the coordinates systematically related to the nurse theorists’ publication dates? Coordinate values on Dimension 1 were correlated, \( r = -0.523 \), with the year in which the theorists published their initial works (see Meleis, 1997; Tomey and Alligood, 1998) suggesting that earlier nurse theorists cited a greater proportion of psychologists than did theorists publishing later in the century. Publication dates did not correlate with coordinate values on Dimension 2 or 3.

Using Fig. 2 and the coordinates in Table 1, it is possible to make substantive comparisons among particular nurse theorists on the various dimensions. We invite the reader to examine coordinate profiles of the nurse theorists with whom they are most familiar in order to assess the utility of our analysis.

4. Discussion

Our original description of epistemic space as two dimensional, stemming from Descartes’ mind–body dualism, was supported, in part, by the alignment of MDS axes with differing degrees of citation from biology and psychology. However, our initial view may have been too simplistic. The three-dimensional model of epistemic space containing the nurse theorists that emerged from our analysis revealed the systematic influence of scholars not identified with any branch of science per se, but with writings in existential philosophy. In an effort to integrate this finding into our initial framework, we offer the following. The accumulation of knowledge referred to as “science” is derived from sense experience and may thus be considered a posteriori in nature. Because sense experience is relative, inconsistent, and not fully reliable, such knowledge is not regarded as certain; rather it is probable knowledge. In contrast, the knowledge offered by philosophy is derived from the function of reason without reference to sense experience and may be considered as a priori knowledge, expressing the definitional relationships among ideas true in themselves due to their own inherent meaning. Such a priori knowledge is, by definition, orthogonal to a posteriori knowledge. To prove useful, our notion of epistemic space must encompass both these categories of knowledge. In hind sight, including this dimension seems obvious if we are to accommodate other a priori knowledge offered by the field of mathematics.
The more central the coordinates of a nurse theorist in our multidimensional model, the more scholars, and the wider the range of disciplines she cited. We might describe these theorists as having a broader scope to their inspirational landscape. By contrast, theorists located more toward the periphery may be described as being more polarized or influenced by a smaller and more homogeneous set of scholars.

The themes of adaptation and wholeness, which are found in the works of various nurse theorists, may be traced to the field of biology, and more specifically, to general systems theory which has its own roots in biology. The study of adaptation to stress, or coping, was pioneered in the 1950s by Hans Seyle, the most often cited biologist in our review. General systems theory, which worked its way into many scientific disciplines from 1950 through the 1970s, grew out of the work of biologists Ludwig von Bertalanffy, Anatol Rapoport, and W. Ross Ashby who directed scientists to consider, as the proper object of study, the various arrangements of components that are so interrelated as to form wholes. The notion that the whole is greater than the sum of its parts has influenced various nurse theorists to expound upon the dynamic context in which patient care takes place and to encourage nurses to move beyond mechanistic thinking.

Based on the prevalence of their citations, humanistic personality theorists Abraham Maslow and Carl Rogers appear to have had the most influence on nurse theorists. Personality theorists differ in their assumptions concerning human nature. According to Feist (1985) these assumptions center on components such as: free choice vs. determinism, pessimism vs. optimism, biological vs. social influences, and the number of basic motives attributed to the person. Carl Rogers’ view of humanity is basically positive and optimistic. He believed that people are essentially forward moving and that under proper conditions will grow toward self-actualization. People ordinarily know what is best for themselves and have a high degree of choice in their lives. Roger’s person-centered therapy is quite teleologic; people are seen as striving with purpose toward goals they freely set for themselves. Maslow’s view of people is that they are fundamentally good and that the basic needs that motivate us are not negative or pathological, but precisely those that result in positive growth and health. When people’s needs are not met, they may act in evil or destructive ways. He also believed that people aim toward self-actualization, thus holding a purposive or teleological view. Maslow felt that individuals are shaped by both biology and society and that the two cannot be separated. Both these psychologists shared an optimistic view of people as being capable of self-care and self-determination, given a secure, nurturing environment; themes that pervade many nursing theories.

MDS techniques have some limitations that must be kept in mind when interpreting the findings reported above. It could be argued that our findings are an artifact of the sample of nurse theorists chosen, the list of scholars assessed, and/or the nature of the algorithm and proximity measure used. Like any flexible modeling framework or data analysis method, MDS is well suited to some types of research questions and less appropriate for others. Nonmetric methods, like the one used here for analyzing binary data are based on the assumption that a monotonic relationship exists between the proximity measures and the interpoint distances derived by the solution algorithm. Different proximity measures summarize relationships between objects in different ways and will produce different MDS results. It is important that researchers using MDS understand these measures and choose the one(s) appropriate to their research goals or questions. Prior to settling on the Russell and Rao index, we compared several proximity measures for revealing known dimensionality in small artificial data sets similar in character to the one analyzed here. A reviewer of an earlier draft of this paper raised the issue of sparse data arrays in MDS analysis. Although the problems resulting from sparse data arrays have been studied in relation to logistic regression (see Greenland et al., 2000; Kuss, 2002 for discussion), MDS techniques are not adversely affected in the same way because MDS analyzes the proximity matrix calculated from the raw data array. Our 20 × 74 raw data array contained 319 “1”s and 1161 “0”s. The resulting 20 × 20 proximity matrix contained 380 proximity scores, 68 of which were 0.00 indicating no shared citations between particular pairs of nurse theorists. So long as the appropriate proximity measure is used to prepare the data for MDS analysis, sparsity in the raw data array does not present the same problem as it does in logistic regression methods.

Future generations of nurse theorists, whose work will no doubt build upon the efforts of the nurse theorists examined here, are likely to incorporate and adapt new developments occurring in other fields of science; such is the nature of scientific progress. As the assemblage of knowledge comprising nursing science increases, the dimensionality of epistemic space required to encompass nursing theory may also increase.

The similarities among nurse theorists in epistemic space, as examined here, were based on commonalities in the sources they cited for their intellectual inspiration. More frequently, similarities among nurse theorists have been derived through systematic content analysis of their writings (e.g., Fawcett, 1993, 2000; Meleis, 1997; Tomey and Alligood, 1998, 2002). The difference in these two methods may be illustrated with a simple example. Consider two nurse theorists who cite identical sources of intellectual inspiration. Our taxonomic approach would describe them as being quite similar.
to one another, while a typologic (content-derived) approach could describe them as being quite similar or quite different from one another depending on how the two interpreted, adapted, or applied the same sources of inspiration. As Kuhn (1977) explained, although proponents of different theories may be looking at the same phenomena, they may focus on different components, and they may see different relations among the same components. We believe, as do many scholars, that a better understanding of any phenomenon is obtained through the use of multiple methods of measurement and analysis. Our notion of epistemic space is offered as a new schema for examining and understanding the relationships among the various fields of science. We invite the reader who is especially familiar with the works of nurse theorists examined here to explore how our coordinate system relates to their own content-derived judgments of the similarities and distinctions among nurse theorists.

Acknowledgement

Dr. Beckstead is an associate professor at the University of South Florida College of Nursing. He works as a statistician/methodologist with nurse researchers and graduate students. Laura Beckstead is a graduate student at the University of Tampa Department of Nursing pursuing her MSN.

The authors wish to thank Drs. Mary E. Evans and Cecilia Jevitt for their help on an earlier draft of this paper, and Drs. Cecile Lengacher and Linda Moody for access to numerous publications by and about nurse theorists. We are also grateful to three anonymous reviewers for their helpful comments and suggestions.

Appendix A. : sources reviewed


References


