

# Mapping the Structure and Dynamics of Psychological Knowledge: Forty Years of APA Journal Citations (1970–2009)

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To understand how subfields of psychology relate to each other as a whole, we analyzed 40 years (from 1979 to 2009) of journal citation data collected from 17 American Psychological Association journals. The results reveal two stable underlying dimensions of psychological knowledge—basic versus applied, and population-specific versus population-general—that organize subfields of psychology. Within the structure, personality and social psychology is located at the heart of psychological knowledge. Analysis of the dynamic flow of knowledge between subfields of psychology further reveals that although the subfields engage in clear division of labor, they also engage in dynamic transactions of knowledge. Finally, an emergent subfield would first obtain its intellectual nutrients from the established disciplines. Once it has found its own niche, it turns into a spin-off and starts to assume the role of knowledge supplier. The implications of these results for psychology as a science are discussed.

*Keywords:* structure, dynamics, development, psychology, multidimensional scaling

Price (1965), who was widely regarded as the father of scientometrics, once attempted to describe the nature of the networks of scientific articles. Forty years later, both new data and new techniques of visualizing complex data matrices are available, creating a surge of new interests in charting the structure and dynamics of scientific knowledge. Recently, Boyack, Klavans, and Borner (2005) created a new map that represents the structure of all of science, including the natural and social sciences. In their map, along with math, physics, chemistry, earth sciences, medicine, and social sciences, psychology emerged as one of the hub disciplines of science (Cacioppo, 2007). Extending this line of inquiry, the present article zooms into this hub, the networks of psychology itself, and presents new maps to describe both the structure and the flow of psychological knowledge during the past 40 years.

Two main questions are asked in this research: What is the underlying structure of psychological knowledge? What is the pattern of dynamic flow of psychological knowledge? To answer the first question, we assume that journals representing similar (or different) areas of knowledge tend to cite each other more (or less) frequently. With modern multidimensional scaling (MDS) technique (Borg & Groenen, 2005), we can analyze and visualize the interjournal citation frequencies by positioning the journals onto a map where distances between journals reflect their similarities and differences. Adequate interpretation of the dimensions of the map would thus reveal the structure of psychological knowledge.

To answer the second question, following Xhignesse and Osgood (1967), we assume that academic journals are both suppliers and

consumers of psychological knowledge. By definition, a knowledge supplier produces knowledge for other journals to cite, whereas a knowledge consumer cites knowledge disseminated in other journals. Furthermore, a journal becomes a knowledge broker when it absorbs knowledge from one set of journals, integrates and transforms the knowledge, and disseminates the end products to another set of journals. The goal of our analysis is to chart the dynamic flow of psychological knowledge through identifying the suppliers, consumers, and brokers of psychological knowledge, as well as the evolutions in the pattern of knowledge transactions in psychology in the last four decades.

## Early Cartography of Psychology

Several early attempts to describe the interrelations between the subfields of psychology have found *basic* versus *applied* to be a major dimension for organizing psychological knowledge. For example, in an early mapping study, Daniel and Louttit (1953) identified two clusters of journals: applied psychology journals and general psychology journals. Applied psychology journals included journals of clinical and consulting psychology, whereas general psychology journals included journals of comparative psychology, physiological psychology, and experimental psychology. Later, Coombs (1964) analyzed citation data in 1960 and found that psychology journals could be placed along the dimension of *hard* versus *soft* or *experimental* versus *clinical* (cf. Weeks & Bentler, 1982).

Two decades later, Doreian (1985) analyzed citation data in 1950 and 1960. This analysis again revealed two major categories: *basic* versus *applied*. The basic category included journals of social, personality, abnormal, experimental, and physiological psychology, whereas the applied category included journals of applied, educational, measurement, and clinical psychology. These two categories also differed on a dimension highly similar to the one discovered in Daniel and Louttit (1953) and Coombs (1964). Given the consistent results across the early studies, we expect that

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the applied versus basic dimension would still be a major dimension that organizes the structure of psychological knowledge in the recent 40 years.

Investigations into the dynamic flow of psychological knowledge began in the 1960s when Xhignesse and Osgood (1967) used the concepts of receiver versus source to describe the roles of journals. These investigators made the first attempt to analyze longitudinal data, including citation data in 1950 and 1960. However, the investigators only reported the map of knowledge in 1960, because according to them, the map in 1950 was fully comparable to that in 1960. This result suggests that the structure of psychological knowledge is relatively stable, at least within one decade.

Earlier attempts to map the structure and dynamics of psychological knowledge had encountered many methodological challenges. For example, one of the earliest endeavors is the work of Cason and Lubotsky (1936), who analyzed the interjournal citation data in 1933. These investigators sought to secure a quantitative measure to reflect how each psychological field influenced each other. However, they did not create a map for the journals or interpret the structure of psychology because at that time, visualization techniques such as MDS were not available. Besides, as in many other studies (e.g., Boyack et al., 2005), this study included citation data at one time point only. As such, the investigators were not able to analyze the dynamic changes in the pattern of knowledge flow over time.

Aside from analyzing citation data, some investigators have sought to identify the structure of psychological knowledge by analyzing psychologists' subjective ratings of journals (e.g., Koulack & Keselman, 1975; Mace & Warner, 1973; Roskam, 1968, as cited in Gifi, 1990). However, as pointed out by Pinski and Narin (1979), results from these analyses are difficult to interpret because subjective evaluations of journals often reflect the distribution of research interests among the evaluators at the time of data collection. Thus, in the present investigation, instead of relying on researchers' subjective perceptions, we analyzed objective, behavior-based citation statistics, which reflect transactions of knowledge among knowledge workers in different subfields of psychology.

The last known attempt to describe both the structure and dynamics of an intercitation network in psychology was reported in 1992. In this attempt, Rodgers and Thompson (1992) analyzed the cocitation data of Psychometric Society presidents between 1970 and 1987. Their approach involved reordering the entries of the citation matrices to discover a seriated order of journals from being cited by others most (or cite others least) to being cited by others least (or cite others most), thus reflecting the dynamic flow of knowledge. Nonetheless, their method has a major limitation—it does not guarantee finding the globally optimal seriated order. To improve the precision of the seriation results, the investigators recommended dynamic programming (Hubert, Arabie, & Meulman, 2001).

In sum, several attempts have been made to map the structure of psychological knowledge and dynamic flow of knowledge across subfields in psychology by analyzing interjournal citation data. In these analyses, the basic versus applied dimension emerged as a major dimension for organizing the structure of psychological knowledge. From the scarce longitudinal data in the 1950s and 1960s, it seems that the structure of psychological knowledge is

fairly stable across time. However, these previous analyses are limited in both the time span of the data included in the analyses and the statistical methods for charting the structure and dynamic flow of psychological knowledge. Moreover, we were not able to find any systematic analysis of citation data of psychology after 1985. To address these issues and to fill the knowledge gap, we collected 40 years of citation data from 1979 to 2009 and analyzed them with advanced MDS techniques, such as combinatorial data analysis and dynamic programming (Hubert et al., 2001). The goal of this analysis is to reveal the structure of psychological knowledge and the evolving pattern of knowledge transactions in contemporary psychological research.

## The Data

### *Journal Selection*

To select representative journals of major psychological fields amid the vast number of psychological journals available, we included only American Psychological Association (APA) journals. At the time when we made the selection decision, there were 60 APA journals, distributed across seven major areas (APA, n.d.). We selected 16 journals from this list that are generally regarded as flagship journals in these major areas. In addition, we included a new journal that began in the mid-1990s to reflect the dynamics of knowledge flow in the last decade. Because our objective is to chart the flow of knowledge across subfields of psychology, we did not include journals that are not devoted to publishing articles in a specialized area of psychological inquiry (e.g., *American Psychologist*, *Psychological Review*, and *Psychological Bulletin*).

The 17 journals included in our analysis are listed in Table 1. The 17 journals differ in the length of their history. Among them, some journals are older (started before 1970) than others, with the youngest journal being about 15 years old. We analyzed the citation data by decades (1970–1979, 1980–1989, 1990–1999, and 2000–2009). To decide starting from which decade we should include a certain journal in the analysis, we applied the following rules: (a) the journals that started before 1970 were included in the analysis in all the four decades; (b) if the journal was introduced in the first half of a certain decade (e.g., 1970–1974), it would be included in that decade (e.g., 1970–1979) and the subsequent decades; and (c) if the journal was introduced in the second half of a certain decade (e.g., 1975–1979), it would be included in the next decade (e.g., 1980–1989) and the subsequent decades. For example, *Psychological Assessment* (PA) started in 1989 and was included in the decades of 1990–1999 and 2000–2009, but not in the decade of 1980–1989. Using these criteria, 10 journals were included in the first decade, 13 in the second decade, 16 in the third decade, and 17 in the last decade.

### *Data Collection and Conversion*

While many studies have used the Journal Citation Reports (JCR) database of ISI Web of Knowledge to obtain the citation statistics (see Boyack et al., 2005), we did not use it because JCR only includes cited and citing journal statistics from 1997 (instead of 1970) onward.

Table 1  
List of Journals

Journal name	Abbreviation	Decade of initial inclusion
<i>Developmental Psychology</i>	DP	1970–1979
<i>Journal of Abnormal Psychology</i>	JAbP	1970–1979
<i>Journal of Applied Psychology</i>	JApP	1970–1979
<i>Journal of Consulting and Clinical Psychology</i>	JCCP	1970–1979
<i>Journal of Counseling Psychology</i>	JCP	1970–1979
<i>Journal of Educational Psychology</i>	JEdP	1970–1979
<i>Journal of Experimental Psychology: Animal Behavior Processes</i>	JEP-A	1970–1979
<i>Journal of Experimental Psychology: General</i>	JEP-G	1970–1979
<i>Journal of Experimental Psychology: Human Perception and Performance</i>	JEP-H	1970–1979
<i>Journal of Personality and Social Psychology</i>	JPSP	1970–1979
<i>Behavioral Neuroscience</i>	BN	1980–1989
<i>Health Psychology</i>	HP	1980–1989
<i>Journal of Experimental Psychology: Learning, Memory, and Cognition</i>	JEP-L	1980–1989
<i>Neuropsychology</i>	Np	1990–1999
<i>Psychological Assessment</i>	PA	1990–1999
<i>Psychological Methods</i>	PM	1990–1999
<i>Cultural Diversity and Ethnic Minority Psychology</i>	CDEMP	2000–2009

To obtain citation records from 1970 to 2009, we used the PsycINFO database.<sup>1</sup> A total of 44,482 articles published during 1970–2009 in the 17 journals were included in the final analysis.<sup>2</sup> The articles cited in each record were analyzed. Four raw matrices of interjournal citation frequencies were constructed, each for one of the four decades.<sup>3</sup>

However, we did not directly analyze the raw matrices because some journals published more articles and hence cited more articles than others. This problem could lead to erroneous conclusions. For example, during 2000–2009, *Psychological Methods* (PM) articles cited a total of 191 *Journal of Applied Psychology* (JApP) articles, whereas *Journal of Personality and Social Psychology* (JPSP) articles cited a total of 394 JApP articles. On the surface, it seems that JApP was more closely related to JPSP than to PM. However, during this decade, PM published 248 articles, whereas JPSP published 1,340 articles. When we divide the raw numbers of citations by the number of articles published in the citing journals, it is apparent that during this period, JApP was more closely related to PM than to JPSP: During 2000–2009, an average PM article cited 0.77 JApP articles, whereas an average JPSP article cited 0.29 JApP articles.

Accordingly, to control for the effect of number of articles published in the citing journal, within a given decade, for each citing journal, we divided the times it cited articles in each cited journal by the total number of articles the citing journal published. In other words, the four raw matrices were converted to four normalized matrices, containing citation frequencies per journal article in respective decades (cf. Rodgers & Thompson, 1992). Finally, we followed the standard practice used in other citation analysis studies (Boyack et al., 2005) and treated entries on the main diagonals in the matrices as missing.

To evaluate both the structure and dynamics within each normalized data matrix, we performed a standard procedure to decompose the data matrix,  $\mathbf{D}$ , into its symmetric portion,  $\mathbf{S} = (\mathbf{D} + \mathbf{D}')/2$ , and its skew-symmetric portion,  $\mathbf{A} = (\mathbf{D} - \mathbf{D}')/2$  (Borg & Groenen, 2005; Rodgers & Thompson, 1992; Saito & Yadohisa, 2005), where  $\mathbf{D}$  equals to the sum of  $\mathbf{S}$  and  $\mathbf{A}$ . The structure of psychological knowledge can then be revealed by analyzing  $\mathbf{S}$ , using multidimensional scaling, whereas the dynamic transactions of psychological knowledge can be revealed by analyzing  $\mathbf{A}$ , using seriation method (Hubert et al., 2001). It should be noted that  $\mathbf{S}$  and  $\mathbf{A}$  are unique, nonoverlapping, and orthogonal to each other (Borg & Groenen, 2005). In addition, the sum of squares of  $\mathbf{D} =$  the sum of squares of  $\mathbf{S} +$  the sum of squares of  $\mathbf{A}$  (Borg & Groenen, 2005). This property of variance decomposition allows us to estimate the size of these two portions in the normalized data matrices. As shown in Table 2, across the four decades, the symmetric portion and the skew-symmetric portion on the average explained 79.23% and 20.77% of the variance of the normalized matrices, respectively. This indicated that although the symmetric portion of the data was dominant and could reveal the structure of psychological knowledge, the skew-symmetric portion still played a sizable role and could reveal the dynamic pattern of knowledge transactions within psychology.

#### Analysis of the Symmetric Portion

As aforementioned, we analyzed the symmetric portion of the citation data to reveal the structure of psychology. Specifically, the symmetric portion,  $\mathbf{S}$ , contains normalized mutual citation frequencies between a pair of journals. For example, during 2000–2009, an average JPSP article cited 0.29 JApP articles, while an average JApP article cited 2.63 JPSP articles. Thus, the symmetric portion is  $(0.29 + 2.63)/2 = 1.46$ , indicating that during this decade, JPSP and JApP mutually cited 1.46 articles of each other. This mutual citation frequency is used in our analyses as an indicator of the proximity in terms of similarity between a pair of journals.<sup>4</sup>

<sup>1</sup> In some rare cases, the citation records in the PsycINFO are missing and we used those from the PsycARTICLES database, if available, to keep the data as complete as possible.

<sup>2</sup> Originally, a total 46,586 articles were retrieved from the databases. However, 4.5% of them do not have citation records or have missing records. Hence they were not included in the analysis. These records are distributed evenly across all journals.

<sup>3</sup> We counted the number of times articles published in a certain citing journal in a certain year (e.g., articles published in JPSP in 2000) cited articles published in a certain cited journal from all years to that year (e.g., articles published in JCCP from all years up to 2000). Next, we aggregated the counts across every 10 years to form the matrices for each decade. The raw matrices are available on request.

<sup>4</sup> Suppose  $C_{ij}$  is the number of times the journal (i) in a given decade (e.g., 2000–2009) cited the journal (j) (e.g., from all years to 2009) and  $N_i$  is the number of articles published in journal (i) in a given decade (e.g., 2000–2009), then each entry in the proximity matrix is given by the following equation:

$$\text{prox}_{ij} = \text{prox}_{ji} = \left( \frac{C_{ij}}{N_i} + \frac{C_{ji}}{N_j} \right) / 2.$$

Table 2  
*The Percentage of Variances Accounted for by the Symmetric and Skew-Symmetric Portions in the Normalized Data Matrices*

Decade	Symmetric portion (S)	Skew-symmetric portion (A)
1970–1979	77.92%	22.08%
1980–1989	80.15%	19.85%
1990–1999	81.52%	18.48%
2000–2009	77.32%	22.68%

*Note.* Symmetric and skew-symmetric portions contain information about the structure and the dynamics of psychological knowledge, respectively.

The symmetric portion of each decade, which is a proximity matrix, was submitted to MDS to reveal the structure of psychological knowledge.<sup>5</sup> The greater the mutual citation frequency is, the more similar the two journals are and should be placed closer to each other on a structural map. To perform MDS, we used PROXSCAL in SPSS 17, with metric (spline) transformation of degree = 3 and interior knots = 0 and two dimensions.<sup>6</sup> To avoid local minima, we used 10 thousand random starts as initial configurations.

#### *Analysis of the Skew-Symmetric Portion*

We analyzed the skew-symmetric portion of the citation data to reveal the dynamic flow of psychological knowledge. Specifically, the skew-symmetric portion, **A**, contains dominance relation between a pair of journals. For example, during 2000–2009, an average JApP paper cited JPSP more than did an average JPSP paper cite JApP,  $(2.63 - 0.29)/2 = 1.17$ , indicating that during this decade, the flow of knowledge was primarily from JPSP to JApP, and not vice versa.

It should be noted that in the matrix **A**,  $A_{ij} = -A_{ji}$ . By reordering the journals in the rows and columns simultaneously to maximize the sum of upper-triangle entries so that ideally the upper-triangle entries are all positive and the lower-triangle entries are all negative (Hubert et al., 2001; cf. Rodgers & Thompsom, 1992), we can obtain the order of the journals from the most citing to the least citing, or the order from the least cited to the most cited between each pair of journals.

For an  $N \times N$  skew-symmetric matrix, there would be  $N!$  differently reordered matrices. It would therefore be impracticable to find the optimal order by complete enumeration. Fortunately, dynamic programming (Hubert et al., 2001) can efficiently accomplish this reordering task and obtain the globally optimal seriated order, which would indicate the asymmetric flow of psychological knowledge between each pair of journals within a given decade.<sup>7</sup> In the results presented below, the dynamics are embedded into the structure, and we use smaller numbers (e.g., 1, 2, 3, . . .) to indicate journals as more citing (or less cited) and larger numbers (e.g., 15, 14, 13, . . .) to indicate journals as less citing (or more cited).

## Analytical Results

### *The Decade of 1970–1979*

*The structure of psychology.* Citation data from 10 journals were included in the analysis for the decade of 1970–1979. The symmetric portion of the normalized data matrices of this decade was submitted to MDS, which resulted in a two-dimensional configuration that accounted for 70.53% of the variance. As shown in Figure 1, we label Dimension 1 (the horizontal axis) the *basic* versus *applied* dimension. Journals located near the applied end aim at applying knowledge from psychology to solving practical problems, whereas journals located near the basic end aim at identifying basic principles of psychology. For example, JApP, a journal in the field of applied psychology, was located close to the applied end, whereas *Journal of Experimental Psychology: Human Perception and Performance* (JEP-H) and *Journal of Experimental Psychology: Animal Behavior Processes* (JEP-A), known for their goals of identifying basic principles of perception and animal behaviors, respectively, were located close to the basic end.

Dimension 2 (the vertical axis) is related to the intended generality of the psychological knowledge communicated in the journals, or the extent to which the communicated knowledge can be generalized to the general human population or is restricted to a specific population. Journals located near the population-specific end aim at disseminating knowledge about specific populations, such as animal psychology, abnormal psychology, and ethnic minorities

<sup>5</sup> Besides the standard matrix decomposition, other methods can also be used to obtain a symmetric interjournal proximity matrix. For example, Jaccard normalization is a widely used method for mapping the structure of science (Boyack et al., 2005). In our study, the symmetric matrix resulted from the standard decomposition and the matrix resulted from Jaccard normalization were highly correlated,  $r_s$  ranged from .88 to .94, with an average of  $r = .91$ , across the four decades. In addition, the resulting configurations from Jaccard normalization were highly similar to those from the standard decomposition. To simplify matters, only results based on the standard decomposition are reported in the text.

<sup>6</sup> We also performed nonmetric (ordinal) MDS on the data matrices. However, the results were not consistent with the cluster analysis results (Fitzgerald & Hubert, 1987). Also, when we performed metric (interval) MDS on the data matrices, the resulting configurations were fully consistent with the cluster analysis results. However, the variances accounted for were small (between 41% and 61%). Thus, we report the results from spline MDS, which were fully consistent with the cluster analysis results and the interval MDS results, and accounted for a satisfactory amount of variances in the data matrices (between 55% and 71%).

<sup>7</sup> Besides dynamic programming, there are other procedures for modeling the skew-symmetric data (Borg & Groenen, 2005; Saito & Yadohisa, 2005). For example, the Gower diagram (Constantine & Gower, 1978) uses the length of vectors to reflect the magnitude of skew-symmetry and the direction of rotation between the vectors to indicate the dominance relation. However, the Gower diagram does not allow embedding the dynamic information into a structural configuration. Another procedure is the drift-vector model (Borg & Groenen, 2005, p. 502), which uses the length of arrows to indicate the magnitude of skew-symmetry and the direction of arrows to indicate the dominance relation. However, the drift-vector model does not provide optimal ranking of the dominant relations. Because dynamic programming enables embedding dynamic information into the structure and provides optimal ranking of dominance among the journals, we used this technique in our analyses.

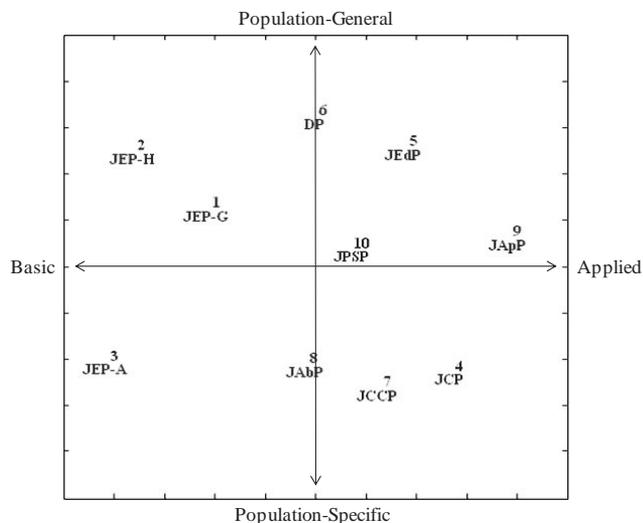


Figure 1. Map of the structure and dynamics of psychological knowledge (1970–1979). Larger (or smaller) numbers indicate that the journal was a more cited and less citing journal (or the less cited and more citing one) between each pair of journals.

psychology. In contrast, journals near the population-general aim at disseminating knowledge about the general population. For example, *The Journal of Abnormal Psychology* (JAbP) and *Journal of Consulting and Clinical Psychology* (JCCP), journals in the field of abnormal and clinical psychology, respectively, were located near the population-specific end, whereas *Developmental Psychology* (DP) and *Journal of Educational Psychology* (JEdP), which seek to disseminate knowledge about developmental and learning processes of the general normal population, were located near the population-general end.

*The dynamics of psychology.* The skew-symmetric portion of the normalized data matrices of this decade was submitted to dynamic programming to obtain a globally optimal seriated order of journals from the least cited (most citing) to the most cited (least citing). Several results from this analysis are noteworthy. First, among the 10 journals in this decade, JPSP (order #10) was the most cited (or least citing) journal. Moreover, JPSP was also located at the center of the knowledge map, suggesting that JPSP, representing social and personality psychology, was a major broker or mediating hub of knowledge; it absorbed knowledge from various other subfields and returned to these subfields value-added knowledge.

Second, JAbP (order #8), another relatively more frequently cited journal, supplied the knowledge of basic principles in abnormal psychology to JCCP (order #7), which in turn, provided inspirations to *Journal of Counseling Psychology* (JCP; order #4). Third, JEdP (order #5) received knowledge from DP, JPSP, and JApP (order #6, #10, #9, respectively). This is reasonable because understanding teaching and learning in educational systems can benefit from knowledge of human development, individual differences, social behaviors, as well as work-related individual differences and organizational behaviors. Finally, among the relatively infrequently cited journals, JEP-H (order #2) was a source of knowledge for *Journal of Experimental Psychology: General*

(JEP-G; order #1). In contrast, other psychology journals seldom cited JEP-A (order #3).

*The Decade of 1980–1989*

*The structure of psychology.* Three new journals, *Behavioral Neuroscience* (BN), *Health Psychology* (HP), and *Journal of Experimental Psychology: Learning, Memory, and Cognition* (JEP-L), were added to the analysis in the decade of 1980 to 1989. The resulting two-dimensional configuration from MDS accounted for 63.48% of the variance. As shown in Figure 2, the relative positions of the previous 10 journals had not changed, and the two dimensions remained to be basic versus applied and population-specific versus population-general. The new journal, BN, was located near JEP-A. This is an expected result because similar to JEP-A, BN also published discoveries on biological bases of behavior. Another new journal, HP, was located near JAbP and JCCP, probably because these three journals shared an interest in issues related to health. The last new journal, JEP-L, was located near the other two experimental psychology journals (JEP-H and JEP-G), probably because all three journals published studies that used experimental methods to identify basic psychological principles.

*The dynamics of psychology.* Dynamic programming results show that during this decade, the pattern of knowledge flow had remained the same. JPSP continued to be a knowledge broker. However, JCCP had replaced JPSP as the most frequently cited journal. In addition, JCCP was located at the center of the other three health-related journals, suggesting JCCP had become a knowledge broker or a mediating hub in health-related psychology, absorbing knowledge from, and in turn informing, other health-related journals.

With the introduction of BN (order #1), JEP-A (order #2) started to receive citations from this new journal. Finally, the three

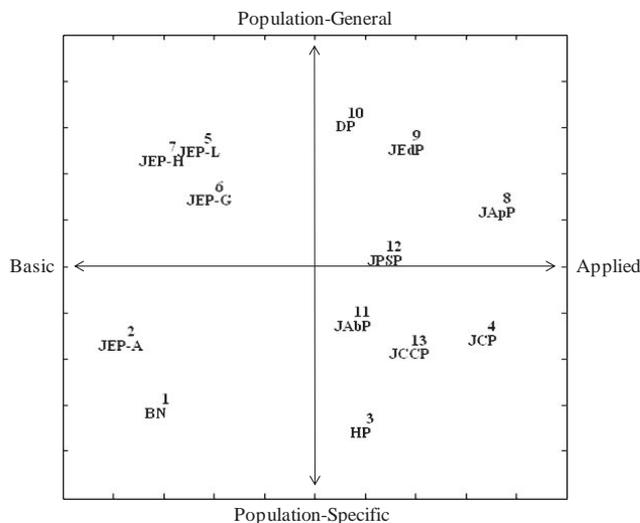


Figure 2. Map of the structure and dynamics of psychological knowledge (1980–1989). Larger (or smaller) numbers indicate that the journal was a more cited and less citing journal (or the less cited and more citing one) between each pair of journals.

new journals were not frequently cited by other journals. Instead, they functioned largely as consumers of knowledge from journals in the vicinity. This result suggests that new journals, being relatively less established, are receptive to ideas and influences from the cognate subfields.

### The Decade of 1990–1999

*The structure of psychology.* Three new journals, *Neuropsychology* (Np), PA, and PM, were included in this decade. The resulting two-dimensional configuration from MDS accounted for 54.70% of the variance. As seen in Figure 3, except for JEdP, which had shifted away from JPSP, the relative positions of the old journals had not changed. The two organizing dimensions were still basic versus applied and population-general versus population-specific. The new journal, Np, was located near the basic end of the horizontal dimension and in the middle of the vertical dimension. This is reasonable because Np focused on understanding the neurological foundations of psychological processes and behaviors, and it published research that studied both brain-injured or brain-disordered individuals, as well as normal people. Another new journal, PA, was located near JCCP. This is reasonable because PA focused on the psychological measurement and evaluation that are applicable in clinical settings. The last new journal, PM, representing quantitative psychology, was located near the applied end, probably due to its focus on analysis of study data in the applied fields.

*The dynamics of psychology.* Results from dynamic programming shows that during this decade, the pattern of knowledge flow among the old journals had remained largely unchanged. JPSP and JCCP continued to be the knowledge mediating hubs within their respective vicinities. In contrast, the three new journals in the previous decade were more frequently cited in this decade, probably because they were more established than before. Specifically,

in the current decade, BN (order #12) exported knowledge to JEP-A (order #6), JEP-L (order #13) exported knowledge to JEP-G (order #9), and HP (order #5) exported knowledge to JCP (order #3) and PA (order #4). Again, the three new journals in this decade took on the role of knowledge consumers, importing knowledge from journals in their vicinities.

### The Decade of 2000–2009

*The structure of psychology.* One new journal, *Cultural Diversity and Ethnic Minority Psychology* (CDEMP), joined the analysis in this decade. The resulting two-dimensional configuration from MDS accounted for 56.14% of the variance. As seen in Figure 4, except for PM and PA, which had shifted toward JPSP and JCCP, respectively, the relative positions of the old journals had not changed. The two organizing dimensions were still basic versus applied and population-general versus population-specific. The new journal, CDEMP, was located near JCP and in the population-specific and applied-oriented area, probably because CDEMP focused on racial and ethnic minorities and aimed to promote the delivery of psychological services to these specific populations.

*The dynamics of psychology.* Dynamic programming results show that during this decade, the pattern of knowledge flow among the old journals had remained the same. JPSP and JCCP continued to play the role of a knowledge broker within their vicinities. PM (order #12), a new journal in the last decade, had become a major supplier of knowledge, whereas the new journal in this decade functioned primarily as a knowledge consumer.

## Discussion

Psychology has been shown to be a major hub in the structure of science (Cacioppo, 2007). To further understand the structure and transactions of knowledge within psychology itself, in the present article, we analyzed citation data from the past 40 years. This analysis allows psychologists to understand how knowledge in their discipline is organized and to appreciate how scientific contributions in each subfield have inspired its cognate subfields.

### Structure of Knowledge

Our analysis shows that psychological knowledge can be organized along two dimensions: basic versus applied, and population-general versus population-specific. The first dimension pertains to the two goals of psychological inquiry: (a) To uncover basic psychological principles for the purpose of explaining and predicting human behaviors, and (b) to apply these principles to regulate behaviors for the purpose of solving practical problems. The second dimension captures the tension between establishing the generality of psychological principles and identifying their significant variations across specific populations. The basic versus applied dimension has repeatedly been found to be an organizing dimension in previous analyses of citation data (Coombs, 1964; Daniel & Louttit, 1953; Doreian, 1985). Unlike most of the previous studies, which analyzed data from very few time points, we analyzed 40 years of citation data. Despite this, the basic-versus-applied dimension emerged in our analysis again. The stability of the two-dimensional model across four decades attests to the

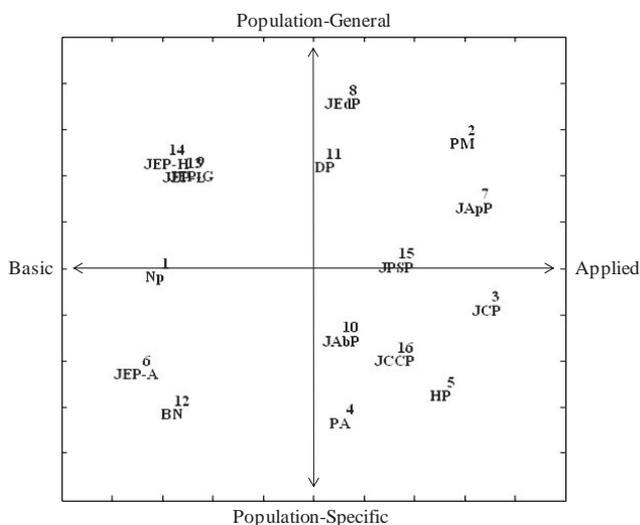


Figure 3. Map of the structure and dynamics of psychological knowledge (1990–1999). Larger (or smaller) numbers indicate that the journal was a more cited and less citing journal (or the less cited and more citing one) between each pair of journals.

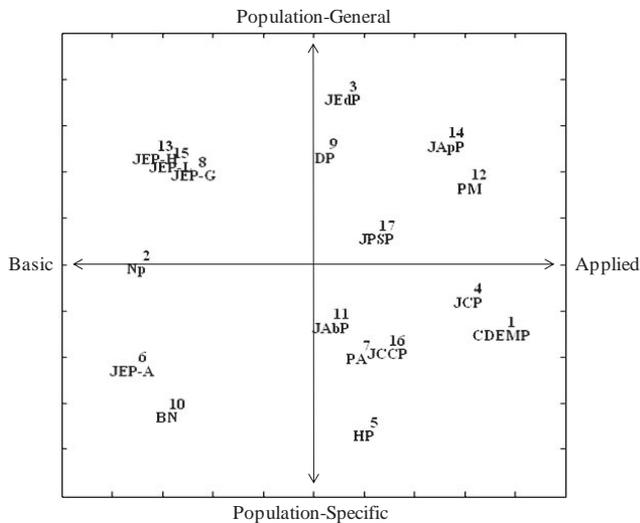


Figure 4. Map of the structure and dynamics of psychological knowledge (2000–2009). Larger (or smaller) numbers indicate that the journal was a more cited and less citing journal (or the less cited and more citing one) between each pair of journals.

maturity of psychology as a scientific discipline with clearly articulated and established goals. The temporal stability of the APA journals' positions on the two-dimensional map indicates clear division of labor in the pursuit of the different scientific goals in the discipline (Durkheim, 1893/1997).

The structure of psychological knowledge also helps us to understand the relationship between psychology and its cognate disciplines, such as education, sociology, gerontology, neurology, radiology, and sports science (Boyack et al., 2005). For example, radiology and neurology, being basic sciences themselves, are closely connected with basic psychology (e.g., neuropsychology), whereas sports science, being an applied science, is closely related to applied psychology. Education and sociology are related to educational psychology and social psychology, probably because they share the goal of identifying population-general principles. Likewise, gerontology is closely related to clinical psychology, probably because of their shared interest in population-specific knowledge. In short, the two-dimensional structure of psychology appears to be very robust and stable across time and across methods, and can provide a useful heuristic for understanding the interconnectedness of knowledge in different subfields of psychology and between psychology and its surrounding disciplines.

### *Dynamic Transactions of Knowledge*

Despite the stability of the structure of psychological knowledge, transactions of knowledge are fluid. In the decade of 1970–1979, JEP-H, DP, JApP, JAbP, and JCCP were the primary knowledge suppliers, and JEP-G, JCP, and JEdP were the primary knowledge consumers. JPSP was the knowledge broker or the hub; it absorbed and integrated knowledge from many other subfields and disseminated value-added knowledge to various consumers. In contrast, JEP-A was relatively isolated. The entry of new journals (BN, HP, and JEP-L) into the field in the decade of 1980–1989

introduced new dynamics. When these journals first entered the field, they were primarily consumers of knowledge from the more established journals. At the same time, the roles of the established journals did not change, with the exception that JEP-A had turned into a major knowledge supplier and JCCP a knowledge broker in addition to JPSP.

In the decade of 1990–1999, after having established themselves, the new journals in the last decade began to assume the role of knowledge providers, supplying inspirations to their surrounding subfields. Meanwhile, new journals that entered the field in this decade (Np, PA, and PM) replaced the new journals in the previous decades as knowledge consumers. A similar process occurred in the decade of 2000–2009. The newly introduced, CDEMP, took on the role of a knowledge consumer, and one of the new journals in the previous decade (PM) took on the role of a major knowledge provider. Again, role of JPSP and JCCP as knowledge brokers did not change during this period.

The above analysis suggests that when a new APA journal representing a new subfield enters the field, it will first play the role of a knowledge consumer. Once it has found a niche and become an established journal, it will start to play the role of a knowledge supplier within its niche. For example, BN was primarily a knowledge consumer in the first decade of its history. However, starting from the second decade, it has assumed the role of knowledge provider, supplying knowledge to JEP-A. The results also suggest that once a journal has established its role, it continues to play the same role.

### *JPSP as a Knowledge Broker*

Across the four decades, JPSP, representing personality and social psychology, has been positioned at the center of different fields of psychology. This phenomenon can be understood with reference to personality and social psychology's long-term aspirations to be an integrated subfield in psychology. According to Buss (2008), "personality psychology aspires to be the broadest, most integrative, branch of the psychological sciences. Its content is not restricted to particular subsets of psychological phenomena, such as information processing, social interaction, or deviations from normality. Personality psychologists historically have attempted to synthesize and integrate these diverse phenomena into a larger unifying theory that includes the whole person in all myriad modes of functioning" (p. 29). Indeed, personality psychology examines how psychological systems work together. This may explain why this subfield can act as a unifying resource for the broader discipline of psychology (Mayer, 2005).

Nonetheless, individuals are not living in a social vacuum, and personality psychologists recognize the importance of understanding personality in terms of individuals' discriminative responding to various social situations (Mischel & Shoda, 2008). Furthermore, as McAdams and Pals (2006) pointed out, every person is like all other persons, like some other persons, and like no other person. On the level where every person is like all other persons, the investigation of personality would become an examination of the consistent pattern that an average individual displays in responses to different social situations, and thus transformed to an inquiry of social psychology. In other words, personality psychology and social psychology are intrinsically connected. They share a holistic perspective on human behaviors, integrate insights from biological

and experimental psychology, suggest general principles for intervention in concrete situations, and examine the contextualized nature of basic psychological processes. These may explain why personality and social psychology are situated at the center of psychology.

### Conclusion

Psychology is a diverse field. However, as our results suggest, it is also a discipline with clearly articulated and established scientific goals, as well as a discipline with clear division of labor. Moreover, the subfields also engage in dynamic transactions of knowledge, constantly supplying inspirations to the cognate subfields. New subfields first obtain their intellectual nutrients from the established disciplines, and turn into a spin-off after having found its own niche and start to assume the role of knowledge suppliers. These processes go on to guarantee continuity and new developments in the field.

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