Sketching the first 45 years of the journal *Psychophysiology* (1964–2008): A co-word-based analysis

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Abstract

This article presents a keyword-based bibliometric study of the thematic evolution of the journal *Psychophysiology* since its first publication in 1964 until 2008. Bibliometric maps showing the most relevant associations among the main topics treated by the journal are provided separately for the periods 1964–1978, 1979–1988, 1989–1998, and 1999–2008. These maps offer insight into the conceptual structure of psychophysiology as a research discipline and help to visualize the division of the field into several interconnected subfields. Bibliometric maps created by co-word analysis can be used by both experts and novices to understand the current state of the art of a scientific field and to predict where future research could lead.

Descriptors: Psychophysiology, Bibliometric studies, Co-word analysis, Scientific structure, Conceptual development

Psychophysiology is a scientific discipline that has experienced a high rate of growth compared to other disciplines within psychology. A bibliometric study published in 1996 showed a mean half-life of 6.5 years for articles published in the journal *Psychophysiology* since its first issue in 1964 until 1993 (Sánchez-Hernández, Pedraja, Quiñones-Vidal, & Martínez-Sánchez, 1996). This short half-life index implies a constant evolution of the discipline similar to that observed in the experimental and natural sciences and probably reflects the dependence of psychophysiological research on rapidly evolving scientific fields such as physics, mathematics, and engineering. Innovations in these fields are bound to lead, sooner or later, to significant breakthroughs in psychophysiological research.

In spite of the corroborating evidence demonstrating that psychophysiology is a lively and rapidly evolving scientific discipline, to our knowledge, no other study has provided concrete bibliometric information, based on the journal *Psychophysiology*, after 1993. The aim of the present study is twofold: first, to extend the analysis period to 2008 and, second, to complement the previous bibliometric data with new thematic analyses based on the associations between key concepts (co-word analysis). Bibliometric maps based on co-word analysis help to visualize the division of one field into several subfields and their relationships, providing interesting insight into the evolution of the main topics being discussed in the field throughout the years (Cho & Khang, 2006; Echchakoui & Mathieu, 2008).

The journal *Psychophysiology* was chosen as our target because of its acceptance among psychophysiologists as one of the most valuable and influential sources of information in the field. The choice of this journal also facilitates the discussion of our results in relation to those provided by Sánchez-Hernández et al. (1996) and by another bibliometric study published in *Psychophysiology* focused on the early years of the field, from 1930 to 1964 (Holguín & Cadaveira, 2003).

Co-word analysis is a content analysis technique that is effective in mapping the strength of association between information items in textual data (Callon, Courtial, Turner, & Bauin, 1983; Callon, Courtial, & Laville, 1991; Coulter, Monarch, & Konda, 1998; Whittaker, 1989). It is a powerful technique for discovering and describing the interactions between different fields in scientific research (Callon et al., 1991; Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011; Bailón-Moreno, Jurado-Alameda, & Ruíz-Baños, 2006; Leydesdorff & Zhou, 2008; López-Herrera et al., 2009; López-Herrera, Cobo, Herrera-Viedma, & Herrera, 2010; Zhang, Wolfram, Wang, Hong, & Gillis, 2008). Co-word analysis reduces the distance between descriptors (or keywords) to a set of network graphs that effectively illustrate the strongest associations between the descriptors (Coulter et al., 1998).

The basic assumption in bibliometric mapping (Börner, Chen, & Boyack, 2003) is that each research field can be characterized by a list of important keywords. Each publication in the field can, in turn, be characterized by a sublist of these global keywords that can be used as a similarity measure: The more keywords two documents have in common, the more similar the two publications are and the more likely they come from the same research area or research specialty at a higher level.

According to Börner et al. (2003), the process of constructing a bibliometric map can be divided into the following six steps: (1) collection of raw data, (2) selection of the type of item to be analyzed, (3) extraction of relevant information from the raw data, (4) calculation of the similarities between items based on the extracted information, (5) positioning of items in a low-dimensional space based on their similarities, and (6) visualization of the low-dimensional space. In the following section, the way in which each of these steps was implemented is described.

Method

Collection of Raw Data. This article presents a corpus of raw data containing 3,517 articles published in the journal *Psychophysiology* that was extracted on January 8, 2009, from the ISI Web of Science using the following query:

SO = Psychophysiology, where SO field is a search
based on the *JournalTitle*.

Four sets of data were collected, one for each period studied: 1964–1978, 1979–1988, 1989–1998, and 1999–2008. In this way, separate bibliometric maps could be constructed for each of the four periods.

Selection of the Type of Item for the Analysis. According to Börner et al. (2003), journals, articles, authors, and descriptive terms or words are the most commonly analyzed items. Each type of item provides a different visualization of the field of science being studied and results in a different analysis. In this article, descriptive words and, more concretely, keywords were chosen. For the purposes of our study, a bibliometric map showing the associations between keywords in a scientific field is referred to as a keyword-based map.

Extraction of Relevant Information from the Collected Raw Data. In this article, the relevant information consisted of the co-occurrence frequencies of the keywords. The co-occurrence frequency of two keywords is extracted from the corpus of articles by counting the number of articles in which the two keywords occur in the keywords section. Prior to counting, a process of keyword filtration was implemented to avoid the duplication of keywords with identical meanings or to join with hyphens words describing a single keyword. In our study, the list of equivalences was limited to synonymous or almost synonymous keywords, for example, *skin-potential* and *palmar-skin-potential*, *orienting-response* and *orienting-reflex*, *stress* and *stress-reactions*. Keywords very closely related but different in meaning were kept separate; for example, *skin-resistance* and *skin-conductance*, *physiological-stress* and *psychological-stress*, *evoked-potential* and *auditory-evoked-potential*, or *startle-reflex* and *eyeblink-reflex*.

Calculation of Similarities between Items. The fourth step in the process of bibliometric mapping is the calculation of similarities

between items based on the information extracted in the third step. In this article, similarities between items were calculated based on the co-occurrence frequencies of the keywords. The minimum number of co-occurrences for each period was 4. When two keywords frequently occur together, they are considered linked, and the intensity of the link is indicated by the *equivalency index* e_{ij} (Michelet, 1988), defined as

$$e_{ij} = \frac{c_{ij}^2}{ci*cj},$$

where c_{ij} is the number of documents in which two keywords, *i* and *j*, co-occur, and c_i and c_j represent the number of documents in which each one appears. When the keywords always appear together, the equivalency index equals unity; when they are never associated, it equals zero. Once the links are quantified, an algorithm called *simple centers* (Coulter et al., 1998) produces groupings of themes. The *simple centers* algorithm makes two passes through the data to produce the desired networks. The first pass constructs networks depicting the strongest associations; links added in this pass are called *internal links*. The second pass adds links of lesser strengths that form associations between networks. The links added during the second pass are called *external links*.

The *density* of a network (the *internal cohesion index*) measures the internal strength of the network and is defined as

$$d = 100 \cdot \frac{\sum e_{ij}}{w},$$

where *i* and *j* are keywords belonging to the theme and *w* is the number of keywords in the theme. The *centrality* of a network (the *external cohesion index*) measures the degree of interaction with other networks and is defined as

$$c = 10 \cdot \sum e_{kh},$$

where *k* is a keyword belonging to the theme and *h* a keyword belonging to other themes. *Isolated networks* are those that have low centrality values. *Principal networks* (also called *motor-themes*) are those that have high centrality and high density values.

Positioning of Items in a Low-Dimensional Space. The fifth step is the positioning of the items in a low-dimensional space based on the similarities calculated in the fourth step. In this article, the low-dimensional space is referred to as a keyword-based map, and only two-dimensional keyword-based maps are considered. The two dimensions are *centrality rank* (c_r) and *density rank* (d_r), calculated as

$$c_r = \frac{rank_i^c}{N}; d_r = \frac{rank_i^d}{N},$$

where $rank_i^c$ is the position of the theme *i* in the theme list in ascending order of centrality, and $rank_i^d$ is the position of the theme *i* in the theme list in ascending order of density. *N* is the number of themes in the whole network. *N* is introduced to standardize the c_r and d_r values between 0 (lowest rank) and 1 (highest rank).

Visualization of Results in the Low-Dimensional Space. The CoPal Red (EC[3], 2006) computer program was used to visualize the networks in a two-dimensional space called a *strategic diagram*. A strategic diagram is a two-dimensional space built by plotting themes according to their centrality and density rank-values along
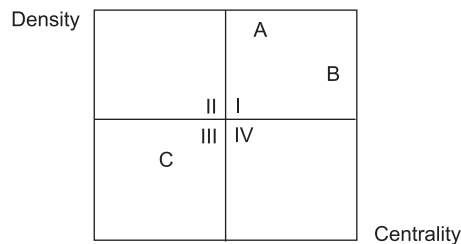
Figure 1. An example of strategic diagram.

two axes: *x*-axis centrality and *y*-axis density. An example of a strategic diagram is presented in Figure 1. The abscissa axis is *centrality*, or the *external cohesion index*. It represents the more or less central position of the theme within the overall network. The ordinate axis is *density*, or the *internal cohesion index*. It represents the more or less conceptual development of the theme. The themes in quadrant I (upper-right) are considered the *motor-themes* of the specialty because they present strong centrality and high density. Themes in quadrant II (upper-left) are considered *very specialized themes*, with high density but weak external interconnections, whereas those in quadrant III (lower-left), with low density and little centrality, represent either *emerging* or *disappearing themes*. Themes in quadrant IV (lower-right) are considered the *general basic themes*, with strong centrality but low internal development.

In strategic diagrams, themes are represented by spheres of different volumes, which are organized in the quadrants according to their internal and external cohesion (density and centrality, respectively). The volume of the spheres is proportional to the number of documents (indicated below the theme label) corresponding to each theme. In our study, the label of the themes in the strategic diagrams was dictated by the keyword with the highest volume in the network.[1] The thematic networks complement the strategic diagrams. In thematic networks, connecting lines represent the internal and external relations among the themes (links). Here, the thickness of the link between two nodes (keywords), *i* and *j*, is proportional to the equivalence index e_{ij}, which ranges from 0 to 1.

Results

Figures 2 to 6 show the strategic diagrams and the thematic networks corresponding to the four periods under examination (1964–1978, 1979–1988, 1989–1998, and 1999–2008). These graphs are used in the following sections to describe the internal and external cohesion of the themes within each period and their associated thematic networks. Uppercase letters are used to indicate the themes in the strategic diagrams and lowercase letters to indicate the keywords in the thematic networks.

Period 1: 1964–1978.

Strategic diagram. In the first period (1,256 published articles), eight major themes were identified by keywords representing five physiological measures (*HEART-RATE, ELECTRODERMAL-*

ACTIVITY, ELECTROENCEPHALOGRAPHY, EVOKED-POTENTIAL, and *ELECTRICAL-ACTIVITY*) and three psychological research areas (*SLEEP, CLASSICAL-CONDITIONING*, and *BIOFEEDBACK*). Because of their strategic position (upper-right quadrant), three themes were identified as the motor-themes of the period: *SLEEP, HEART-RATE*, and *ELECTRODERMAL-ACTIVITY* (see Figure 2). Because of its high/medium density and low centrality (upper-left quadrant), *CLASSICAL-CONDITIONING* was regarded as a specialized theme with high conceptual development but weak external interconnection. Similarly, because of its high/medium centrality and low density (lower-right quadrant) *ELECTROENCEPHALOGRAPHY* was regarded as a general basic theme with strong external interconnection but low conceptual development. However, the strategic position of *ELECTRICAL-ACTIVITY, BIOFEEDBACK*, and *EVOKED-POTENTIAL* (lower-left quadrant), which had low density and low centrality, indicated that they were either emerging or disappearing themes.

Thematic network. The thematic network of this period helps to characterize each of the themes in relation to their internal and external cohesion. As can be seen in Figure 3, the three motor-themes, *SLEEP, HEART-RATE*, and *ELECTRODERMAL-ACTIVITY*, had numerous internal and external connections forming thematic subclusters. *HEART-RATE* showed a complex network of internal connections with *cardiovascular-system, blood-pressure, respiration, skin-conductance, skin-resistance*, and *operant-conditioning* and external connections with *ELECTRODERMAL-ACTIVITY* and *ELECTRICAL-ACTIVITY*. Similarly, the *SLEEP* network had internal connections with *eye-movement, electromyography, REM-sleep, dream*, and *drugs* and external connections with *ELECTROENCEPHALO-GRAPHY* and *BIOFEEDBACK*. However, themes with few internal or external interconnections tended to appear isolated, such as *EVOKED-POTENTIAL*, which had little density (radial disposition of the network around the central keyword), and *CLASSICAL-CONDITIONING*, which had little centrality (few and weak connections with other themes).

Period 2: 1979–1988.

Strategic diagram. In this period (737 published articles), eight major themes were identified, six representing physiological measures (*HEART-RATE, ELECTRODERMAL-ACTIVITY, ELECTROENCEPHALOGRAPHY, EVOKED-POTENTIAL, AUDITORY-EVOKED-POTENTIAL*, and *PHYSIOLOGICAL-CORRELATES*), one representing a psychological research area (*SLEEP*), and one representing a methodological procedure (*AUDITORY-STIMULATION*). The number of motor-themes increased from three to five. *HEART-RATE* and *SLEEP* were again motor-themes. The new motor-themes were *EVOKED-POTENTIAL, PHYSIOLOGICAL-CORRELATES*, and *AUDITORY-STIMULATION*. Three themes, present in the previous period, disappeared: *CLASSICAL-CONDITIONING, BIOFEEDBACK*, and *ELECTRICAL-ACTIVITY*. Two additional themes that were also present in the previous period, *ELECTROENCEPHALOGRAPHY* and *ELECTRODERMAL-ACTIVITY*, decreased in density and centrality and had relocated to the lower-left quadrant, suggesting that they might be disappearing themes. Finally, a new theme, *AUDITORY-EVOKED-POTENTIAL*, which is different from *EVOKED-POTENTIAL*, appeared in the lower-left quadrant, suggesting that it might be an emerging theme.

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[1]There were two exceptions: (a) in Period 4, two keywords having similar volumes were both included in the theme label (CARDIOVASCULAR-REACTIVITY/HEART-RATE) and (b) themes related to electrodermal activity but with different labels (GALVANIC-SKIN-RESPONSE in Periods 1 and 4 and SKIN-RESISTANCE in Periods 2 and 3) were both labeled ELECTRODERMAL-ACTIVITY.
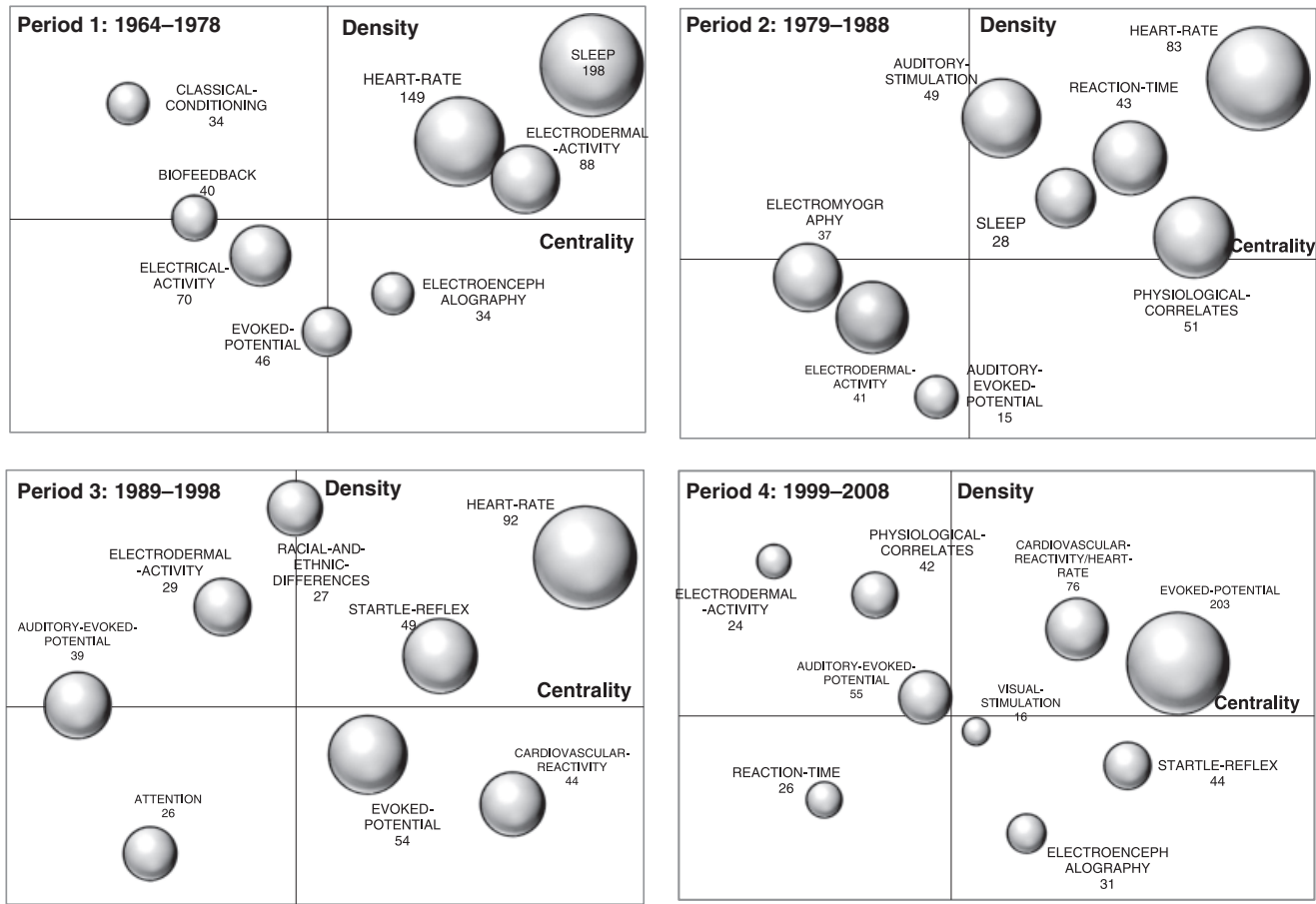
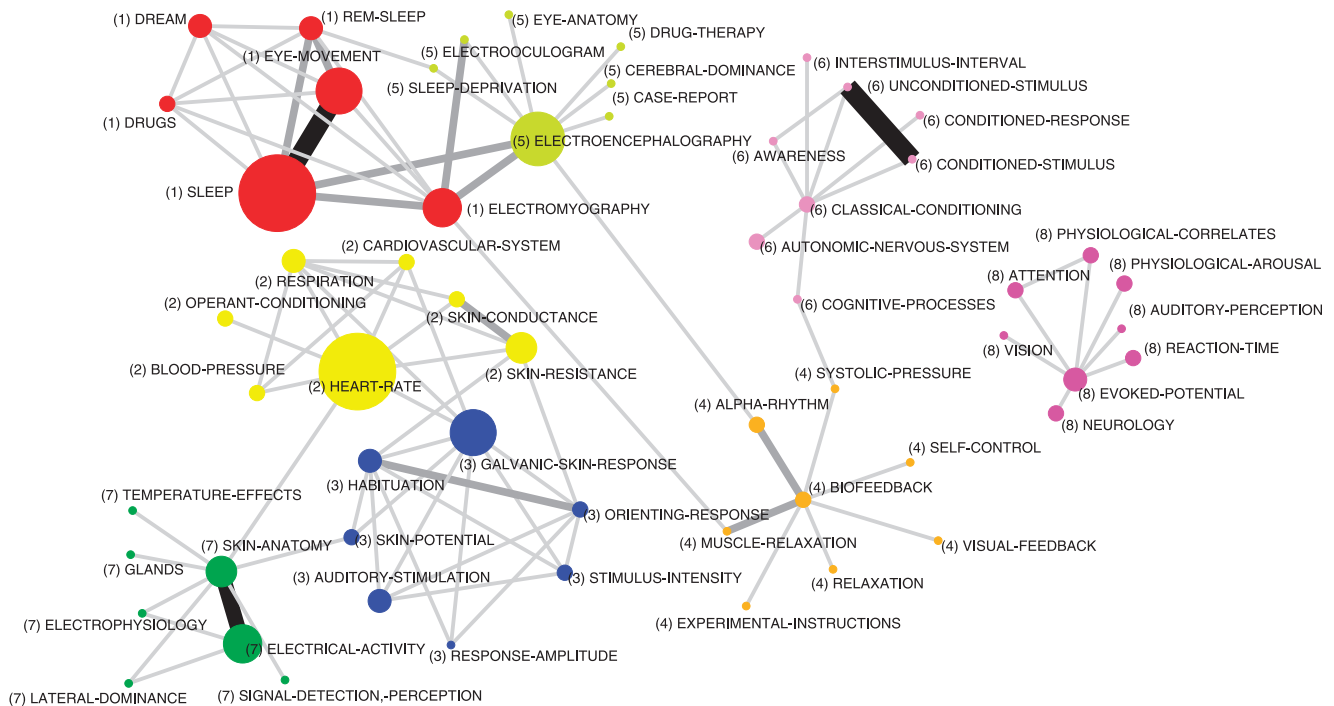**Figure 2.** Strategic diagrams for the four periods.

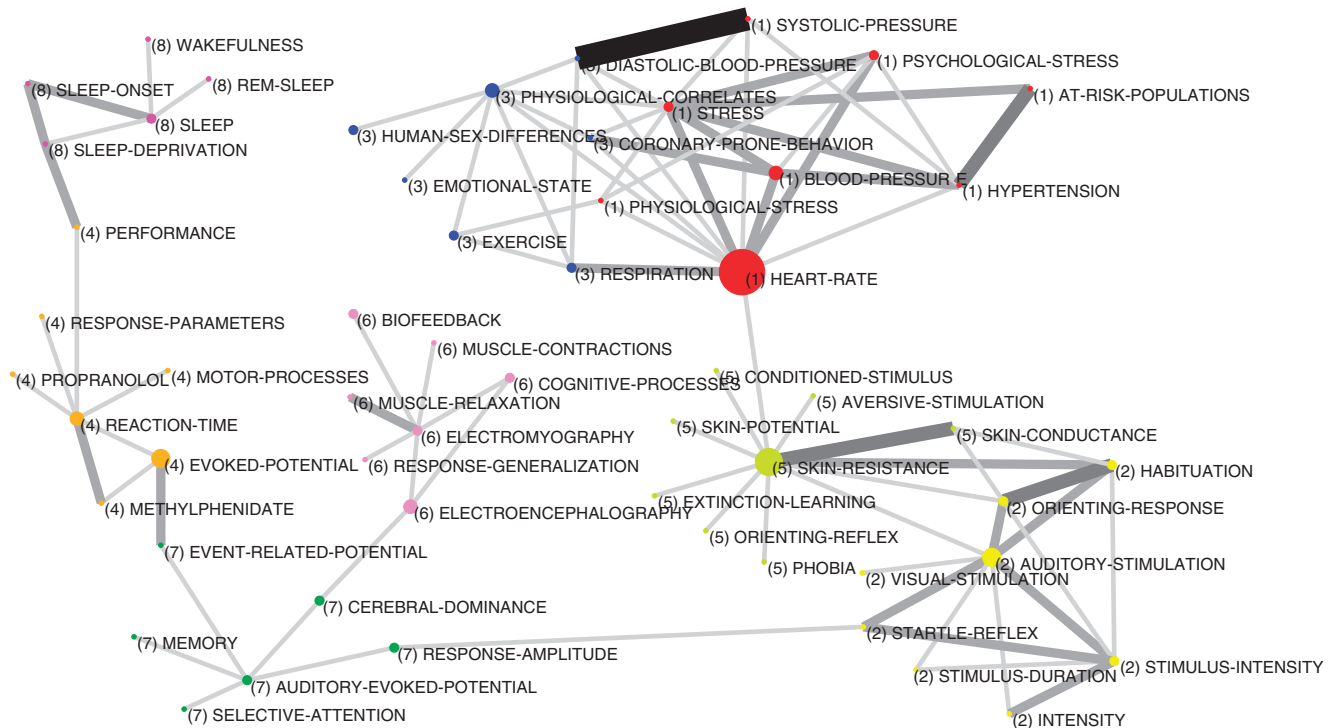**Figure 3.** Thematic network of Period 1: 1964–1978.

Figure 4. Thematic network of Period 2: 1979–1988.

Thematic network. The thematic network of this period (see Figure 4) clearly shows the high centrality and density of *HEART-RATE*. It is characterized by keywords related to other cardiovascular variables and various stress-related concepts. The *HEART-RATE* network also showed strong external interconnections with *PHYSIOLOGICAL-CORRELATES*, other motor-theme in this period with internal networks formed by cardio-respiratory variables, and research topics related to motivational and emotional processes. *EVOKED-POTENTIAL* became a motor-theme in this period because it had higher density and centrality than in the previous period. It showed internal connections with *reaction-time*, *motor-processes*, and *performance*, and external interconnections with *SLEEP*, *AUDITORY-EVOKED-POTENTIAL*, and *ELECTROENCEPHALOGRAPHY*. *AUDITORY-STIMULATION* appeared for the first time as a motor-theme, with high density and moderate centrality. It included keywords that describe stimulus parameters, like *intensity* and *duration*, and specific research areas, like *habituation*, *orienting-response*, and *startle-reflex*; it also had various external connections with *ELECTRODERMAL-ACTIVITY*, the theme with the lowest density and centrality in this period.

Period 3: 1989–1998.

Strategic diagram. In the third period (645 published articles), eight major themes were also identified, six representing physiological measures (*HEART-RATE*, *ELECTRODE-RMAL-ACTIVITY*, *EVOKED-POTENTIAL*, *AUDITORY-EVOKED-POTENTIAL*, *STARTLE-REFLEX*, and *CARDIO-VASCULAR-REACTIVITY*) and two representing psychological research areas (*ATTENTION* and *RACIAL-AND-ETHNIC-DIFFERENCES*). In this period, only two motor-themes were found: *HEART-RATE* and *STARTLE-REFLEX*. *STARTLE-REFLEX* appeared for the first time as an independent theme. *EVOKED-POTENTIAL* showed some decrease in density compared to the previous period and had relocated to the lower-right quadrant. *AUDITORY-EVOKED-POTENTIAL* continued as an independent theme; but it was still located in the lower-left quadrant as a disappearing or emerging theme. *ELECTRODERMAL-ACTIVITY*, on the contrary, left this quadrant, having increased in both density and centrality, and was relocated in the upper-left quadrant but with a significant reduction in number of articles. Three themes, present in the previous period, disappeared: *ELECTROENCEPHALO-GRAPHY*, *PHYSIOLOGICAL-CORRELATES*, and *AUDI-TORY-STIMULATION*. Three new themes, in addition to *STARTLE-REFLEX*, appeared: *CARDIOVASCULAR-REACTIVITY*, *RACIAL-AND-ETHNIC-DIFFERENCES*, and *ATTENTION*.

Thematic network. The thematic network of this period (see Figure 5) continued to show the high centrality and density of *HEART-RATE*. As in the previous period, *HEART-RATE* showed a complex network of internal and external connections. Internally, it showed strong connections with keywords describing cardiovascular and stress-related concepts. Externally, *HEART-RATE* had links with two new themes: *RACIAL-AND-ETHNIC-DIFFERENCES*, which had high density (numerous interconnections with thick lines) in spite of having relatively few articles, and *CARDIOVASCULAR-REACTIVITY*, which had low density (radial distribution of the keywords). *STARTLE-REFLEX* is the second motor-theme in this period. Its network showed internal connections with keywords describing stimulus characteristics and emotion-related concepts (*aver-sive-stimulation*, *pictorial-stimuli*, *fear*, *emotional-response*). Of the remaining themes, three had networks specifically related to event-related potentials: *EVOKED-POTENTIAL*, *AUDITORY-EVOKED-POTENTIAL*, and *ATTENTION*. Their networks
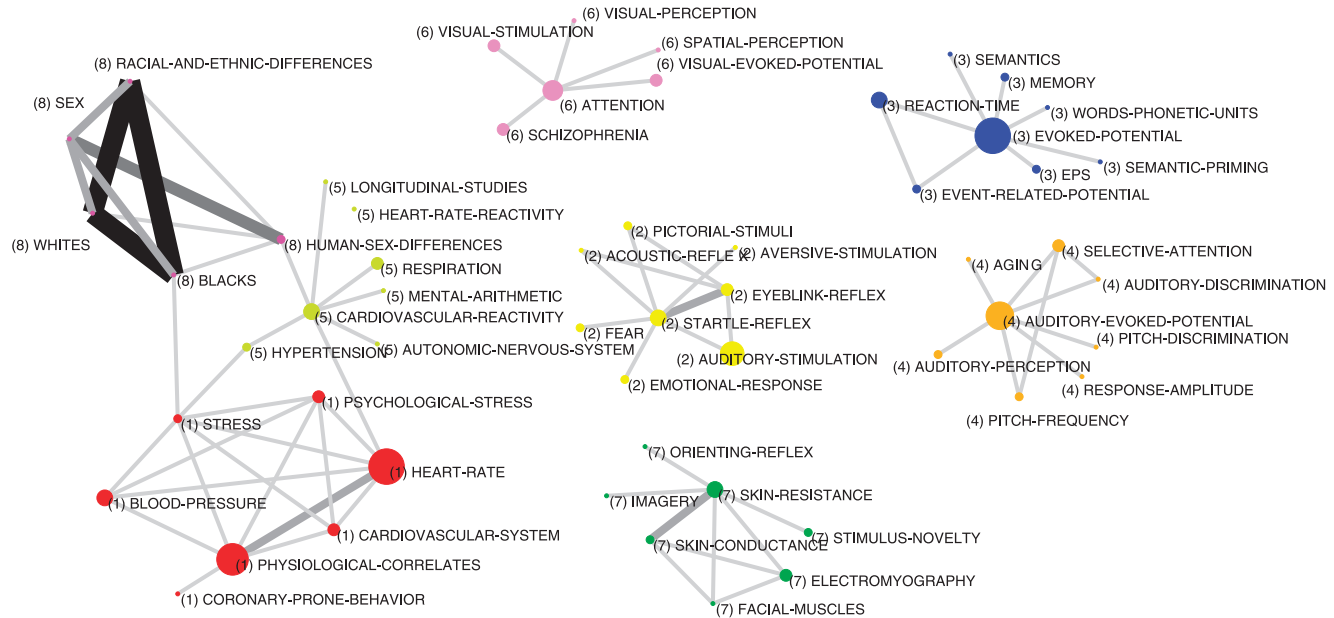
Figure 5. Thematic network of Period 3: 1989–1998.

showed low internal and external cohesion. As can be seen in Figure 5, the three themes had predominant radial distribution and no common connecting keywords.

Period 4: 1999–2008.

Strategic diagram. In the last period (879 articles), nine major themes were identified, seven representing physiological measures (*EVOKED-POTENTIAL, CARDIOVASCULAR-REACTIVITY /HEART-RATE, STARTLE-REFLEX, ELECTRODERMAL-ACTIVITY, ELECTROENCEPHALOGRAPHY, AUDITORY-EVOKED-POTENTIAL*, and *PHYSIOLOGICAL-CORRE-LATES*) and two representing methodological procedures (*VI-SUAL-STIMULATION* and *REACTION-TIME*). The major motor-theme was *EVOKED-POTENTIAL*, followed by *CAR-DIOVASCULAR-REACTIVITY/HEART-RATE*. *EVOKED-POTENTIAL* experienced the largest increment in number of articles for all themes in all periods. *HEART-RATE* decreased in density and centrality as well as in number of articles but remained a motor-theme. *STARTLE-REFLEX* decreased in number of articles and moved from the upper-right (motor-theme) to the lower-right quadrant (general basic theme), whereas *AUDITORY-EVOKED-POTENTIAL* increased in centrality but maintained its location near the lower-left quadrant (as an emerging or disappearing theme). Two themes that in the previous period had disappeared, *PHYSIOLOGICAL-CORRELATES* and *ELECTROENCEPHALOGRAPHY*, reappeared, and two themes present in the previous period (*ATTENTION* and *RACIAL-AND-ETHNIC-DIFFERENCES*) disappeared.

Thematic network. The thematic network of this period (see Figure 6) clearly showed an increase in the number of keywords and interconnections between keywords. *EVOKED-POTEN-TIAL* appears as the network with the strongest internal cohesion. It has connection with *attention, cognitive-processes, brain, memory*, and *semantics*, all interlinked between themselves. *CARDIOVASCULAR-REACTIVITY/HEART-RATE* also showed a strongly interconnected network of keywords describing stress-related concepts and individual differences. Of the

remaining themes, only two themes showed external intercon-nections: *PHYSIOLOGICAL-CORRELATES* (with *CARDIO-VASCULAR-REACTIVITY/HEART-RATE*) and *VISUAL-STIMULATION* (with *STARTLE-REFLEX*). The new emerg-ing theme, *REACTION-TIME*, showed a typical low density network (radial disposition) integrated by keywords describing motor and cognitive processes (*choice-behavior, task-switching, perceptual-motor-processes*) and one specific evoked potential (the *lateralized-readiness-potential*). Two other themes in this period included in their networks keywords describing specific event-related potentials: *AUDITORY-EVOKED-POTENTIAL* (the *mismatch-negativity*) and *ELECTROENCEPHALO-GRAPHY* (the *contingent-negative-variation*). No specific event-related potential appeared in *EVOKED-POTENTIAL*.

Discussion

The present results provide interesting insights into some general characteristics of the evolution of the journal *Psychophysiology*. Although bibliometric maps can be read and interpreted in many different ways, our discussion will concentrate on two specific aspects: first, the dynamics of the strategic diagrams along the four periods and, second, the inner structures of the thematic networks regarding psychological research topics and their re-lation to physiological variables.

Discussion of the dynamics of the strategic diagrams can be based on five characteristics of the themes: (a) type of central keyword defining the themes, (b) major motor-themes, (c) main-tained themes, (d) disappearing themes, and (e) emerging themes.

The central keywords that give their names to the themes can be classified into three categories: physiological, psychological, and methodological. Of the 33 themes appearing in the four strategic diagrams, 73% have a physiological keyword, 18% a psychological keyword, and 0.9% a methodological keyword. The larger percentage of themes with defining keywords of a physiological nature highlights the weight that psychophysiology,
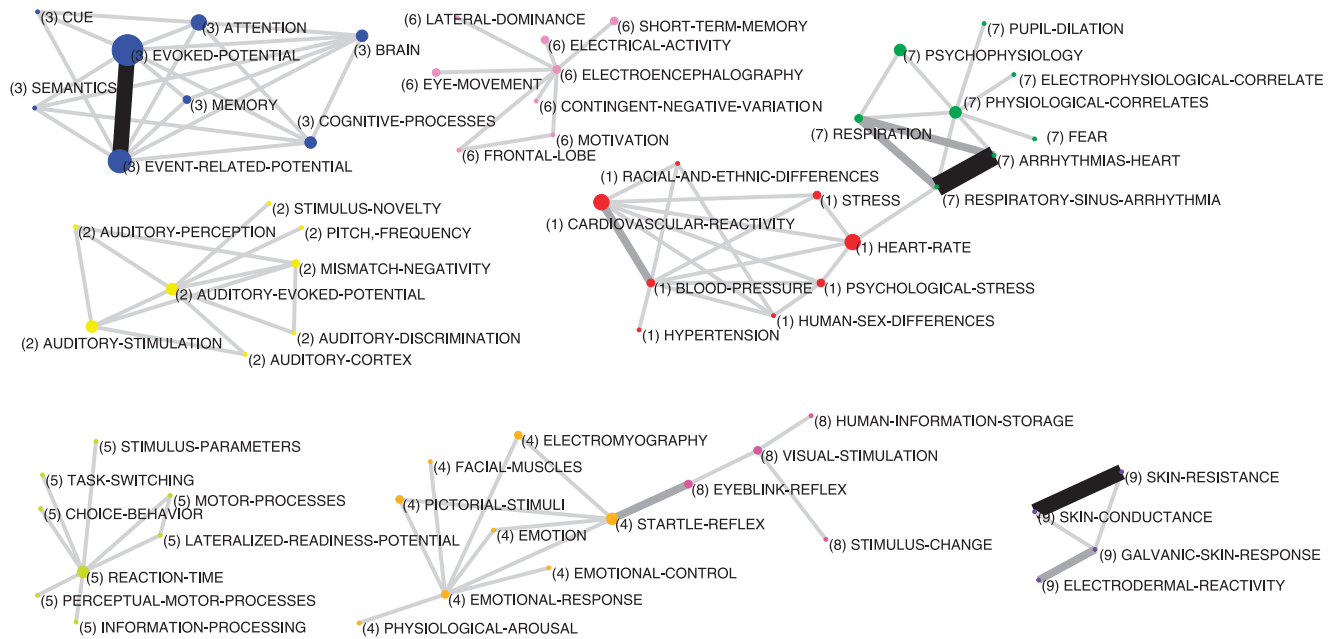
Figure 6. Thematic network of Period 4: 1999–2008.

as a scientific discipline, gives to physiological measures over psychological research topics and methodological issues.

Several motor-themes appeared in the upper-right quadrant of the diagrams due to their high density and centrality. The largest motor-themes in each period were *SLEEP* in Period 1 (1964–1978), *HEART-RATE* in Period 2 (1979–1988), *HEART-RATE* in Period 3 (1989–1998), and *EVOKED-POTENTIAL* in Period 4 (1999–2008). *HEART-RATE* appeared as a motor-theme in all four periods. *SLEEP* appeared as motor-theme in Periods 1 and 2. *EVOKED-POTENTIAL* appeared as motor-theme in Periods 2 and 4. Motor-themes that appeared only once were *ELECTRODERMAL-ACTIVITY* (Period 1) and *STARTLE-REFLEX* (Period 3).

Only three themes in the diagrams were present in all four periods: *HEART-RATE*, *EVOKED-POTENTIAL*, and *ELECTRODERMAL-ACTIVITY*. Three themes that were present in Period 1 later disappeared: *CLASSICAL-CONDITIONING*, *BIOFEED-BACK*, and *ELECTRICAL-ACTIVITY*. New themes that emerged after Period 1 followed different evolution patterns. Some themes emerged and were maintained in the periods that followed (*AUDI-TORY-EVOKED-POTENTIAL*, *STARTLE-REFLEX*, and *CAR-DIOVASCULAR-REACTIVITY*), some emerged and disappeared (*AUDITORY-STIMULATION*, *RACIAL-ETHNIC-DIFFER-ENCES*, and *ATTENTION*), and some emerged, disappeared, and reemerged (*ELECTROENCEPHALOGRAPHY* and *PHYSI-OLOGICAL-CORRELATES*).

Although the evolving dynamics of the themes over the four periods revealed interesting features of the discipline, they also highlighted some of the limitations of co-word analysis based exclusively on strategic diagrams. One of the major limitations was the selection of the keyword defining the theme. A defining keyword can be selected according to different criteria: centrality, density, or volume. The keyword with the largest centrality, however, does not necessarily coincide with the keyword with the largest density or volume. Moreover, there are different keywords that are clearly synonymous or closely related. Indeed, the lack of homogeneity in the use of keywords is a major problem for bibliometric studies (Kevork & Vrechopoulos, 2009). In

addition, authors may be inclined to choose keywords that distinguish their articles (e.g., new physiological measures versus stable theoretical concepts), thus biasing the data in a way that would overrepresent or underrepresent how methodologically or theoretically oriented the field is.

The limitations of the strategic diagrams can be partly compensated for by a complementary analysis of thematic networks. Thematic networks have their own limitations, especially those derived from the specific thresholds chosen to accept or reject keywords. Depending on the selected threshold, thematic networks will be larger or smaller, with more or fewer keywords within each theme and with more or fewer internal and external connections between keywords and themes. In our study, the threshold criteria allowed a balanced number of themes within each period (between eight and nine) and keywords within each theme (between four and eight). An overall analysis of the four thematic networks clearly revealed an increase in the number of themes and interconnected keywords in the most recent period (1999–2008), which may suggest a trend toward a richer and more complex discipline.

Our discussion on the thematic networks will focus on three characteristics: (a) specific links between physiological and psychological keywords, (b) evolution of the major psychological research topics across the four periods, and (c) future evolution of the discipline.

The thematic networks showed several specific links between physiological measures and psychological research topics. *ELEC-TRODERMAL-ACTIVITY*, for instance, appeared to be specifically linked to *orienting-response*; *HEART-RATE* to *stress*; *EVOKED-POTENTIAL* to *attention*, *perception* and *memory*; *STARTLE-REFLEX* to *emotion*; and *ELECTROENCEPHALO-GRAPHY* to *cerebral-dominance*. Other physiological measures, such as *electromyography*, *eye-movement*, *respiration*, *blood-pressure*, *pupil-dilation*, and *temperature*, did not show clear associations with specific research topics.

The thematic networks provide some insight into how the major research topics evolved throughout the years. In Period 1 (1964–1978), the major research topics were related to learning

processes (*classical-conditioning*, *operant-conditioning*, *habituation*). In Period 2 (1979–1988), the major research themes were motivational in nature (*stress*, *psychological-stress*, *human-sex-differences*). In Period 3 (1989–1998), the primary interest was in cognitive processes (*attention*, *auditory-perception*, *memory*). In Period 4 (1999–2008), the primacy of cognitive processes continued. This thematic evolution parallels changes in psychology—from learning and motivation to cognition—revealing the strong connection between the two disciplines.

Finally, the thematic network of the latest period also allows some speculation on the future evolution of the discipline. Emotional themes, which experienced an increment from Period 3 to Period 4, might consolidate and continue growing. Motor processes, which appeared to be integrated in the emerging theme *REACTION-TIME*, may also experience some future increment and move toward higher density and centrality. Two new keywords, which appeared only in the latest period (*brain* and *frontal-lobe*), may suggest the increasing future relevance of neuroscientific and neuroimaging approaches within psychophysiology.

To our knowledge, this is the first bibliometric study of the journal *Psychophysiology* based on co-word analysis. The bibliometric study by Holguín and Cadaveira (2003) examined the consolidation of the field between 1930 and 1964, prior to the publication of the journal *Psychophysiology*. According to Holguín and Cadaveira, this *consolidation period* was characterized by a predominance of methodological articles, which advanced the standardization of techniques and procedures necessary to support further empirical research. A second bibliometric study by Sánchez-Hernández et al. (1996) examined the records of the first three decades of the journal *Psychophysiology* (1964–1993). The authors divided the topics of the articles published by the most productive authors in that period into two different categories: (a) *content*, for the articles dealing with some specific psychological topic (e.g., *attention*, *stress*, etc.) and (b) *measures*, for those articles whose main focus was the optimal measure of a given psychophysiological response (Sánchez-Hernández et al., 1996). No data on the evolution of the topics were reported.

The information provided by the bibliometric maps presented in this article complement the previous findings by adding new information and a new perspective. The strategic diagrams and the thematic networks not only identified the major themes of the field, they also provided information about less visible themes and the strength of their interconnections. Moreover, by examining the strategic diagrams across the years, it is possible to recognize specific transient trends that emerged as a result of a technological advancement or theoretical development but that later disappeared or merged with a broader experimental or theoretical context. Such analysis aids understanding of the dynamic structure of a discipline and provides an opportunity to anticipate its future developments.

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