**60 years of Psychophysiology: mapping thematic developments and seminal publications**

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**Abstract**

Keywords:

**Introduction**

The year 2023 marked the 60th anniversary of *Psychophysiology*, the most established international Journal specifically dedicated to the dissemination of cutting-edge psychophysiological research. The journal was founded in response to the need to bring together researchers who sought to explore the relationship between the mind and the body, as before that time, according to the opening of the inaugural issue, “*scientists had to search through more than 80 Journals to find reports of psychophysiological research*” (Ax, 1964). The 1960s, with the formation of the Society for Psychophysiological Research in 1960 and of *Psychophysiology* in 1964, set the basis for the establishment of psychophysiological research as a contemporary and formal discipline. Since then, *Psychophysiology* has been publishing research aimed at building and improving theoretical models on the effects of psychological processes on central and peripheral physiological functions, both in healthy and clinical populations (e.g., with psychosomatic or psychiatric disorders). Over the past 60 years, *Psychophysiology* has shaped and promoted the growth of contemporary psychophysiological research and set methodological standards with guideline papers (e.g., Blumenthal et al., 2005; Keil et al., 2022; Picton et al., 2000; Steinhauer et al., 2022), and continues to be an important outlet for psychophysiologists to disseminate methodologically rigorous work and explore new advances in the field.

Although current research relies upon theoretical frameworks advanced decades ago and the core questions being incredibly similar, the past sixty years have been characterized by an ever-expanding progression in the employed methodological tools and technology. For instance, the field has encountered a shift from analog systems to sophisticated digital systems that enable the exploration of physiological measures with unparalleled details (e.g., impedance cardiography, high-density EEG, functional magnetic resonance imaging). These developments lead to a further shift from the study of peripheral visceral functions to central measures. Indeed, much of the early research published in *Psychophysiology* focused on peripheral components (e.g., autonomic responses) and lower reflexes (e.g., baroreceptor) associated with basic psychological processes (e.g., conditioning) (Berntson et al., 2002). In contrast, recent research is predominantly centered on the study of the human brain (both in health and pathology), to the extent that, almost a decade ago, Monica Fabiani devoted an Editorial entitled “The embodied brain” to encourage scientists to “re-embody” the brain, that is, to integrate multiple bodily systems to fully characterize the behaving human organism (Fabiani, 2015).

In addition to numerous technological and theoretical advances, *Psychophysiology* has gone through several structural changes over the past 60 years. The Journal grew in terms of manuscripts published per year, going from publishing 768 to 1020 pages per volume in 2003. Also, in 2015, *Psychophysiology* ended its printed version and became an online journal, which allowed the free publication of color pictures and freedom from page counts - since then, Journal submissions started growing and nearly doubled.

The occurrence of *Psychophysiology*’s anniversary is a moment to both showcase the successes and productivity of psychophysiological research, but also to objectively analyze and outline the development and trends of the Journal. To this end, the current study quantitively portrayed the entire 60 years (1964-2023) of *Psychophysiology* by analyzing bibliographic data through performance analyses (i.e., standard indicators of productivity) and a science mapping approach (Van Raan, 2014). The latter allowed tracing the thematic development over time, analyzing frequencies and co-occurrences of key terms, and creating a historic map of seminal *Psychophysiology* publications revealing thematic clusters and citation patterns between papers.

**Method**

*Literature search.* We searched Web of Science on September 9, 2023, to acquire bibliometric data for all 5,776 available Psychophysiology documents from 1964 to 2023, which included the October issue 2023. We included publications of type “Article” and “Review Article” thereby excluding meeting abstracts, editorial material, notes, book reviews, letters, biographical items, items about individuals, discussions, meeting info, and a software review. We also explicitly excluded “Early Access” papers, which had not yet been assigned to an issue, and “Correction” papers. The Boolean search term is presented in Table 1.

**Table 1. Boolean search terms for Web of Science search**

|  |
| --- |
| SO = (("Psychophysiology"))  AND  PY = ((1964-2023))  AND  DT = ((Article) OR (Review))  NOT  DT = ((Correction) OR (Early Access)) |

*Note. SO = publication name, PY = publication year, DT =document type.*

The full record and the cited references were downloaded for each document.

*Data preparation and analysis*

Data preparation and analysis was conducted in R 4.3.1 (R CORE TEAM), in the RStudio environment 2023.06.0 (XXX) and using the *bibliometrix* package 4.1.3 (XXX).

*Journal performance.* We used the *biblioanalysis* function of the *bibliometrix* packagetoobtain the total count of articles published per year. In addition, we obtained 2-year impact factors for the years 1997 to 2021 from the Clarivate Journal Citations Report.

*Title key terms.* For content analyses, key terms were extracted from the article titles which were available for all documents. To this end, in a first step, we defined key terms consisting of multiple words (for example, “heart rate”). Recurring word combinations of 2 to 4 words were identified by the tableTag function in *bibliometrix* and defined as a single key term if it had at least 5 occurrences across articles. Words were grouped in a way that longer combinations were prioritized over shorter combinations (i.e., “heart rate variability” was not split up in “heart rate” and “variability”). Afterwards, all key terms identified by tableTag (1 to 4 words) were exported for manual screening, after automatically filtering out.

The exported key terms were screened manually and independently by the two authors to create a key term dictionary. This was done for two purposes: First, uninformative key terms (e.g., “study” or “participants”) were deleted from the list of key terms to use. Second, key terms were recoded if there were several key terms that were deemed to have essentially the same meaning (e.g. “ERP”, “event-related potential”, and “event-related potentials”). Disagreements were resolved by discussion.

We share the list of all extracted terms and dictionaries in the Supplement.

*Historical Direct Citation Network.* To obtain an overview of seminal papers in Psychophysiology, we constructed a historical direct citation network as implemented in the *histNetwork* and *histPlot* functions of the *bibliometrix package*. Fifty papers with the highest local citation counts (here, papers that have been cited by other Psychophysiology papers) were extracted and a network was constructed in which nodes represent papers and are linked if one paper cites the other. In addition, papers were clustered by the Infomap algorithm as implemented in the *cluster\_infomap* function of the *igraph* package (Csardi & Nepusz, 2006). The algorithm defines clusters to minimize the expected description length of a random walker trajectory through the network (expressed as Shannon entropy) – maximizing information flow within clusters and minimizing flow between clusters (see Rosvall & Bergström, 2008, for details).

*Open data and materials*

**Results**

*Journal Performance.* The number of annual publications in Psychophysiology increased from 37 to 167 in the years from 1965 to 2022, (i.e., the first and last complete calendar year at the time of data collection) with a peak of 220 articles in 2021 (Figure XA). In the 25 years we could obtain the 2-year impact factor for (1997 to 2021), the impact factor mostly varied around 3 (median: 3.12, 1st quartile: 2.85, 3rd quartile: 3.32) with its lowest value in 2003 (impact factor: 2.07) and its highest value recently, in 2021 (4.35). The impact factor has been on the rise since 2017 (Figure X).

* Impact Factor

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**Figure 1.** (A) Number of publications from 1964 (first issue in July) to 2023 (latest issue at time of data collection: October). (B) 2-year impact factor from 1997 to 2021.

*Development of author teams.*

Team size

Country collab

Country collab

*Influential articles.* From the fifty selected papers with the highest local citation counts, 47 had links between each other (i.e. cited at least one or were cited by at least one of the other selected papers) and were therefore included in the network (see Figure X). The infomap algorithm identified 9 clusters (see Supplement XX for a complete list of the papers included in the network, see Supplementary Table X).



*Thematic development.* In order to track thematic development, we extracted the 10 most common key terms appearing in article titles for each of the journal’s decades. In the first 10 years, papers in Psychophysiology mostly addressed the topics of sleep, conditioning, and orienting while using mostly peripheral autonomic measures (see Table X). “EEG” was already a top-10 key term in early journal titles and EEG studies became more popular over time until “ERP” became the top key word in the journal’s third decade (i.e., 1984-1993) and continued to be so until 2023. Here, the P300 was the most commonly mentioned component, particularly in the time windows from 1984 to 2013. Overall, psychological constructs mentioned in article titles became broader as terms like “attention” (starting in the window 1984-1993), “emotion” (1994-2003) and cognition (2004-2013) became consistently part of the Top 10 key terms until today. Table X lists all Top 10 key terms across the time windows and for all time.

**Table 2. Most frequent key terms in article titles over time.**

| **1964-1973** | **1974-1983** | **1984-1993** | **1994-2003** | **2004-2013** | **2014-2023** | **all time** |
| --- | --- | --- | --- | --- | --- | --- |
| heart rate | heart rate | ERP | ERP | ERP | ERP | ERP |
| sleep | sleep | cardiovascular | attention | attention | emotion | attention |
| conditioning | electrodermal | sleep | cardiovascular | emotion | neural | emotion |
| autonomic | feedback | P300 | P300 | electro-physiological | attention | heart rate |
| orienting | function | behavior | human | cognition | behavior | cardiovascular |
| cardiac | EEG | heart rate | emotion | perception | cognition | EEG |
| electrodermal | autonomic | blood pressure | memory | auditory | EEG | cognition |
| time | cardiac | electrodermal | schizophrenia | neural | control | behavior |
| EEG | conditioning | human | heart rate | P300 | electro-physiological | sleep |
| human | habituation | attention | visual | cardiovascular | adult | visual |

*Note. Top 10 key terms for each decade and for all time in descending order of frequency.*

To get a different perspective on key term trends over time, we extracted the 50 most frequent terms of all time and plotted the median publication year of all articles using it as well as their 25th and 75th percentiles (Figure X).

**Table 3. Temporal distribution of most frequent key terms in article titles.**



*Note. Top 50 key terms from article titles in descending order of frequency. Dots indicate the median year of occurrences; error bars span from the 25th to the 75th percentile.*

**Table 4. Trend key terms for each year.**



*Note. XXX*

*Key term co-occurrences.*

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Structure results

1. Journal Performance
   1. Publications
   2. Impact Factor
2. Author Teams
   1. Team size
   2. Nationality – which countries? how many different countries? How many international collaborations
   3. Gender
3. Influential Articles/ Seminal Papers
   1. Historical Direct Citation Network
4. Thematic development
   1. Key term tables
   2. Trend key words
   3. Co-Occurrence Networks
5. Current Structure of the field 🡺 Thematic maps