A Bibliometric Analysis of the Cognitive Turn in Psychology

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Abstract

We analyzed co-citation patterns in 332.498 articles published in Anglophone psychology journals between 1946 and 1990 to estimate (1) when cognitive psychology first emerged as a clearly delineated subdiscipline, (2) how fast it grew, (3) to what extent it replaced other (e.g., behaviorist) approaches to psychology, (4) to what degree it was more appealing to scholars from a younger generation, and (5) whether it was more interdisciplinary than alternative traditions. We detected a major shift in the structure of co-citation networks between approximately 1955 and 1975 and draw novel conclusions about the developments commonly referred to as 'the cognitive turn'.

A Bibliometric Analysis of the Cognitive Turn in Psychology

In the 1960s and 1970s, American psychology appears to have witnessed a 'cognitive turn'. Whereas experimental psychology had been dominated by behaviorism in the first half of the century, cognitive psychologists developed a new framework for the study of mind and behavior in the decades after the War. Inspired by the invention of the computer and developments in neuroscience and linguistics, psychologists started to doubt the feasibility of the behaviorist approach (e.g., Breland & Breland 1961; Chomsky 1959; Garcia & Koelling 1966), replacing it with new methods to study 'mental' processes in a strictly empirical fashion (e.g., Jenkins et al. 1958; Miller 1956; Newell et al. 1958).

Both the nature and the significance of the cognitive turn have been disputed by historians of psychology. Some scholars view the development as a prototypical Kuhnian revolution (Baars 1986; Lachman et al. 1979). They describe it as a process in which the dominant behaviorist paradigm was displaced by a competing cognitivist framework that prevailed by "winning the allegiance of the most gifted students of the succeeding generation" (Gardner 1985, p. 209), drawn in by the innovative methods and the promise of a truly interdisciplinary research program. Others are more hesitant and describe the cognitive turn as a "theoretical discontinuity" (Greenwood 1999, p. 1) or even as a "slow and piecemeal" evolution (Mandler 2002, p. 339). Still others suggest that that there is much *continuity* between cognitive psychology and methodological behaviorism (Leahey 1992), or even that the very notion of a 'cognitive turn' should be dismissed as a "socio-rhetorical term" (O'Donohue et al. 2003) or an "origin myth" (Hobbs & Chiesa, 2011), invented by cognitive psychologists (Dember 1974; Joynson 1970) in order to foster a shared identity.

Despite these strong disagreements about the theoretical and methodological (dis)continuity between behaviorist and cognitivist approaches to psychology, most historians agree that the American psychological landscape drastically changed in the 1960s and 1970s.

They agree that fewer and fewer psychologists identified as behaviorists, that the new generation of psychologists started to classify their work as cognitivist, and that psychologists increasingly started to emphasize the value of recent results in linguistics, artificial intelligence, and neuroscience. Even if it is unclear whether the rise of cognitive psychology should be categorized as a Kuhnian revolution, in other words, there seems to be widespread consensus about the cognitive turn as a sociological phenomenon.

In this paper, we seek to map these changes to the psychological landscape in more detail, thereby testing the standard narrative about the development of psychology in the second half of the twentieth century. Using advanced bibliometric tools, we analyze the metadata of 332.498 articles published in Anglophone psychology journals between 1946 and 1990 in order to estimate (1) when cognitive psychology first emerged as a clearly delineated subdiscipline, (2) how fast it grew in subsequent decades, (3) to what extent it replaced other (e.g., behaviorist) approaches to psychology, (4) to what degree it was more appealing to the new generation of psychologists, and (5) whether it could be characterized as more interdisciplinary than alternative psychological schools.

Thus far, the cognitive turn has proven to be notoriously difficult to chart. Much depends on how one defines 'cognitive psychology' or 'behaviorism'. Even if one aims to answer the seemingly straightforward question of whether graduate students were more drawn to cognitive psychology than to behaviorism in the 1960s and 1970s, for example, one requires relatively strict criteria to determine which papers and dissertations classify as behaviorist or cognitivist. Yet it seems impossible (even misleading) to try and devise any such clear-cut definitions; school labels like 'cognitivism' and 'behaviorism' are notoriously vague and historically contingent. Although most historians agree that there are some archetypical behaviorists (e.g., J. B. Watson and B. F. Skinner) and cognitivists (e.g., G. A. Miller and Noam Chomsky), it is

highly questionable whether it makes sense to strictly divide a diverse community of psychologists into two distinct categories.

In order to circumvent these methodological problems, most bibliometric studies analyze the cognitive turn by focusing on the period after 1975, when specialist journals like *Cognitive Psychology* (first issue in 1970), *Memory and Cognition* (1973), and *Cognition* (1975) had been founded. Both Friman et al. (1993) and Robins et al. (1999), for example, examine the cognitive turn by analyzing the citation numbers and impact factors of four cognitivist journals (the three above-mentioned journals plus *Journal of Experimental Psychology: Learning, Memory, and Cognition)* and four behaviorist journals (*Behavior Research and Therapy; Journal of Experimental Analysis of Behavior; Behavior Therapy; Journal of Applied Behavior Analysis*). Similarly, Leydesdorff and Goldstone (2014) and Núñez et al. (2019) studied the development of cognitive science by analyzing, among others, the citation data of papers published in *Cognitive Science* (first issue in 1977). A major disadvantage of these studies is that they cannot tell us anything about the development of psychology *before* the 1970s. If one focuses on cognitivist journals, one examines the discipline in a period when it was already mature enough to warrant its own journals. Little can be said about the birth or the early development of cognitive psychology, i.e., about the very developments that gave rise to discipline. A second disadvantage is that it is not clear whether the papers published in specialist journals constitute a representative sample of the field. Studies that focus on specialist journals neglect data from generalist outlets like *Psychological Review* and *American Journal of Psychology*, even though these are the journals with the biggest impact on the development of the field.

In this paper, we use an alternative method to circumvent the challenges surrounding studies of the cognitive turn. Instead of relying on specialist journals or on controversial classification criteria, we use citation data of generalist and specialist psychology journals to

generate networks of co-citation clusters and to study the development of these clusters over time. Co-citation networks reflect which authors are perceived to be doing similar work by the total community of authors publishing in these journals (Small 1973). If a group of psychologists (e.g., E. Tulving, U. Neisser, and A. Paivio) is perceived to be doing similar work, it is likely that they are often co-cited and, hence, that they form a relatively robust co-citation cluster. Similarly, if two groups of psychologists (e.g., the behaviorists and the cognitivists) are perceived to be using different approaches it is likely that they are less frequently co-cited and, hence, that the two groups form distinct co-citation clusters. In studying the size and development of these behaviorist and cognitivist co-citation clusters over time, we can study the cognitive turn without relying on controversial definitions and without restricting ourselves to specialist journals that only emerged from the 1970s onwards.[1]

A major advantage of our approach is that it is compatible with the idea that school concepts like 'cognitive psychology' and 'behaviorism' are multidimensional, such that an

[1] One might object that the proposed approach does not solve the above-mentioned problem because we still require external criteria to determine which co-citation clusters count as 'behaviorist' and which as 'cognitivist'. In theory, this might be true. In practice, however, it turns out to be relatively easy to identify clusters without appealing to controversial criteria. Since most networks, as we shall see, contain one clearly delineated cluster containing all authors that are typically viewed as behaviorists and one cluster containing all authors that are typically perceived as cognitive psychologists, it seems hardly controversial to use these labels in interpreting the networks. Moreover, even if one *is* hesitant to apply school labels like 'behaviorism' or 'cognitivism' to these co-citation clusters, the networks do reveal actual patterns in the citation data and will therefore offer us interesting information about the development of psychology in the second half the twentieth century.

author's oeuvre can be behavioristic or cognitivist in one sense but not in another. Second, our approach allows that labels like behaviorism and cognitive psychology have changed over time.[2] Because we examine which authors were *perceived* to be doing similar work by a community of citing authors during a clearly delineated period, we can allow that co-citation networks in different periods carve up the field in different ways.

Method

Data collection and preparation

Publication data were retrieved from the Science Citation Index Expanded and the Social Science Citation Index in Web of Science (WoS). The advanced search query "WC=(psychology) or SU=(psychology)" (with WC standing for WoS Category and SU standing for Research Area) was run with the additional restrictions that the results should be (1) in English, (2) of the document type "Article", and (3) published in the years 1946 through 1990.[3] The results were downloaded with full record and cited references. Duplicate articles were removed based on the attributes Author, Title, Publication Name, Cited References, and International Standard Serial Number. This resulted in 332.498 unique articles, published in 529 different journals.

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[2] Co-citation analysis is not the only bibliometric technique that has these advantages. Term co-occurrence analysis can also be a valuable instrument to study the development of a discipline without relying on external definitions. See, e.g., Flis & van Eck (2018) who employed this tool to study the structure and development of the schism between 'correlational' and 'experimental' psychology. We explored the use of co-occurrence analyses to study the development of behaviorism and cognitive psychology in Braat et al. (2020).

[3] Data for the years 1946-1970 were downloaded from WoS earlier, using the same query, as part of an earlier study (Braat et al. 2020).

A known artefact of variation in citation conventions, both across journals and across time, is that there can be a many-to-many correspondence between author names and authors (Smalheiser & Torvik 2009). As a case in point, cited references contain the authors 'freud, s', 'freud, sigmund', and simply 'freud'. The former two probably refer to the same author, whereas the latter might refer to Sigmund Freud, Anna Freud, or a few others. To address this issue, we created a renaming script in Python according to the following procedure. First, frequencies were computed for each unique author name (surname, initials) that occurred in the cited references in the full dataset. Then, for each surname, all authors whose surname and initials were consistent with the highest-ranked author, were renamed to the highest-ranked author. This meant that 'freud' (which is consistent with 'freud, s', the highest-ranked author) would get renamed to 'freud, s', but that 'freud, a' would not. The resulting renaming rules were stored in a so-called 'thesaurus file', which VOSviewer uses to rename authors at runtime. We then manually inspected this file and added some improvements, for example with regards to hyphenated last names (e.g., to make sure that 'frenkelbrunswik, e' was renamed to 'frenkel-brunwik, e' if the latter was also in the dataset). While these procedures do not perfectly solve the many-to-many correspondence described above, they significantly help to prevent authors appearing in the co-citation networks multiple times under different names.

The data were then split into nine different files, corresponding to each successive 5-year period from 1946 through 1990, and further analyzed using the VOSviewer software, version 1.6.14 (Van Eck & Waltman 2010). The number of articles for each of these periods are provided in Table 1. These show an exponential growth in each successive period between 1946 and 1970, which decelerated in the years after that.

Table 1 about here

Data analysis

Co-citation maps

Author co-citation maps were created with VOSviewer. When analyzing co-citations, items (be it papers, journals, or authors) are considered similar to the extent that they are cited together. The similarity measure of choice was *association strength*, a normalized measure that has several desirable properties compared to alternatives (Van Eck & Waltman 2009). Its value is proportional to the ratio between the observed number of co-citations and the expected number of co-citations under the assumption of statistical independence. Informally, to have a high association strength, a pair of authors who both have a large number of citations require more co-citations than a pair of authors who both have a small number of citations.

To map the association strengths for all pairs of authors onto a two-dimensional space, VOSviewer uses the *visualization of similarities* (VOS) method, which is similar to multidimensional scaling. The distance between any two items in a map provides an indication of their similarity. VOSviewer also clusters the items (in this case, authors) in a map using a technique similar to modularity-based clustering. In general, authors with a high association strength are assigned to the same cluster. It is these clusters that are of most interest for our interpretation of the maps. For a more technical discussion of the mapping and clustering algorithms, we refer to Waltman, Van Eck, and Noyons (2010). The default clustering resolution (a parameter that determines the level of detail of the clustering) of 1.0 was used for every map, and the minimum cluster size was set to 1, meaning that a cluster could, in principle, consist of a single author. In the maps shown in the Results section, clusters are indicated by colors.

For each 5-year period, four co-citation maps of the top-*n* most cited authors were generated, with *n* ranging from 200 to 12.800 authors. The rationale for this was that any one map is unlikely to give a perfect representation of the field in a given period. More specifically, the map consisting of the top-200 authors might present a clear picture at the expense of

ignoring some of the meaningful complexities of the field. Conversely, the map consisting of the top-12.800 authors might show a lot of complexity at the risk of confusing noise (e.g., spurious associations between less-cited authors) for signal. By comparing the maps of different sizes on several key indicators (e.g., the absolute and relative sizes of particular clusters in terms of the number of authors and the number of citations), then, one is most likely to arrive at a comprehensive and robust understanding of the co-citation relations in the field. In addition, where appropriate, we will provide a *range* of estimates rather than a single point estimate. The increments in map size were exponential (a fourfold increase with each increment, i.e, 200-800-3200-12.800) to mirror the distribution of the number of authors per number of citations (i.e., there are a few authors with a very large number of citations, and a very large number of authors with a few citations).[4] Thus, each increment should include a new 'stratum' of authors.

Age

For each of the five-year periods, we retrieved the birth years of the 25 most-cited authors in the cognitivist and behaviorist clusters and the 40 most-cited authors from the rest of the network. For each of these groups, the median birth year was calculated and subtracted from the mid-point of the five-year period. For example, the median birth year of the 25 most-cited behaviorist authors in 1946-1950 was 1903, and thus their median age was set at 44.5 years.

Interdisciplinarity

To approximate the interdisciplinarity of the work produced by authors in the most relevant clusters, we counted, for each article published by authors belonging to that cluster

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[4] To be even more comprehensive, maps of 51.200 authors were initially considered for the 5-year periods containing at least this number of cited authors. This resulted in such large numbers of clusters, in which many authors with fewer than five citations were included, that interpreting the maps was virtually impossible.

during that specific 5-year period,[5] the proportion of cited references that were publications in non-psychology journals. We restricted the cited references to journals, as for other types of documents it would be intractable to determine what research area they are part of. For journals, on the other hand, we could rely on information provided by WoS and a small number of heuristics. We counted as 'intradisciplinary' any journal that had (1) a 'Psychology' research area tag in WoS, or (2) whose title matched the string 'psycho*' (to capture citations of journals that are not covered by WoS). Any remaining journals were labelled as 'extradisciplinary'.

To prepare the data for this process, we first had to parse the cited references provided by WoS. This was done with a script that extracted the journal articles from the cited references, based on several syntactic rules. It resulted in a list of 96,843 unique journal titles from the full dataset. Because WoS provides journal titles in cited references in an abbreviated format, these were subsequently matched with a list of full titles (Web of Knowledge, 2020). Finally, these full titles were matched with the WoS Master Journal List (MJL), which provides research area tags for each journal.

For the top-250 cited journals that were labeled as 'extradisciplinary', we manually checked whether this decision was valid. For 65 titles, the label was reversed to 'intradisciplinary'. Among these, 19 titles were less-common spelling variants of more widely-used abbreviations, resulting in failure to match with the WoS MJL. Furthermore, 39 titles were predecessors of titles that have a 'Psychology' research area tag in WoS but were absent in the

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[5] As a rule, authors appear in the co-citation maps because they are *influential* during a specific period, not because they are *productive* during that period. In some extreme cases, this meant that authors were part of a cluster who did not publish any work during that period. For interpretation, it means that the articles produced by authors in a cluster are a rather rough and not strictly time-locked proxy for the real activity of that part of the field.

WoS MJL (such as *Journal of Verbal Learning and Verbal Behavior*, which continued as *Journal of Memory and Language* in 1985).

To obtain an estimate of the false-positive rate for the remaining 96.593 titles, we drew a random sample of 100 titles. Four titles in this sample warranted an 'intradisciplinary' label.[6] We conclude that this small margin of error allows for a sufficiently accurate estimate of the proportion of extradisciplinary citations for our purposes. To follow up on these proportions with a qualitative analysis, we also extracted the titles of the top-100 most cited psychology and non-psychology journals for each of the relevant clusters in each time period.

Results

Co-citation networks per decade

Table 2 provides an overview of the 36 co-citation networks generated for the nine consecutive five-year periods between 1946 and 1990.[7] For each network, the table lists the number of clusters generated by VOSviewer, the minimum number of citations an author required to be included in the network, the number of authors actually included in the network,[8] and the average and total number of citations the authors in the network received in the period.

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[6] The much lower false-positive rate for less-cited journals can be explained, in part, by the fact that highly-cited titles are much more likely to be related to psychology, and by the fact that the less-cited journals include many foreign-language (e.g., German, French, Russian) titles, which are not covered in the WoS dataset.

[7] The complete set of co-citation maps is available on Open Science Framework:

https://osf.io/3hqk2/?view_only=3244a7ad17384b55a7af1a380f22b2e1

[8] When authors were tied for a rank, we always included all these authors, creating maps that contained *at least* the desired number of authors. In the period 1951-1955, for example, multiple authors were cited 69 times, such that a total of 201 authors is included in the top-200 network.

The table shows that the minimum number of citations an author required to belong to the most-cited scholars of the field increased exponentially over time. Whereas 41 citations in a five-year period sufficed to belong to the top-200 most-cited authors just after the Second World War, scholars needed 460 citations in a five-year period to belong to the top-200 authors between 1986 and 1990. Similarly, the minimum number of citations to belong to the top-12.800 authors in a period increased from 1 in the 1946-1950 period to 23 citations forty years later.

An analysis of the networks reveals that the VOSviewer clustering algorithm only produces interpretable results when it has sufficient citation data for most authors in the network. When a large number of authors is cited only a few times, the co-citation relations between the authors become too dependent on chance to generate interpretable co-citation clusters. This is likely the reason why VOSviewer generated large numbers of clusters in all the networks in which the minimum number of citations per author was smaller than 5. We therefore decided only to use networks in which the minimum number of citations is 5 or larger. This left us with 31 co-citation networks for our analysis of the period-by-period development of psychology between 1946 and 1990 (at least two networks per period).

Table 2 about here

1946-1950

For the period 1946-1950, we analyzed two co-citation networks: one with the top-200 most-cited authors and one with the top-800 most-cited authors. The first of the two networks is shown in Figure 1 and divides the authors into seven clusters. The largest cluster is a group that received 35% of the total citations of the period and is dominated by authors who worked on intelligence (e.g., L.L. Thurstone, R. B. Cattell, J. P. Guildford, C. Burt, and D. Wechsler) and authors who wrote about personality (e.g., D. Rapaport, S. R. Hathaway, S. J. Beck, and B.

Klopfer).[9] In the top-800 network of the period, this group splits quite neatly into two separate clusters, one representing the major intelligence psychologists (Thurstone, Cattell, Guilford, Burt, and L. M. Terman) and one representing the most influential personality theorists (Rapaport, Hathaway, Beck, Klopfer, and, more surprisingly, Wechsler).[10] The second-largest cluster contains mostly behaviorists (e.g., C. L. Hull, E. C. Tolman, O. H. Mowrer, and E. L. Thorndike), comprising 21% of the total citations. The third big cluster represents psychoanalysis (most-cited authors: S. Freud, O. Fenichel, and F. Alexander, 18% of the total citations).

Figure 1 about here

The clustering of the top-200 network strongly suggests that behaviorism was not the dominant approach to psychology in the first years after the Second World War. The cluster comprising the paradigmatic behaviorists is not the largest cluster of the network and only 21% of the total citations in the period were citations to authors from this cluster. This result is confirmed by the second co-citation network we generated for the period. In this second network, comprising the top-800 most-cited authors, the behaviorist cluster only represents 14% of the total citations, a substantially smaller proportion than the cluster comprising the

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[9] Not all names mentioned are visible in Figure 1.

[10] In the bigger network, these clusters comprise 23% and 13% of the total citations respectively.

psychologists working on intelligence (23 percent, see footnote 8). In addition, only one behaviorist (Hull) is part of the top-10 most-cited authors of the period.[11]

It might appear odd that our estimate of the proportion of behaviorists quite strongly diverges between the two generated co-citation networks (21 percent for the top-200 vs. 14 percent for the top-800). It is important to note, however, that the two networks 'measure' different things. The top-200 network provides an estimate of the relative impact of the *most influential* behaviorists whereas the top-800 network examines a broader selection of authors. The gap between the two networks therefore suggests that the behaviorist approach was not yet widely practiced in Anglophone psychology (or, if it was, that the additional behaviorists were not cited very frequently). Indeed, when we, in the top-800 network, only take into account the authors who received *less* than 41 citations in the period (i.e., all authors who are represented in the top-800 network but *not* in the top-200 network), the behaviorists account for only 11% of the total citations. The converse conclusion can be drawn about the clusters comprising the psychologists working on intelligence and personality. Whereas these 'mental testers' comprise 35% of top-200 network, as we have seen, 36% of the authors who received less than 41 citations are grouped in one of the mental testing clusters, suggesting that the subject was also widely studied by less influential authors.

A second explanation for the divergence between the two generated networks is that several authors who are grouped with the behaviorists in the top-200 network are grouped into a different cluster in the top-800 network. A closer analysis of this set of authors reveals that it mostly comprises of people who were cited regularly because they raised important objections

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[11] The top-10 most-cited authors of the period are Freud (1017 citations), Hull (511), Thurstone (375), Cattell (322), Guilford (306), G. W. Allport (293), K. Lewin (269), Burt (267), Wechsler (262), and C. R. Rogers (255).

to behaviorism (e.g., N. R. F. Maier, whose work on rats challenged key behavioristic principles) or authors who are cited regularly because they wrote influential textbooks or methodology papers (e.g., E. F. Heidbreder and G. W. Snedecor). Naturally, the converse can also happen: authors that are grouped with one school in a large network can be grouped in a different cluster in a smaller network. In general, this implies that one should always approach the clustering with caution. One cannot blindly trust the data about the cluster sizes without taking a closer look at which authors are clustered together. This is one reason why do not provide a single estimate of the size of a certain psychological school in a particular period. Our estimate of the relative size of behaviorism in 1946-1950, for example, is 14 to 21 percent.

Neither the top-200 nor the top-800 network contains a cluster comprising mostly cognitive psychologists. This should not be surprising as most histories of the cognitive turn date the birth of cognitive psychology in the late 1950s or early 1960s. Still, especially the top-800 network contains quite a few authors who would come to play an important role in the development of cognitive psychology (e.g., G. A. Miller, B. J. Underwood, L. Postman, W. K. Estes, and J. S. Bruner). Most of these authors (Miller, Underwood, and Estes) are grouped in the behaviorist cluster. Again, this should not be surprising as many first-generation cognitive psychologists started out doing behaviorist work.[12] The other (proto)cognitive psychologists (Postman and Bruner) are part of a cluster that can be best described as a group comprising alternative (non-behaviorist) approaches to experimental psychology. This cluster accounts for twelve percent of the total citations and contains mostly Gestalt psychologists (e.g., W. Köhler and K. Koffka), operationists (e.g., S. S. Stevens and E. G. Boring), and functionalists (e.g., R. S. Woodworth and E. Brunswik).

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[12] See, for example, Miller and Postman (1946), Kendler and Underwood (1948), and Verplanck, Skinner, and Estes (1954).

1951-1955, 1956-1960, 1961-1965

For the next three periods, we generated three networks each, representing the top-200, the top-800, and the top-3.200 most-cited authors. In most of these networks, we see roughly the same pattern as in the period 1946-1950. The biggest clusters are groups dominated by mental testers, whereas the behaviorists receive a significantly smaller proportion of the citations.[13] In the top-800 network for the period 1956-1960 (Figure 2), for example, the biggest cluster comprises mostly mental testers (most-cited authors Cattell, Guilford, and A. L. Edwards; 36% of the citations) and the behaviorists occupy the second-largest cluster (most-cited authors: Hull, K. W. Spence, and C. E. Osgood; 26% of the citations). Still, it is notable that the behaviorist clusters are rapidly growing throughout the 1950s and early 1960s. The proportion of citations to the behaviorist clusters grows from 21 to 38 percent (top-200 networks) and from 14 to 22 percent (top-800 networks) between 1946-1950 and 1961-1965.

Figure 2 about here

Part of the explanation for the rapid growth of the 'behaviorist clusters' is that the behaviorists became more influential in the first two decades after the Second World War. Unlike the received view, which tells us that the behaviorists were most dominant in the years

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[13] One exception is the top-800 network in 1951-1955, in which the behaviorist cluster *is* the largest cluster of the network. This deviating result is explained by the fact that the most-cited intelligence testers are divided into two clusters, one containing Thurstone, Guilford, and Cattell and another containing Eysenck and Wechsler. Combined, the two clusters are bigger than the behaviorist cluster. A second exception is the top-200 network in 1961-1965 and will be discussed in detail below.

just before and after the War, the co-citation networks suggest that behaviorism started to play a chief role only in the late 1950s and early 1960s, when a new generation of behaviorists (e.g., D. E. Berlyne, C. B. Ferster, M. Sidman, and A. Amsel; all born in the 1920s) gave the movement new impetus. 1961-1965 is also the first period in which B. F. Skinner is represented in the top-20 most-cited psychologists, suggesting that it is only in the early 1960s that the latter's radical behaviorism started to become more influential.

Another explanation for the rapid growth of the 'behaviorist clusters' is that the forerunners of the cognitive turn started to play a significant role inside these groups. The 'behaviorist cluster' in the top-200 network for 1961-1965, for example, comprises 38 percent of the total citations but it should be noted that this cluster prominently features quite a few authors that are often associated with the cognitive turn. The top 20 most-cited authors in this cluster consist both of paradigmatic behaviorist authors (e.g., Spence, Hull, Skinner, Mowrer, and N. Miller) as well as important (proto-)cognitive psychologists (e.g., Underwood, Postman, G. Miller, and Bruner). Indeed, this cluster splits into two (or more) clusters in the larger networks for this period. The top-800 and the top-3.200 network both contain a separate cluster comprising mostly cognitive psychologists (e.g., Osgood, Underwood, Postman, and Bruner). These clusters represent the first genuine cognitivist clusters we found, suggesting that the split between behaviorist and cognitivist experimental psychologists had fully emerged by 1965.[14]

In interpreting co-citation networks, it is important to keep in mind that they reflect co-citation patterns in the total set of publications in a period, regardless of whether these publications are authored by developmental psychologists, behaviorists, or

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[14] Or better, that the split was fully visible in the citation patterns of that period. As there will generally be a time lag of a few years between the publication of an article and its first citations, any dating of the split on the basis of co-citation patterns will necessarily be conservative.

psychophysiologists. This implies that the clustering will not always be sensitive to co-citation patterns *within* a certain subdiscipline. J. B. Watson and E. R. Guthrie, for example, could both be viewed as 'behaviorists' by social psychologists and psychoanalysts (and therefore be robustly grouped into the same cluster in all co-citation networks), whereas their approaches might be worlds apart to cognoscenti. In order to capture the more subtle, 'internal' co-citation patterns, it is possible to generate more fine-grained networks using only articles published by the authors within a certain cluster in a particular period of time. We did this for the 'behaviorist cluster' in the top-200 network of 1956-1960, in order to check whether signals of a split between behaviorist and cognitivist experimental psychologists could already be detected in the late 1950s. The resulting network shows that there are such early signs of the cognitive turn. The network contains a separate cluster comprising the co-founders of the groundbreaking Harvard Center for Cognitive Studies (Bruner and Miller), Harvard psychologists and linguists sympathetic to the cognitive approach (e.g., Stevens, E. B. Newman, N. Chomsky), and authors that paved the way for the cognitive turn (e.g., the British psychologist D. E. Broadbent and the information theorist C. E. Shannon), whereas the paradigmatic Harvard behaviorists from the period (e.g., Skinner, Sidman, Ferster) are grouped into a different cluster. Even though the first center for cognitive studies was still to be founded, in other words, the first signals of the impending rupture can already be detected in the co-citation patterns.

1966-1970, 1971-1975

For the next two periods, we generated four networks each, representing the top-200, the top-800, the top-3.200, and the top-12.800 most-cited authors. Unlike the networks generated for the previous periods, every one of these eight networks (even the two top-200 networks) contains one or more clusters comprising predominantly cognitive psychologists, showing that the approach had acquired solid footing by the late 1960s. In fact, in three out of

four small networks, the cognitivist cluster is slightly bigger than the behaviorist one.[15] In the top-200 network for the period 1971-1975 (Figure 3), for example, we see that the cognitivists and the behaviorists are divided into two clusters of roughly equal size, representing 22% and 19% of the field respectively. The most-cited authors in the cognitive cluster are A. Paivio, Stevens, E. Tulving, G. A. Miller, Underwood, G. H. Bower, U. Neisser, M. I. Posner, Broadbent, and D. H. Hubel, whereas the most-cited authors in the behaviorist clusters are B. J. Winer, S. Siegel, Skinner, Berlyne, N. Miller, Estes, Azrin, Ferster, Amsel, R. C. Bolles, and Mowrer. The remaining large clusters are groups comprising mostly mental testers (21% of the citations; most cited authors: J. Piaget and Cattell), social psychologists (17%; D. Byrne and J. B. Rotter), psychotherapists (14%; A. Bandura and Eysenck), and psychoanalysts (7%; Freud; E. H. Erikson).[16]

The cognitive psychology clusters are gradually on the rise in the late 1960s and early 1970s, growing from 18% to 26% (top-800 networks) and from 13% to 20% (top-3.200

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[15] In the large networks of 12.800 authors, the behaviorist clusters are significantly larger than the cognitivist ones (23-25% vs. 13-16%), suggesting that the changing orientation among the 'elite' had not yet completely trickled down to the entire community of psychologists.

[16] Some of the authors mentioned in this paragraph are boundary figures (most notably, Thorndike, Estes, Winer, Siegel, and Piaget), since they regularly flip between clusters depending on the parameter settings. Estes, for example, is part of the behaviorist cluster in the top-200, and top-800 networks but flips to the cognitivist cluster in the top 3.200 and the top-12.800 networks. This is probably due to the fact that Estes used both approaches in different stages of his career. Winer, on the other hand, is a boundary figure because of his work on statistical analysis, which was used by both types of experimental psychology.

networks) between 1961-1965 and 1971-1975.[17] Interestingly, this growth is not accompanied by strongly declining citation numbers for the behaviorists. The proportion of citations to authors occupying the behaviorist clusters remains relatively stable with an estimated proportion of 20%-22% in the 1961-1965 period and 21% ten years later. It appears that the 'extra space' for cognitive psychology is mostly created by the declining influence of the mental testers and the psychoanalysts. Especially the psychoanalyst clusters rapidly started to shrink in the 1960s and early 1970s, declining from 15-17% of the total citations in 1961-1965 to only 5-6% of the citations ten years later.

We also see some significant changes *within* the cognitivist clusters. Whereas the most-cited cognitive psychologists in the 1960s all received a traditional education, the clusters in the early 1970s already prominently feature psychologists educated in the emerging cognitivist tradition (e.g., G. Sperling, S. Sternberg, and M. I. Posner).[18] In addition, the cognitivist clusters in the early 1970s show the growing influence of authors who explicitly thematized the 'cognitive turn'. Some of the most influential voices in debates about the advantages and disadvantages of cognitivism and behaviorism (e.g., U. Neisser, N. Chomsky, and G. Mandler) are part of the top-20 most-cited authors of the cognitivist cluster in 1971-1975. Finally, we see that the study of language and the connections with linguistics start to become more important in the late 1960s and early 1970s. The three the fastest-rising authors of the late 1960s (R.

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[17] There is no data for the top-200 networks as the behaviorists and cognitive psychologists were still clustered together in the top-200 network for 1961-1965 (as mentioned above).

[18] Sperling received a Ph.D. from Harvard in 1959, writing a dissertation on short-term memory; Sternberg received his Ph.D. (in social psychology) from the same institution one year later. Posner wrote a thesis on informational approaches to thinking and received his Ph.D. from the University of Michigan, Ann Arbor, in 1962.

Brown, Chomsky, and D. S. Palermo) as measured in terms relative increase in number of citations were all working on the psychology of language.

Figure 3 about here

1976-1980, 1981-1985, 1986-1990

For the final three periods, we generated four networks each, representing the top-200, the top-800, the top-3.200, and the top-12.800 most-cited authors. Figure 4 shows the top-800 network for the final period. The network contains six clusters, comprising roughly cognitive psychology (28% of the total citations, discussed in more detail below), mental testing and psychometrics (27% of the citations; most-cited authors Eysenck, J. Cohen, and Cattell), psychotherapy and psychiatry (21% of the citations; most-cited authors A. T. Beck, the American Psychiatric Association, and Bandura), developmental psychology (11% of the citations, most-cited authors M. Rutter, T. M. Achenbach, and L. Kohlberg), psychoanalysis (6% of the citations, most-cited authors, Freud, Erikson, and H. Kohut), and behaviorism (5% of the citations, most-cited authors, Skinner, R. A. Rescorla and Siegel).

Figure 4 about here

The final three periods show the consolidation of cognitive psychology and the rapid decline of the behaviorists. Whereas the clusters representing the two approaches had still been of roughly equal size in the late 1960s, we see the proportion of citations to behaviorist clusters strongly decline across all network sizes. In the top-200 networks we see the sharpest decline

(from 21% to 0% between 1966-1970 and 1986-1990)[19] but the top-800, the top-3.200, and the top 12.800 networks show similar patterns (from 20-23% in 1966-1970 to 5-9% twenty years later). The cognitivist clusters on the other hand gradually grow from 16-22% to 23-33% between 1971-1975 and 1986-1990.

Within the cognitivist clusters, we see the emergence of cognitive neuroscience in the late 1970s and 1980s. Two of the fastest rising authors in these two periods are M. Kinsbourne and J. L. McClelland, suggesting that neuropsychology quickly started to become more influential in the periods under discussion. Indeed, by the late 1980s, cognitive neuroscience is already represented by a separate cluster in the biggest network, one comprising the most prominent cognitive neuroscientists (e.g., Kinsbourne, A. R. Luria, and B. Milner) and one comprising the more classical cognitive psychologists (e.g., J. R. Anderson, E. Tulving, A. D. Baddeley). A second important development is that the cognitivist clusters often start to merge with clusters comprising developmental psychologists, showing the influence of the cognitivist approach on educational and developmental psychology (and vice versa). From the late 1970s onwards, the cognitivist clusters feature authors studying cognitive development (e.g., J. H. Flavell and W. D. Rohwer) and in nine of the twelve networks generated for these periods Piaget is the most-cited author in the cognitivist cluster.

Overview of the co-citation networks

Table 3 presents an overview of all the behaviorist and cognitivist clusters of the 31 networks we generated for the nine periods. Although some individual networks likely overestimate or underestimate the number of behaviorists and cognitivists due to some of the

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[19] There is no separate behaviorist cluster in the top-200 network for 1986-1990. The few behaviorist authors that are still present in the top-200 most-cited psychologists (most notably, Skinner and Rescorla) are grouped into the cognitivist cluster.

processes described above, collectively they neatly reflect the rise and fall of behaviorism (peaking in the late 1950s and early 1960s) as well as the rapid but soon flattening growth of cognitive psychology from the early 1960s onwards.

Table 3 about here

In addition to the rise-and-fall pattern, another interesting feature of the cognitive turn emerges when one compares the relative proportions of the behaviorist clusters across different network sizes. It is notable that in all periods until 1965, the proportion of behaviorists is smaller in the large networks. As we discussed above, this is evidence that the behaviorist approach was not yet widely practiced in Anglophone psychology. The reverse pattern occurs from the early 1970s onwards, however. Especially in the eight networks from the 1980s, it is clear that the behaviorists occupy a larger proportion of the total citations in the top-3.200 and top-12.800 networks. One explanation for this phenomenon is that the population of psychologists is relatively inert to major shifts in theoretical and methodological orientation due to educational practices. Although behaviorism was clearly in vogue in the decades after the Second World War, only a small proportion of experimental psychologists had been educated to conduct behaviorist experiments, resulting in a relatively small proportion of behaviorist work among the least-cited authors. The process appears to have repeated itself after the 1970s, when many psychologists, now finally educated in the behaviorist tradition, continued to do behaviorist work despite the changing trend among the most-cited psychologists. A similar though somewhat less pronounced effect is visible if one compares the sizes of the cognitive psychology clusters across network sizes within a period.

Table 4 presents the top-10 most-cited and the three fastest-rising authors in the (combined) cognitivist clusters between 1961-65 and 1986-90, thereby providing an overview

of the *internal* development of cognitive psychology. Here, it is notable that many of the authors who played a key role in the cognitive turn in the late-1950s and early 1960s (e.g., Miller and Bruner) or who theoretically paved the way for the new approach (e.g., Underwood, Postman, Woodworth, and Broadbent) are gradually superseded by a new generation of cognitive psychologists (e.g., A. Paivio, Tulving, Posner, Kahneman) from the 1970s onwards. In addition, the table suggests that topics like memory, representation, attention, and reasoning remained central to the cognitivist program (as is evinced by the prominent positions of Posner, Kahneman, J.R. Anderson, Tulving, Sternberg, and Baddeley in the late 1980s), despite the above-discussed influence of new subdisciplines like psycholinguistics, cognitive neuroscience, and cognitive development.

Table 4 about here

Age

Table 5 provides an overview of the median age of the top-25 most-cited authors in the behaviorist and cognitivist clusters in each period as well as the development of the median age of the top-40 most-cited authors in the rest of the field. The table shows that both the behaviorists and the cognitivists are, on average, significantly younger than the psychologists in the remaining clusters. In most periods, the age gap is substantial, indicating that there were fewer barriers for behaviorists and cognitive psychologists to rise through the ranks. In the years before the cognitive turn there was a substantive gap between the behaviorists and the rest of the field. Whereas half of the most-cited psychologists in the 1956-1960 period were born in the 19th century (including, among others, Freud, Guilford, Thurstone, H. Hartmann, Fenichel, Piaget, A. Freud, and Lewin), the number of 19th century scholars among the most-cited behaviorists was three times smaller (viz. only Hull, Thorndike, Tolman, and J. A. McGeoch).

In the first years of the cognitive turn (the early 1960s), the most-cited cognitivists were not younger than the behaviorists. This supports the above-discussed finding that *both* approaches were on the rise until at least the mid-1960s and that both behaviorism and cognitivism still appealed to the young generation of researchers. In the early 1960s, about twenty-five percent of the authors in both lists are younger than 40.[20] It is only in the late 1960s and 1970s that the most-cited authors in the cognitivist cluster start to become younger on average, suggesting that cognitive psychology, once it became an established subdiscipline, was more appealing to the next generation of researchers. Indeed, by the late 1970s almost two-thirds of the most-cited authors in the cognitivist clusters were authors educated after the Second World War, compared to fifty percent of the most-cited authors in the behaviorist cluster.

Table 5 about here

Journals and Interdisciplinarity

Table 6 provides an overview of the most-cited journals in the behaviorist and cognitivist clusters per period. In both groups we see a growing specialization over the decades. Whereas the cognitivists were predominantly citing generalist periodicals like *Journal of Experimental Psychology, Psychological Review*, and *American Journal of Psychology* in the early 1960s, we see a growing influence of specialist venues like *Journal of Verbal Learning*

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[20] In the behaviorist cluster, they are the aforementioned Berlyne, Ferster, Sidman, and Amsel, as well as W. Edwards, S. Levine, and H. W. Stevenson. In the cognitivist cluster, Broadbent, Mandler, W. A. Russell, J. J. Jenkins, E. A. Fleishman, J. A. Adams, and R. D. Luce were younger than 40 and represented in the top-25 most-cited authors.

and Verbal Behavior (first issue in 1962), *Perception & Psychophysics* (first issue in 1966), and *Cognitive Psychology* (first issue in 1970) in later periods. The behaviorists already had a few specialized journals in the early 1960s—e.g., *Journal of Comparative and Physiological Psychology* (first issue 1947) and *Journal of the Experimental Analysis of Behavior* (1958) — but we still see the influence of these more specialized journals (e.g., *Physiology & Behavior*, established in 1966) increase over time.

Table 6 about here

These commonalities notwithstanding, there is an important difference in the development between the two groups. Although both cognitivists and behaviorists increasingly cite specialist journals, we see that generalist venues remain important to the former but not to the latter group. In the cognitivist clusters, for instance, *Journal of Experimental Psychology* was by far the most-cited publication until the journal was split into three independently edited sections (in 1975) and, after the split, the generalist journal *Psychological Review* became the most-cited publication. In the behaviorist cluster, on the other hand, we see a strong decline of such 'generalist citations' across the board. In 1976-80, when *Journal of Experimental Psychology* was still the most-cited publication by cognitivists, it had already fallen outside the top-5 of most-cited venues by behaviorist authors. Similarly, *Psychological Review*, the most-cited journal by cognitivists in the 1980s, is much less influential in behaviorist circles in the same period. Likely, this development is due to the changing orientation of these generalist journals. As cognitivist approaches started to become mainstream in the 1970s, behaviorists had to increasingly rely on less central publications in order to publish their studies. It is therefore not surprising that these periodicals are also cited less frequently by behaviorists.

Table 7, finally, provides an overview of (1) the average number of citations per paper and (2) the proportion of citations to non-psychology journals. In both fields, we see the average number of citations increase over time in a comparable rate, growing from 10 to 13 citations between 1946 and 1965 to 28-31 citations in 1986-1990. Even though the behaviorists and cognitivists gradually started to cite different venues, in other words, the increasing professionalization of psychology had a similar effect on citation norms in both fields.

Table 7 about here

Surprisingly, though, there *is* a significant gap between the levels of interdisciplinarity in the behaviorist and cognitivist clusters. Although cognitive psychologists (and especially cognitive scientists) have always explicitly self-identified as interdisciplinary researchers, only a small proportion (approximately 6-10%) of the citations in the field are to non-psychology journals. In the late 1980s, for example, prominent neuroscience journals (e.g., *Brain* and *Journal of Neuroscience*), artificial intelligence journals (e.g., *Artificial Intelligence* and *Machine Learning*), and linguistics journals (e.g., *Language* and *Syntax and Semantics*) only received a very small number of citations. On average, these six journals received no more than 10 citations per journal per year. In the behaviorist cluster, on the other hand, the proportion of citations to non-psychology journals is almost twice as large from the late 1970s onwards, climbing to 15-19% interdisciplinary citations by the late 1980s. Again, this development is evidence for the declining relevance of psychology journals for behaviorists as cognitivism started to become the mainstream approach in psychology. Another possible explanation of these surprising results is that they are the result of a 'presentist bias'. Because our classification of journals as either 'psychology' or 'non-psychology' journals partly depends on WoS labels

devised after the cognitive turn, one might suspect that some of the journals that have no 'psychology' label today *would* have been classified as such in the 1950s and 1960s.[21]

Discussion and Conclusion

We set out to probe several aspects of the developments in American psychology that are commonly referred to as the 'cognitive turn'. By analyzing the metadata of 332.498 articles published in Anglophone psychology journals between 1946 and 1990, we provided estimates of (1) when cognitive psychology first emerged as a clearly delineated subdiscipline, (2) how fast it grew after that, (3) to what extent it replaced other approaches to psychology, in particular behaviorism, (4) to what degree it was more appealing to a younger generation of scholars, and (5) whether cognitive psychology could be characterized as more interdisciplinary than other approaches. An important part of our analysis strategy was to not focus on a single co-citation network for a given period, but rather to compare a range of networks of different sizes. This should make our analyses more robust, because if there are patterns that are shared between maps, it is unlikely that these patterns are the result of an arbitrary size limitation. At the same time, they allow us to make comparisons between which scholars are perceived as doing similar work focusing on the most influential authors of that period, and which authors are perceived as doing similar work when taking a broader sample of the field.

Our findings largely support the standard narrative, but also provide new perspectives on the developments that collectively contributed to the 'cognitive turn'. First, cognitive

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[21] Indeed, the journals *Learning and Behavior* and *Animal Behavior* are among the top-10 most-cited 'non-psychology' journals cited by behaviorists. On some definitions of psychology, these would classify as psychology journals. Most journals in this top 10, however, are not proper psychology journals on any definition (e.g., *Science, Nature, Brain Research, American Journal of Physiology*).

psychology did emerge fast. That is, once it had clearly separated from behaviorism in the early 1960s, it required less than a decade to establish itself as one of the major subdisciplines within psychology. Yet, rather than a sudden shift, this pattern can be seen as the culmination of various longer-term developments. Already in the late 1950s, authors that came to play a pivotal role in the cognitive turn formed a robust co-citation cluster within the larger behaviorist cluster. Some of these authors then rose through the ranks quickly to become part of the most influential authors in the late 1960s. By then, cognitive psychologists were also a major presence in the top-800 and top-3.200 networks, and they would continue to comprise a larger proportion of these networks in the 1970s. In the late 1970s, cognitive psychologists were also a major presence in the top-12.800 networks, reflecting the broadest sample of the field in our study.

Second, cognitivism seems to have replaced behaviorism as the dominant paradigm for the study of mind and behavior, but only in the long run. For about a decade, both approaches were quite prominent in the co-citation networks. This is true despite the fact that some pioneers of cognitive psychology, who already received a lot of citations before 1960, came from behaviorist clusters. Until the late 1970s, both approaches flourished side by side, while the field in general shifted away from psychoanalysis and mental testing. In the 1970s, we already see behaviorists citing less generalist periodicals in their own work, perhaps pointing to an increasingly peripheral position in the overall field. Still, it was only after this period that behaviorism started to decline in terms of number of authors and citations. This decline was most pronounced in the small networks that reflect the most influential authors in the field.

Third, in the 1960s and 1970s the most influential cognitive psychologists were younger than the most influential scholars in the rest of the field, by six years on average. So were the leading behaviorist authors, at least in the early 1960s. This suggests that in the years after the Second World War, both approaches were appealing to young researchers. Once cognitive psychology had firmly established itself in the 1970s, the influx of young researchers working

in that paradigm was greater than that in behaviorist psychology. By the late 1980s, however, the median age of the most-cited authors associated with cognitive psychology was as high as in the rest of the field, suggesting that by then, the discipline had quite literally matured.

Fourth, when it comes to the interdisciplinary nature of cognitive psychology, our findings challenge the idea that that cognitivism was more interdisciplinary than other schools. The proportions of interdisciplinary citations within cognitive psychology between 1960 and 1990 are almost twice as low as those within behaviorism. In absolute numbers, the average cognitive psychology publication from the 1980s had two or three citations to non-psychology journals, whereas a behaviorist publication had four or five. A caveat is that the numbers for behaviorism might be so high because psychology journals, especially more generalist journals, were gradually leaning more toward cognitive psychology, thus making it necessary for behaviorists to both publish and cite work published elsewhere. It must also be noted that interdisciplinarity is a property usually ascribed to the broader field of cognitive science (including linguistics, artificial intelligence, anthropology, philosophy, and neuroscience) rather than cognitive psychology *per se*. Given that psychology has for a long time been the dominant discipline within cognitive sciences, it should be no surprise if there are more citations of psychology journals in those disciplines than vice versa. Still, our findings align with earlier work, using different indicators such as author affiliations (Núñez et al. 2019) in that the written work published by cognitive psychologists does not bear clear signs of strong interdisciplinarity.

Some general caution is warranted with regard to our conclusions. Even though we used a very large and representative collection of journal articles, the numbers only reflect approximations. The Web of Science data do not constitute a *census* of the written work produced in Anglophone psychology since the Second World War. While the coverage of journals is strong, it does not include monographs, edited volumes, or conference publications,

which also were a factor in the publication culture. The data do, however, contain citations *to* such works, and considering that they only make up a small proportion of the total volume of published work, omitting them in our primary data probably does not skew the results significantly.

Then, in our analysis pipeline, the data had to pass through various bottlenecks. First, the author names provided in the cited references did not contain unique identifiers. Therefore, it is unavoidable that there are cases where citations of multiple authors are assigned to one author, or where a single author is represented in the citation data under multiple aliases. We mitigated this problem by using a set of heuristics for disambiguation, knowing that more sophisticated, but also technically more complex machine-learning approaches exist (e.g., Cota et al. 2010; Veloso et al. 2012). Second, the construction of co-citation networks based on WoS data necessarily relies on the first author of each cited document. This means that co-authorship is not taken into account. Still, we submit that such issues merely add random noise to the data. We see no reason to assume that citation counts for cognitive psychologists would be over- or underestimated relative to those for authors in other subdisciplines.

Furthermore, the nature of the bibliographic relationships we studied, namely co-citation relations, makes a precise dating of historical developments difficult. The co-citation networks we constructed always *look back* in time. For any given period, the clusters reflect which authors are perceived as doing work deserving of being co-cited, based on citations of work up to and including the final year of that period. The clustering algorithm is indiscriminate about how old a certain cited work is. Thus, any network may contain a certain residue of similarity based on work dating back well before that period. Although we have been deliberately non-committal about *when* certain developments took place, using rough approximators such as decades and half decades, we can be quite certain *that* these developments took place.

A major advantage of our strategy to compare a range of co-citation networks of different sizes, is that it does more justice to the multidimensional character of school labels such as 'cognitive psychology' and 'behaviorism', such that an author's work can be cognitivist in one sense but not in another. Indeed, in analyzing the co-citation networks, we occasionally encountered authors who were not robustly grouped into either cluster. An author like Estes, for example, used behaviorist and cognitivist approaches in different stages of his career and we found that he was included in a cognitivist cluster in some networks but not in others (see fn. 16). These findings suggest that our method of analysis can help historians to detect these types of 'boundary' figures. Still, we should note that there are alternative ways move beyond a strict dichotomy between 'behaviorists' and 'cognitivists' in one's analysis. We could have selected documents instead of authors as the unit of analysis (thereby separating Estes's behaviorist papers from his cognitivist papers) and we could have opted for a different clustering algorithm, working with 'fuzzy' clusters in which an author such as Estes could belong to both clusters in different degrees.[22] There are some disadvantages to these strategies (e.g., the resulting networks would have been much more difficult to interpret) but an advantage of especially the last strategy is that it could have shed light on the question to what degree the behaviorist and cognitivist clusters overlap. Considering (1) the small number of boundary figures we encountered in our analyses and the robustness of behaviorist and cognitivist cluster groupings across networks of different sizes, and (2) the robustness of behaviorist and cognitivist cluster groupings across different periods, however, we expect that the overlap between the two movements (on the author and on the document level) was minimal once the cognitivist approach had acquired solid footing by the late 1960s.

Finally, it is worth reiterating that there can be many reasons why publications are cited or co-cited. In a typical psychology paper one might cite a list of papers that provide evidence

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[22] We thank an anonymous referee for these suggestions.

for a particular hypothesis, but also include one or two that provide evidence against it; one might cite a particular method to endorse it, but also mention alternative methods to argue why they are less suitable; one might cite authors who proposed a particular theoretical framework, and juxtapose it with another theoretical position. Citation theorists have proposed various typologies of citation motives, which usually include categories like state-of-the-art, supporting, and confirmative citations, but also less favorable categories like critical, correctional, and perfunctory citations (Garfield 1962; Moravcsik & Murugesan 1975; Petrovich 2018). Overall, though, negative citations seem to be very rare. A recent study, using a very large dataset, found that only 2.4% of all citations were negative, and that only about 7.1% of papers (at least in the discipline of immunology) ever receives a negative citation (Catalini et al. 2015).

These provisions aside, we contend that the present work yields valuable insights into the developments within American psychology after the Second World War. Without imposing overly rigid or ahistorical criteria in classifying authors, the co-citation networks, along with several bibliographic indicators derived from them, show that the cognitivist approach to psychology emerged as a strictly delineated co-citation cluster in the 1960s, and that it expanded rapidly after that. While this expansion started to attenuate in the 1970s, it is at that time that the alternative framework for the study of mind and behavior, that of behaviorism, started to lose its influence in psychology. While our findings do not so much speak as to whether these developments reflect a theoretical and methodological revolution (cf. Greenwood 1999; Mandler 2002), they do show that from a sociological perspective, the 'cognitive turn' in psychology was both swift and profound.

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Web of Knowledge. 2020. Web of Science Journal Title Abbreviations. http://images.webofknowledge.com/images/help/WOS/A_abrvjt.html

Table 1

Number of Articles for Each Five-Year Period

Period	Number of Articles
1946-1950	6,915
1951-1955	9,924
1965-1960	15,669
1961-1965	24,857
1966-1970	39,030
1971-1975	45,794
1976-1980	59,937
1981-1985	63,667
1986-1990	66,705

Table 2

Properties of the 36 Generated Co-Citation Networks for the Periods 1946-1950 to 1986-1990

Period	Top-200 network				Top-800 network				Top-3,200 network				Top-12,800 network			
	Clusters	Citation threshold	Authors	Citations	Clusters	Citation threshold	Authors	Citations	Clusters	Citation threshold	Authors	Citations	Clusters	Citation threshold	Authors	Citations
1946-50	7	41	203	19,121	9	13	865	33,464	18	3	3970	49,678	90	1	15,093	63,077
1951-55	4	69	201	31,724	6	22	803	53,263	14	5	3477	77,949	96	1	19,643	102,226
1956-60	4	89	202	41,688	5	32	800	71,941	12	8	3392	109,770	37	2	12,883	140,298
1961-65	6	143	201	60,615	7	53	804	110,815	12	15	3255	175,966	26	3	14,811	241,507
1966-70	6	237	200	90,079	8	91	800	174,675	8	27	3284	290,644	17	6	13,395	406,587
1971-75	6	260	201	97,603	7	108	811	195,814	9	37	3225	339,222	12	9	12,831	499,983
1976-80	7	351	201	127,021	7	155	801	260,794	10	54	3256	469,823	11	14	13,326	728,671
1981-85	5	410	200	144,498	7	186	803	303,470	7	68	3246	559,196	10	19	12,989	888,669
1986-90	5	460	200	161,574	6	215	801	343,994	8	81	3237	646,693	11	23	13,036	1,044,239

Note. Citation threshold refers to the minimum number of citations an author required to be incorporated in the network.

Table 3

Percentage (%) of Citations to Behaviorist and Cognitivist Clusters per Period.

Period	Behaviorist clusters					Cognitivist clusters				
	Top-200	Top-800	Top-3,200	Top-12,800	Range	Top-200	Top-800	Top-3,200	Top-12,800	Range
1946-50	21	14			14-21	0	0			0
1951-55	26	31	18		18-31	0	0	0		0
1956-60	37	26	15		15-37	0	0	0		0
1961-65	38	22	20		20-38	0	18	13		13-18
1966-70	21	20	20	23	20-23	28	18	24	13	13-28
1971-75	19	21	21	25	19-25	22	26	20	16	16-26
1976-80	11	21	15	16	11-21	23	26	21	22	21-26
1981-85	7	8	10	11	7-11	29	25	21	26	21-29
1986-90	0	5	8	9	5-9	33	28	28	23	23-33

Note. For the periods up to 1961-1965, it was not possible to generate co-citation networks

with 3,200 or 12,800 authors such that every author had at least five citations. Therefore,

these networks are not interpreted.

Table 4

Most-Cited Authors and Authors With the Fastest Growing Number of Citations in the Cognitivist Clusters per Period

Rank	1961-1965		1966-1970		1971-1975		1976-1980		1981-1985		1986-1990	
	Author	Cit.	Author	Cit.	Author	Cit.	Author	Cit.	Author	Cit.	Author	Cit.
1	osgood, ce	905	underwood, bj	1327	piaget, j	1856	piaget, j	2831	winer, bj	1651	piaget, j	2465
2	underwood, bj	810	miller, ga	883	paivio, a	1020	paívio, a	1239	posner, mi	1273	wechsler, d	1734
3	piaget, j	713	postman, l	880	stevens, ss	793	tulving, e	1150	flavell, jh	1032	posner, mi	1436
4	lindquist, ef	605	thorndike, el	822	tulving, e	786	craik, fim	1028	craik, fim	1028	kahneman, d	1372
5	stevens, ss	569	cofer, cn	520	miller, ga	780	posner, mi	1016	tulving, e	942	anderson, jr	1186
6	bruner, js	497	luce, rd	516	underwood, bj	776	flavell, jh	895	paivio, a	938	winer, bj	1174
7	thorndike, el	480	woodworth, rs	500	bruner, js	740	bruner, js	869	kahneman, d	913	tulving, e	1165
8	postman, l	461	broadbent, de	486	bower, gh	728	miller, ga	864	bower, gh	885	flavell, jh	1068
9	miller, ga	459	tulving, e	470	neisser, u	661	broadbent, de	776	bruner, js	859	baddeley, ad	1063
10	woodworth, rs	423	murdock, bb	450	posner, mi	638	kimura, d	772	anderson, jr	852	sternberg, rj	957
		Cit. Incr.		Cit. Incr.		Cit. Incr.		Cit. Incr.		Cit. Incr.		Cit. Incr.
↑1	murdock, bb	477%	brown, r	598%	sternberg, s	320%	kinsbourne, m	418%	rosch, e	222%	mcclelland, jl	272%
↑2	jenkins, jj	419%	chomsky, n	451%	paivio,	261%	bransford, jd	363%	mandler, jm	206%	treisman, am	256%
↑3	archer, ej	365%	palermo, ds	438%	rohwer, wd	243%	craik, fim	357%	loftus, ef	202%	fodor, ja	243%

Table 5

Median Age of the Most-Cited Authors per Period.

Period	Behaviorism (n = 25)	Cognitive Psychology (n =25)	Other (n = 40)
1946-1950	44.5		52.0
1951-1955	48.5		55.5
1956-1960	49.5		57.5
1961-1965	46.5	47.0	53.5
1966-1970	51.5	43.4	51.5
1971-1975	54.5	47.5	53.5
1976-1980	52.0	50.5	56.5
1981-1985	52.5	53.5	60.5
1986-1990	53.5	57.5	56.5

Table 6

Most-Cited Journals in Behaviorist and Cognitivist Clusters per Period

Period	Rank	Behaviorism		Cognitive Psychology	
		Journal	Citations	Journal	Citations
1961-65	1	J Comp Physiol Psych	1398	J Exp Psychol	1565
	2	J Exp Psychol	1355	Psychol Rev	621
	3	Psychol Rev	522	Am J Psychol	602
	4	J Exp Anal Behav	328	J Psychol	277
	5	Science	315	Psychol Bull	201
1966-70	1	J Comp Physiol Psych	1273	J Exp Psychol	1678
	2	J Exp Psychol	883	J Verb Learn Verb Be	927
	3	J Exp Anal Behav	556	Psychol Rev	595
	4	Science	457	Am J Psychol	345
	5	Psychol Rev	335	Q J Exp Psychol	296
1971-75	1	J Comp Physiol Psych	1324	J Exp Psychol	1435
	2	J Exp Psychol	542	J Verb Learn Verb Be	820
	3	J Exp Anal Behav	541	Percept Psychophys	586
	4	Psychon Sci	440	Psychol Rev	477
	5	Science	428	Am J Psychol	308
1976-80	1	J Comp Physiol Psych	970	J Exp Psychol	1017
	2	J Exp Anal Behav	493	Percept Psychophys	724
	3	Science	352	J Verb Learn Verb Be	637
	4	Physiol Behav	318	Psychol Rev	588
	5	Psychol Rev	318	Cognitive Psychol	318
1981-85	1	J Exp Anal Behav	745	Psychol Rev	910
	2	J Comp Physiol Psych	274	Percept Psychophys	821
	3	Psychol Rev	239	J Exp Psychol	648
	4	J Exp Psychol Anim B	229	J Verb Learn Verb Be	575
	5	Anim Learn Behav	212	J Exp Psychol Human	511
1986-90	1	J Exp Anal Behav	420	Psychol Rev	1093
	2	J Exp Psychol Anim B	277	Percept Psychophys	819
	3	J Comp Physiol Psych	213	J Verb Learn Verb Be	751
	4	Psychol Rev	212	J Exp Psychol Learn	659
	5	Anim Learn Behav	186	J Exp Psychol Human	623

Table 7

Lower and Upper Bound Estimates of Mean Number of Citations per Paper and Percentage

of Citations to Non-Psychology Journals per Period.

Period	Citations per Paper		Interdisciplinary Citations	
	Behaviorism	Cognitive Psychology	Behaviorism	Cognitive Psychology
1946-1950	12		5%	
1951-1955	11-12		4-5%	
1956-1960	12-13		5-8%	
1961-1965	12-13	13	8-11%	5-9%
1966-1970	16-19	15-17	13-15%	5-9%
1971-1975	19	17-18	15-19%	7-9%
1976-1980	21-22	21-22	17-20%	8-9%
1981-1985	22-23	26-27	11-18%	8-9%
1986-1990	28-29	30-31	15-19%	8-10%

Note. For the periods up to 1956-1960, no clearly delineated cognitive psychology clusters

could be identified.

Figure 1

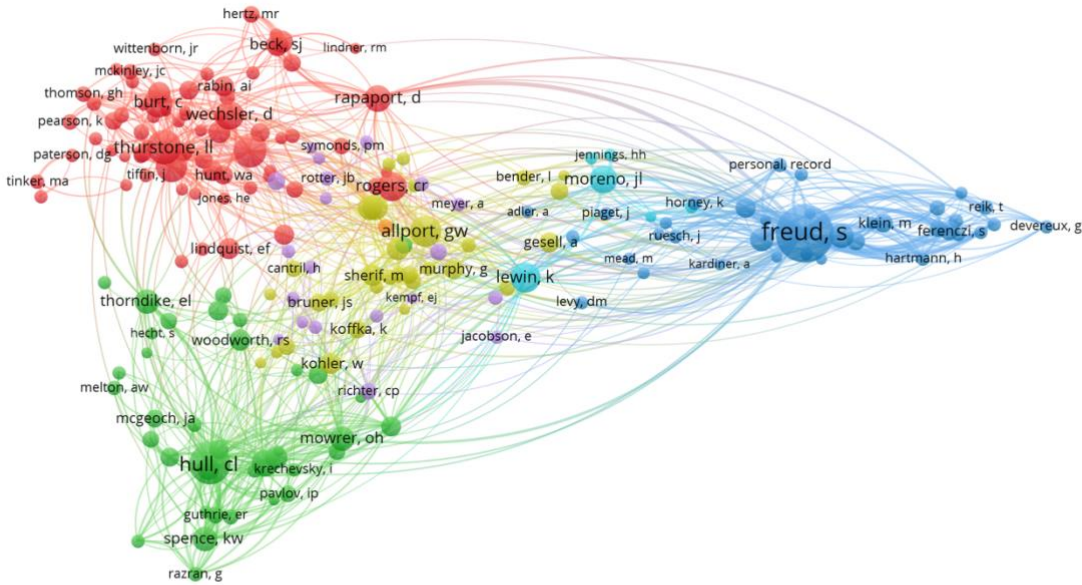*Co-Citation Network of the 203 Most-Cited Authors From the Period 1946-50*

Figure 2

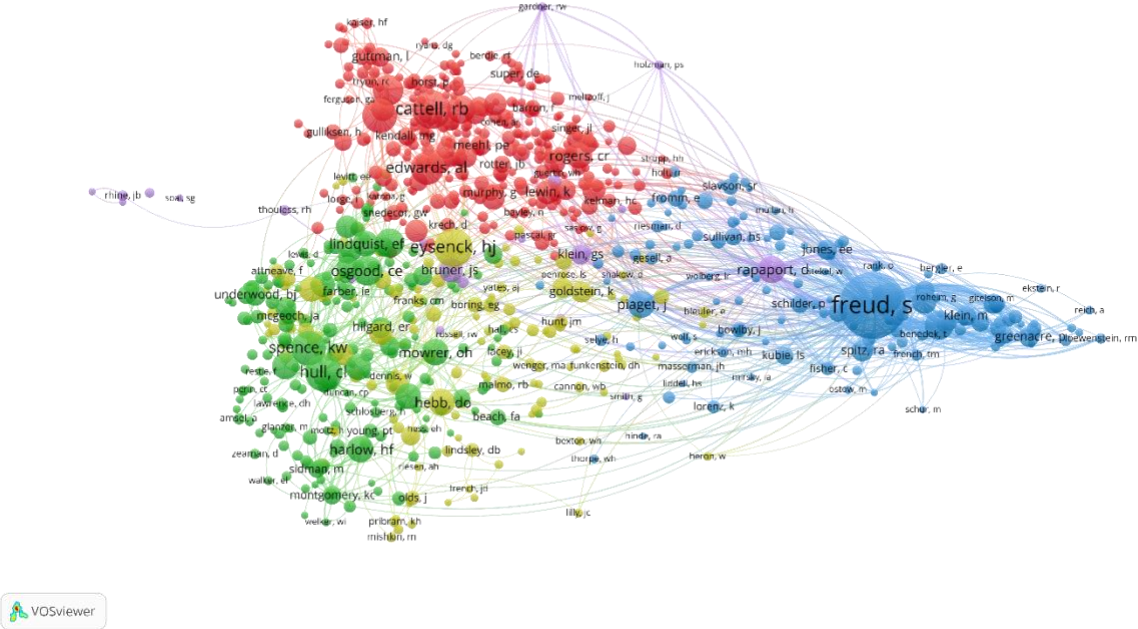*Co-Citation Network of the 800 Most-Cited Authors From the Period 1956-60*

Figure 3

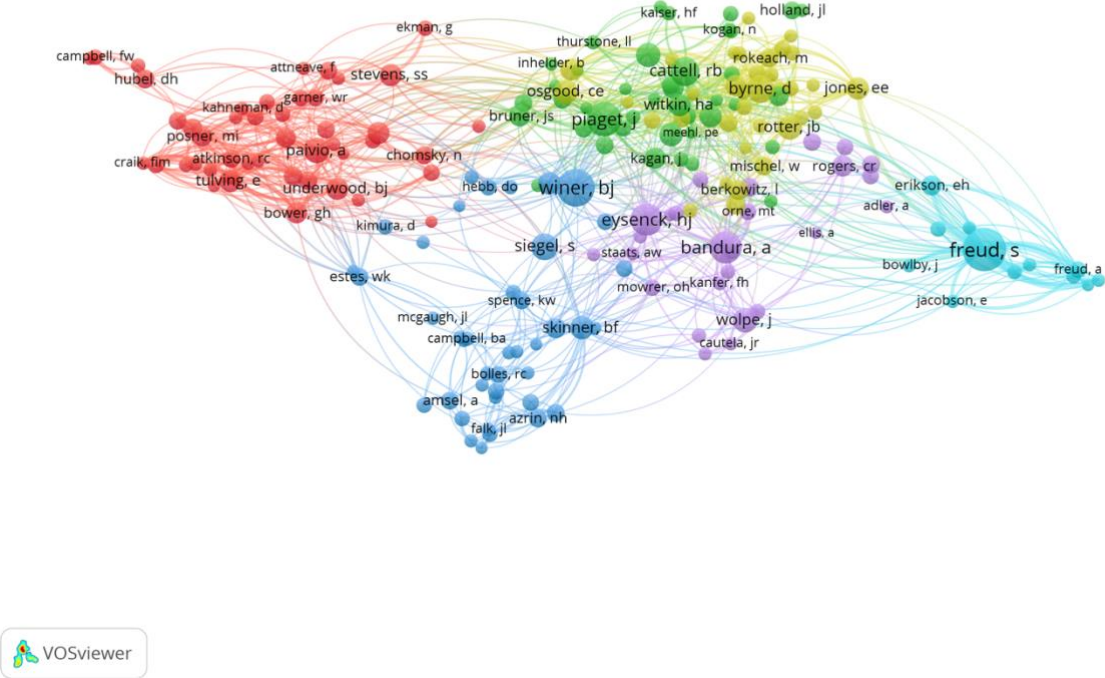*Co-Citation Network of the 201 Most-Cited Authors From the Period 1971-75*

Figure 4

Co-Citation Network of the 801 Most-Cited Authors From the Period 1986-90