Mapping the Themes, Impact, and Cohesion of Creativity Research over the Last 25 Years

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This article describes the themes found in the past 25 years of creativity research. Computational methods and network analysis were used to map keyword theme development across ~1,400 documents and ~5,000 unique keywords from 1990 (the first year keywords are available in Web of Science) to 2015. Data were retrieved from Web of Science using the search string: “creative process” OR “creative personality” OR “creative product” OR “creative place” OR “creativity research” OR “creative style” OR “creative potential” OR “creative problem.” The largest three keyword themes (36% of all documents) reflect three dominant foci of creativity research in the past 25 years: (a) innovation in the workplace, (b) the role of personality and intelligence in divergent thinking, and (c) creative performance with a focus in idea generation. Articles with the highest citation rates tended to be those with more unique keyword signatures; having a very common keyword signature was more consistently associated with low impact. Peak citation trends for each keyword theme suggests the following development: Foundational research on creativity in education and collaborative problem solving peaked in the early 1990's. This was followed by high impact work in 1995–2000 on the creative process and creative performance—particularly idea generation and brainstorming. 2001–2010 saw the rise of highly cited research on innovation in the workplace, and this was followed by more recent high impact work on the role of personality and intelligence in divergent thinking. This broad trend from descriptive to more applied and then more predictive research themes may be characteristic of any emerging research field maturing over time.

The benefits of creativity are now widely recognized. Turn on the TV and you will see a wide range of advertisers bragging that their companies, products, or services are valuable precisely because they are creative and innovative. Nissan, Microsoft, Adidas, Bravo TV, and even Absolut Vodka are just a few of innumerable examples. Apparently good advertising is both

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creative and conveys the idea that the company being advertised is, itself, creative. At least as obvious are the benefits of creativity for education, business, science, technology, the arts, and even health. No wonder the research on creativity is growing faster than ever before.

Various content and trend analyses have been done over the years to examine progress and to identify trends in the creativity research. Feist and Runco (1993) presented one such analysis after coding 27 years of articles published in the Journal of Creative Behavior. They reported a rise in the research on the following topics: enhancement, education, problem solving/ incubation, influences on creativity, and personality characteristics associated with creativity. Other topics showed a downward trend, with less and less research. These were emotion, freewill, intuition, humor, and brainstorming. Feist and Runco also found an increase in the number of articles devoted to educational and social issues, as well as increased in the number of authors per article and the number of references. Most common method involved a test, then a multimethod approach. In the words of Feist and Runco (1993), “Laboratory and meta-analytic methods were practically non-existent” (p. 277).Significantly, Feist and Runco depended on judges to code the contents of the articles. Interjude reliability was acceptable, though there was quite a range. Agreement on the structural characteristics was over .90, but agreement on topics just above .60, and agreement on some of the methodologies even lower.

Beghetto, Plucker, and McKinster (2001) examined authorship patterns in 32 volumes of the same journal. Beghetto et al. suggested that looking specifically at authorship patterns is useful for understanding where (e.g., which universities) the most research is being done, and by whom, as well as how many articles are coauthored or published by single authors. Beghetto et al. found an increase of first-time authors and a decrease in articles published by the previously-prolific contributors to the Journal of Creative Behavior. Root-Bernstein and Pawelec (2016) recently published another article that addressed the question of where good research is being done.

Wehner, Csikszentmihalyi, and Magyari-Beck (1991) reported a content analysis using only doctoral dissertations. They were particularly concerned about which disciplines were being used to study creativity and what they felt was a confusion among key terms. As they put it,

The phenomena encompassed by the word creativity span many disciplines and several levels of analysis. An art historian describing Leonardo da Vinci’s working methods, a sociologist reflecting on why Paris became such a magnet for talent in the 19th century, an organizational psychologist testing different group processes affecting entrepreneurship, and an educator studying children’s drawings may all contribute to our understanding of creativity. This holds true despite the fact that they are likely to use different terms for the phenomena they are focusing on—words such as creativity, innovation, entrepreneurship, or artistic and scientific development. (p. 261)

Their analyses indicated that no dissertations focused on creativity were being completed within the biological sciences, chemistry, mathematics, statistics, physics, the earth sciences, nor engineering. Dissertations were being completed in psychology, health, education, business, history and the history of science, sociology, literature, and political science.

Wehner et al. (1991) also reported that most dissertations focused on the creative process and on creative individuals. Traits were not often studied (only 20% of the dissertations) and products were similarly rare (11%). Very importantly, “in 92% of cases, researchers did not recognize any relationship among the search terms. Only 8 records of the 100 had more than one of the terms in the title, keywords, and abstract” (p. 269). Wehner et al. employed judges to code their data, with 88% agreement between judges.

Kahl, Hermes da Fonseca, and Witte (2009) also focused on keywords in dissertations. As they described their method,

Abstracts were coded by discipline, research aspect (trait, process, or product), social level of analysis (individual, group, organization, or culture), and research approach (empirical vs. theoretical; quantitative vs. qualitative). Classification trees were built to explore the relationships between disciplines and their terminology, research aspect and social level of analysis. (p. 1)

Significantly, Kahl et al. found that the words ‘innovation’ and creativity tended to be used interchangeably, at least in some fields. This is contrary to what is done in the creativity research, where innovation is viewed as dependent on but more complicated that creativity (e.g., Runco, 2014). Kahl et al. also reported that most dissertations on creativity were done in psychology (25%), education (24%), business administration and economics (29%), social sciences (29%), and engineering and the sciences (18%). There was a miscellaneous category as well, with the arts, communication, literature, philosophy, and theology and religion (21%). Also interesting was that research on individuals (45%) was more common than research on groups (17%), but that difference disappeared when organizations (23%) and culture (7%) were added. Indeed, that implies a near balance between individual and social research efforts. Eight percent did not fall into any of those categories.) Kahl et al. reported good agreement among the raters coding the abstracts, with kappa coefficients of .92, .61, .77, and .67.

Long, Plucker, Yuc, Ying, and Kaufman (2014) examined 1891 articles published in the four leading creativity research journals between 1965 and 2012. This included the Journal of Creative Behavior (JCB), Gifted Child Quarterly, Creativity Research Journal (CRJ), and Psychology of Aesthetics, Creativity, and the Arts. Long et al. reported that these articles had been cited 11,709 times and that the impact factor of the four journals had more than doubled in the period of time studied. The JCB had published the most
articles and the CRJ had been cited the most. As you might expect given Lotka’s Law (Runco, 2014; Simonton, 1984), approximately 30% of the articles had never been cited.

Computational Analysis of Keyword Cooccurrences

Each of the investigations just reviewed offered interesting data, but there are new methodologies that use computational text analysis to eliminate much of the subjectivity of ratings and categorizations. This new method was demonstrated by Zhang, Zhang, Yu, and Zhao (2014). They used K-core and multidimensional scaling analysis of a network computed using a coword analysis of 163 keywords in 4,575 articles in the Web of Science Database. Importantly, Zhang et al. found 13,931 keywords but chose those which had been used 26 time or more in the articles. The most common keyword, not surprisingly, was creativity (1,696 occurrences), followed by performance (510), innovation (430), model (349), personality (272), organization (226), behavior (213), work (205), knowledge (177), and divergent thinking (172). Other notables included intelligence, which was 11th (161 occurrences), brainstorming (12th, with 146), management (14th, 143), education (18th, 118), motivation (23rd, 95), technology (27th, 87), art (35th, 77), economy (124th, 32), and style (163rd, 25). Zhang et al. inferred five main topics: creativity applications, pathology & physiology of creativity, individual creativity, organizational creativity, and theories and methodology. They also inferred that very little attention was being devoted to the creative process.

The work of Zhang et al. (2015) shows how the analysis of cooccurrences can help to identify common themes and topics. Zhang et al. (2015) also suggested that their method can point to “research hotspots” and “display the research structure” of a field and “let us clearly understand the specific distribution of research paradigms, thus contributing to better discover other topics we need to study” (1029). Their report was quite informative, and a thought provoking beginning.

This investigation, based on a more recent set of documents, took a different approach to the analysis of keywords in documents. Instead of linking a small set of the most frequent keywords based on their cooccurrence, as in Zhang et al. (2015), here documents were linked if they shared similar sets of keywords. The resulting network is then a network of documents rather than keywords, and highly interconnected clusters of documents in this network show groups of documents about similar themes. Our methodology allowed us to retain all keywords in the analysis, rather than limiting our analysis to a set of common terms, and allows us to identify particular documents that are central to themes or documents that connect between themes. Connections between documents are of special interest because new ideas are in fact often integrations of previously existing ideas (Dietrich, 2015; Runco, 2016).

METHOD

Document Retrieval

Data were retrieved from Web of Science using the search string: “creative process” OR “creative personality” OR “creative product” OR “creative place” OR “creativity research” OR “creative style” OR “creative potential” OR “creative problem.” Hereafter we refer to this suite of terms as creativity research. Document types were restricted to article, review, proceedings paper; dates were restricted to January 1, 1990 to December 31, 2015. Documents that had at least two unique keywords in author keywords and/or keywords plus were retained. The search resulted in 1,472 documents and 5,051 unique Keywords.

Document Similarity Computation

Each document was assigned a feature vector where each dimension in the vector was a keyword as defined above. Similarity between all pairs of documents, a matrix where each element $s_{ij}$ is the similarity between the feature vectors $f_i$ and $f_j$ of documents $i$ and $j$, is computed using cosine similarity $\sum p_{ij} p_{ji}$. Each node’s similarity to another node arises because of shared keywords, the nonzero terms in the dot product $f_i \cdot f_j$ where $f_i$ is the feature vector of document $i$. This means that each similarity value has associated with it a set of keywords that contribute to the document pair’s overall similarity. Two common keywords (creative, creativity) were blacklisted from the similarity computation because there ubiquity meant that they had little information value. Model was problematic as a keyword because it was quite common and also used in a variety of contexts ranging from statistical model to a person who is a model in an advertisement. It was also blacklisted (and thus excluded from analyses).

Similarity Matrix Thresholding

Each document had to be connected to at least one other document, so the similarity matrix has a global threshold equal to the minimum maximum similarity of each document, $s_{ij} = 0$ if $s_{ij} < s_{\text{minmax}}$. The intent was a sparse network, and thus it was optimal to have each document connected on average to six other documents and the target total number of links $L_{\text{target}} = 3 N$, where $N$ is the number of documents (each link has two ends and a document cannot be linked to itself, so connections per document is approximately twice the number of links). This resulted in a network with $L_{\text{init}} > 3 N$, so a second thresholding step was used to approximately preserve the distribution of the number of links per document found in the overly dense initial network. $L_{\text{target}} = k L_{\text{init}}$, $k < 1$ was the fraction of links to keep. That fraction of links was kept for each node, so $L_{\text{target}} = \text{int} (k L_{\text{init}})$ where $L_i$ is the degree of node $i$, rounded to the nearest integer, but always keeping one link, even when $k L_i < 0.5$. The...
highest similarity links were kept, and if there were multiple links with the same similarity leading to more links than the target number, they were selected at random. The final result was a sparse network with $L \approx 3N$. Documents which shared no keywords with any other document, and thus no links, were excluded from the analysis, leaving a network of 1,355 documents with at least one neighbor.

Network Analysis

Clusters of related nodes were found using the Louvain community detection method (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). This algorithm produces a hierarchical clustering, and we used the coarsest clustering level. Several properties were computed to characterize each node’s role within its assigned cluster:

\[ \text{fracIntracluster} = \frac{\text{(# of links connected to node } i \text{ that connect to nodes in the same cluster) }}{\text{(total # of links connected to node } i \text{)}}. \]

\[ \text{diversity} = \frac{p_i}{lnp_i}, \text{where } p_i = \text{fraction of links of node } i \text{ that connect to nodes in cluster } j, j \text{ ranged over all clusters with one or more links connecting to node } i. \] Higher diversity nodes were connected to a larger number of clusters and their links were more evenly distributed across those clusters.

These two properties were used to define two metrics that we report: the extent to which a node was an archetype, or canonical representative of the cluster, and the extent to which a node strongly connected the cluster to other clusters.

\[ \text{ archetype} = \# \text{ of intragroup links connected to node } i/(1 + \text{ diversity}), \text{ normalized across each cluster. This finds nodes that were highly connected and have most of their connections to nodes in the same cluster.} \]

\[ \text{bridging} = \text{diversity} \times \text{ total # of links connected to node } i, \text{ normalized across each cluster. This finds nodes that were both highly connected and have high diversity, and so were important connectors between clusters.} \]

Network Layout

The network layout used a force-directed layout (Fruchterman & Reingold, 1991) modified to bring nodes assigned to the same cluster closer together by decreasing the repulsion between nodes that were in the same cluster.

Cluster Labels

Each cluster was named by finding the most important keywords within the cluster, where importance is defined as the sum of keyword weights across all intracluster links divided by the global keyword frequency. This served to emphasize keywords that are common in the cluster but downweight globally common keywords. The label was the three most important keywords in order of decreasing importance.

Network generation, analysis and visualization was performed with software developed by Vibrant Data Inc.

RESULTS

Over 1,350 peer-reviewed articles in the creativity research suite were published between 1990 and 2015, in 665 journals. The top 5 most common keywords across all documents were: performance, innovation, personality, divergent thinking, and creative process. The patterns of keywords cooccurrence defined 10 emergent keyword themes that contained at least 60 documents (Figure 1). Six more keyword theme clusters had at least 10 documents; the remaining clusters had only 2–6 documents and were too small to reliably interpret (Table 1). The focus of the subsequent analysis is on the top 10 keyword themes, which represent over 77% of the documents.

Table 1 lists the most important keywords in all keyword themes that contained at least 10 documents. The largest three keyword themes, which together comprise 36% of all documents, reflect three dominant foci of creativity research in the past 25 years (Figure 1, Table 1): (a) innovation in the workplace (b) the roles of personality and intelligence on divergent thinking, and (c) creative performance with a focus in idea generation (as opposed to other aspects of the creative process). The latter theme is adjacent to the first due to many cross-cluster links via documents that had overlapping keywords (e.g., employee creativity was common in documents about both innovation as well as creative performance). Other distinct keyword themes that contained at least 60 documents included: creativity in education (students, education); the creative process; problem solving (problem solving, insight, creative thinking), creativity and design (design), group creativity (collaboration, creative problem solving, perception), and the role of mood and memory in creativity (memory, positive affect, mood). One unexpected emergent keyword theme with at least 60 documents (communication, evolution, adaptation) included studies that mentioned creativity in the context of evolution and natural selection.

To evaluate trends in keyword cooccurrence themes over time, we summarized for each 5-year interval the proportion of all documents published and the proportion of total citations in each of the top 10 largest keyword themes (Figure 2a and b, respectively). In general, across all keyword themes, there was much more variability over time in proportional allocation of impact (i.e., total citations) than in number of publications (Figure 2a vs b). Of the top three largest themes overall, the innovation, work, organizations and personality, intelligence, and divergent thinking keyword themes have consistently been among the largest fraction of total papers published in each time period; performance, idea generation, and brainstorming

| Table 1 | Most Frequent Keywords in All Themes | |
|---------|-------------------------------------|--|
FIGURE 1  (a) Keyword Themes in 25 years of Creativity Research. Every node is a peer-reviewed publication. They are linked if they share Web of Science keywords. Colored clusters define emergent “Keyword Themes” based on distinct groups of documents that are most similar to one another. The labels for each Keyword Theme cluster are the top shared keywords that determine the links among documents within the group. Nodes are sized by log (Total Citations) as of January 2016 (the date the search was conducted). (b) Zoom in to the “Creative Process” Keyword Theme showing the most cited papers (larger nodes and labels). (c) Example of a document in the “Creative Process” cluster whose links bridge multiple clusters (“Innovation, Work, Organizations,” “Children,” and “Personality, Intelligence, Divergent Thinking”) via overlapping keywords. It was placed in the “Creative Process” cluster. This cross linking creates relationships among Keyword Themes. This network visualization was created with VibrantData.io, and is a static snapshot of the full interactive literature map available online at http://bit.ly/2adOAah.
TABLE 1

All emergent Keyword Themes that contained greater than 10 documents sorted by total document count. Keywords are listed in order of importance measured as (within-group frequency)/ (global frequency), where ‘frequency’ is the proportion of documents which have a given keyword. Only keywords that were present in at least 3 documents in the group are included.

| Keyword Theme                                      | Total Documents | Median Year Published | Citations/Paper | Top 15 Keywords                                                                 |
|----------------------------------------------------|-----------------|-----------------------|-----------------|--------------------------------------------------------------------------------|
| innovation, work, organizations                    | 178             | 2011                  | 17              | innovation, work, management, organizations, perspective, performance, leadership, employee creativity, teams, work-environment, support, transformational leadership, contextual factors, product development, individual creativity |
| personality, intelligence, divergent thinking      | 173             | 2010                  | 15              | personality, intelligence, divergent thinking, validity, reliability, 5-factor, tests, artists, latent inhibition, scale, implicit theories, achievement, torque tests, young-children, openness |
| performance, idea generation, brainstorming groups | 133             | 2012                  | 19              | performance, self-efficacy, productivity loss, idea generation, brainstorming groups, employee creativity, thought, job-satisfaction, leader-member exchange, social innovation, goal orientation, individual creativity, psychological empowerment, strategies, activation |
| students, education                                | 98              | 2009                  | 15              | students, education, school, community, representation, teachers, artistic creation, program, teaching, curriculum, creativity research, teaching/learning strategies, teaching, curriculum, design process |
| creative process                                   | 96              | 2011                  | 12              | creative process, anterior cingulate cortex, working-memory, dance, gesture, labor, modulation, chaos theory, prefrontal cortex, art, EEG, poetry, FMRI, body, metaphor |
| problem solving, insight, creative thinking        | 83              | 2011                  | 10              | problem solving, insight, critique, creative thinking, youth, adolescence, stimulus-independent thought, hierarchy, task, depression, alcohol, identity, working-memory capacity, dreams, incubation |
| design                                             | 77              | 2010                  | 9               | design, chance discovery, drawing, human-computer interaction, methodology, outcomes, craft, leaning, examples, creative product, constraints, teaching |
| communication, evolution, adaptation               | 76              | 2010                  | 4               | evolution, communication, creation, adaptation, dementia, computational creativity, process, craft, brain, chaos, interaction, psychoanalysis, system, planning, agencies, frontotemporal dementia |
| collaboration, creative problem solving, perception | 72              | 2011                  | 6               | collaboration, war, play, creative economy, ethics, resilience, evaluation, emergence, school-children, stress, creative industries, perception, growth, engineering design, creative problem solving |
| memory, positive affect, mood                      | 66              | 2010                  | 24              | memory, mood, information, positive affect, selective retention, implicit, blind variation, music, systems, hedonic tone, intrinsic motivation, flow, autonomy, experience, similarity |
| art, self, emotions                                | 58              | 2011                  | 7               | emotions, self, art, user involvement, patterns, regeneration, dimensions, literature, pedagogy |
| creative potential, knowledge, aesthetics          | 54              | 2009                  | 6               | creative potential, aesthetics, knowledge, transference, context, genius, media, fixation |
| schizophrenia, behavior, schizotypy                | 49              | 2010                  | 12              | schizophrenia, schizotypy, creative writing, experiences, behavior, o-life, magical ideation, illness, future, risk, writers |
| science                                            | 44              | 2011                  | 6               | science, constructivism, history, discourse, love, philosophy, transformation, space, gender, styles |
| children                                           | 38              | 2008                  | 20              | children, brain plasticity, prevention, classroom |
| imagination, entrepreneurship, mediation           | 18              | 2010                  | 15              | imagination, mediation, entrepreneurship |
only emerged as a dominant theme in 1995–2000 (Figure 2a), when it also produced its highest impact papers (Figure 2b). Some keyword themes, like memory, positive affect, and mood and students, education have declined in size over time, but others like creative process and collaboration, creative problem solving, perception were large in the early 1990s, declined, and then had a resurgence of publication volume in 2011–2015 (Figure 2a).

Collaboration, creative problem solving, perception and student, education publications from 1990 to 1995 had unusually high impact, especially relative to the number of papers published in each keyword theme (Figure 2a vs b). The creative process theme had its highest cited papers in 1996–2000 and since then has tended to have both low volume and low impact (Figure 2a and b). The innovation, work, and organizations theme had disproportionately high impact in 2001–2005 and otherwise tended to have fewer
total citations than expected based on the volume of papers published. Total citations for the performance, idea generation, and brainstorming keyword theme peaked in 1995–2000, also a high volume time period, and then produced fewer disproportionately high impact publications in the next time interval (2001–2005). Peak citation trends for each keyword theme (Figure 2b) suggests the following conceptual development: Foundational research on creativity in education and collaborative problem solving peaked in the early 1990s. This was followed by high impact work in 1995–2000 on the creative process and creative performance—particularly idea generation and brainstorming. 2001–2010 saw the rise of highly cited research on innovation in the workplace, and this was followed by more recent high impact work on the role of personality and intelligence in divergent thinking.

The keyword themes are derived from clusters of documents that tend to be more linked to one another than to documents in other clusters. Although some documents are a good fit to one keyword theme (i.e., all their links are to documents within the same cluster), many documents have cross links to documents in other clusters via overlapping keyword usage (Figure 1c). Thus, for a given keyword theme cluster, the average fraction links each document has to documents in different clusters is a measure of the degree to which that keyword theme is cohesive. Figure 3 shows cohesiveness across the top 10 keyword themes within each time period. In the early 1990s the keyword themes were highly variable—some like innovation, work, organizations and problem solving, insight, and creative thinking were extremely cohesive, but others like collaboration, creative problem solving, and perception and performance, idea generation, and group brainstorming were very loose (i.e., high average fraction intercluster links). By 2011–2015, there was more homogeneity in cluster cohesiveness across keyword themes with most consistently having an average of 25% inter-cluster links per document. Some documents had up to 100 links to other documents that had similar keywords; others had more unique keyword patterns that resulted in links to fewer than 10 other documents. The more unique a document’s keywords, the greater the maximum citation rate (Figure 4). Documents with very common keyword signatures (i.e., many links to similar documents) tended to have low citation rates, and the documents with the highest citation rates tended to be those with more unique keyword signatures (i.e., few links to other documents). Having a unique keyword signature does not guarantee high impact (i.e., there are many poorly cited
papers with few links), but having a very common keyword signature is more consistently associated with low impact. A notable exception was Mumford’s (2003) review, which was tagged performance, innovation, personality, and work.

CONCLUSIONS, LIMITATIONS, AND FUTURE DIRECTIONS

The entire interactive literature map is available online at http://bit.ly/2adOAh. It can be used by anyone to explore the trends presented here in more detail, to discover new trends, or to test hypotheses. The literature often contains statements about trends in the field (e.g., “this is rarely investigated,” “this is studied more than that”) and many of these can be tested empirically with this interactive literature map.

A critical point is that the keyword themes discussed in the results arose from author-provided and Web of Science keywords, not from separate natural language processing of the text of the documents. Thus, the keyword themes reflect trends in bundles of keywords that tend to go together, but not necessarily trends in research results or specific research topics within the main document text. A second limitation of the results is that a relatively small number of search targets was used in this investigation. They were chosen a priori. There are other possibilities; for example, analysis of this map might suggest more refined search criteria.

The methods used here differ from those used in earlier trend analyses and reviews. Recall here that the method used here built a map where the nodes were not just keywords but documents, linked because of a shared keyword signature. This allowed us to leverage every keyword that was used more than once in the entire set of documents found by searching the creativity research suite. As expected, this approach provided a unique view of all publications in keyword-space and allowed us to identify various trends and emerging themes of keyword usage. Periods of research cohesiveness were also identified. The findings about citation impact (Table 1) were also interesting, and potentially very practical.

Thus the method used here has proven its usefulness. It could be used in a number of alternative ways in future, even exploring the various tendencies and capacities Runco (2014, chap. 11) listed in his chapter, “Creativity: What it is and what it is not.” Simonton (2016) also took this tack when he asked, “Don’t we also need to define what is not creative?” Future research could use different suites of search terms, perhaps with some of the specific concepts suggested by the earlier reviews of the creativity literature. The methods used here could also be applied to analyze the literature of other research areas.

Creativity research is a relatively young field. The Creativity Research Journal was launched in 1988, only 2 years before the earliest publications in our sample. Thus, our analysis spans a large portion of the creativity research explosion. The general trends in in keyword theme development we observed may be characteristic of any emerging research area. In particular, the earliest themes tended to be descriptive in nature (e.g., creative process, creative thinking, education). These were followed by more applied themes (e.g., performance, innovation), and then followed by themes focused on prediction and causal mechanisms (e.g., personality, intelligence, divergent thinking).
Similarly, the trend of decreasing variability in keyword theme cohesiveness may be characteristic of any research field maturing over time. If so, identifying new keyword themes that are unusually tight or diffuse may predict new sub-disciplines over time. Similar analyses of other emerging research areas would help test whether these patterns are universal.

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