A Bibliometric Analysis on Cognitive Processing of Figurative Language

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Abstract: Figurative language is ubiquity in daily communication; however, the cognitive processing of figurative language is a neglected area. Hence, this paper aims to investigate the growth of studies on figurative language processing. Co-citation and co-occurring terms are analyzed by using CiteSpace software. Through visualizing the references obtained from web of science (WoS) core collection of Thomson Reuters, the main research patterns and the hot topics were identified. The research pattern includes exploring correlates of metaphor processing and the role of right hemisphere and the comparison between conventional metaphors and novel metaphors. The hot themes are: the role of the left and right hemispheres in metaphor processing and brain laterality; bilingual figurative language processing; the difference of processing different type of metaphors such as anaphoric metaphor and metaphor related to emotion; the relationship between processing figurative language and autism. The present study offers a new approach to visualizing relevant data to synthesize scientific research findings on figurative language processing. Suggestions for future work are provided.

Keywords: Figurative language; Bibliometric analysis; Cognitive processing

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1. Introduction

Figurative language is ubiquity in daily communication. The relationship between figurative language and cognition has been the spotlight of recent studies. As a special type of language possessing, the cognition process of figurative language in native language and foreign language has gained many interests. The study of figurative language processing is of great significance.

Researchers have mainly investigated the processing of figurative language from four perspectives. Firstly, researchers have great interest in the role of the left and right hemispheres in metaphor processing and brain laterality. The top five cited articles are all interested in the role of the left and right hemispheres in metaphor processing. Among them, some studies have found a special role of the right hemisphere in metaphor comprehension, others show no difference of these two hemispheres in processing metaphor. Based on studies mentioned above, we can see that the metaphor type and language complexity have crucial influence on this dispute. Further studies need to be done in this topic. Secondly, researchers study how bilingual figurative language processing. The third perspective is to probe into the difference of processing different type of metaphors such as anaphoric metaphor and metaphor related to emotion. The fourth perspective is to delve into the relationship between processing figurative language and autism. The research patterns and hotspots in figurative language processing are revealed to gain a more complete picture of emotional word processing in the framework of psychology, linguistics and neuroscience.

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2. Method

(1) Data collection

The bibliometric articles were collected from Advanced Search in the WoS Core Collection, incorporating Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (A and HCI), Conference Proceedings Citation Index-Science (CPCI-S), as well as Emerging Sources Citation Index (CCR-EXPANDED). All articles were written in English. The data set was collected through the following strategies: Topic = ('figurative* language' AND process*), which means that articles with those words in title or abstract, or keywords will be retrieved. Time span 1990–2019. 286 papers in total were obtained from 153 journals distributed in 39 WoS categories such as "psychology", "neurosciences neurology", "linguistics", "behavioral sciences", "audiology speech language pathology", and "education educational research". The present study attempted to focus on figurative language processing in the fields of linguistics, psychology, and neurosciences. Therefore, only 236 articles were analyzed, which were collected from WoS categories of "psychology", "neurosciences neurology", "linguistics", "behavioral sciences", "audiology speech language pathology" and "education educational research".

(2) Instrument

CiteSpace is a freely available Java application for visualizing and analyzing trends and patterns in scientific literature. It is designed as a tool for progressive knowledge domain visualization (Chen, 2004). It focuses on finding critical points in the development of a field or a domain, especially intellectual turning points and pivotal points. CiteSpace provides various functions to identify the fast-growth topical areas, find citation hotspots in the land of publications, decompoe a network into clusters, automatic label clusters with terms from citing articles, geospatial patterns of collaboration, and unique areas of international collaboration. In this study, co-citation documents and cooccurring terms analysis were administered to find critical references, identify the research patterns and detect the research hotspots in the knowledge domain of figurative language processing.

3. Results

(1) Publication Years and Journals

No articles related to figurative language processing were published until 1994. From 1994 to 2006, no more than 10 papers appeared every year. However, since 2007, more papers appeared every year which climax to 24 papers a year in 2016. Annual research outputs are illustrated in Fig.1. The findings demonstrate a continued growth of publications on figurative language processing.

These articles on figurative language processing were carried in 249 journals, which meant that the study on figurative language processing is favored and interested by many different journals and scientific fields. *Frontiers in Psychology* (48), followed by *Brain and Language* (40) and *Metaphor and Symbol* (32). Table 1 presents the top ten most fruitful journals.

Table 1 The top ten most fruitful journals

NUMBER	THE NAME OF JOURNALS	THE NUMBER OF PUBLISHED PAPERS
1	Brain and Language	17
2	Neuropsychologia	17
3	Frontiers in Psychology	14
4	Journal of Neuroscience	13
5	Frontiers in Human Neuroscience	9

6	Journal of Experimental Psychology: Learning, Memory, and Cognition	9
7	Neuroimage	9
8	Journal of Cognitive Neuroscience	6
9	Behavior Research Methods	5
10	Brain Research	4

(2) Document Co-Citation analysis

The 236 bibliographic recordings from 1994 to 2019 were visualized and a three-year time slice was selected for analysis. The results are illustrated in Fig. 2. Table 2 presents the top five most cited articles in the field of figurative language.

The most cited article is an empirical study published by Mashal *et al.* (2007). In this article, researchers aimed to explore brain correlates of metaphor processing and the role of the right hemisphere (RH) in processing the non-salient meanings of novel metaphors which in turn can have some implications for RH involvement in verbal creativity. In this study, 15 participants read four types of linguistic expression (literal expressions, familiar metaphorical expressions, novel metaphorical expressions taken from poetry and unrelated word pairs) and decided which relation exists between the two words (metaphoric, literal, or unrelated). The comparison of the novel metaphors and the conventional metaphors revealed significantly stronger activity in right posterior superior temporal sulcus (PSTS), right inferior frontal gyrus, and left middle frontal gyrus. These results support the Graded Salience Hypothesis and suggest a special role for the RH in processing novel metaphors. And the right PSTS may be selectively involved in verbal creativity. sentences with fMRI using paralleled stimuli. Stimuli were simple, short German sentences of the form "An A is a B" in order to avoid the effects of other elements. Subjects were supposed to read sentences silently and judge by button press whether the sentence had a positive or negative connotation. Reading metaphors in contrast to literal sentences revealed changes in the left lateral inferior frontal, inferior temporal and posterior middle/inferior temporal gyri. Researchers concluded with the activation in the left inferior frontal gyrus may reflect semantic inferencing processes during the understanding of a metaphor. Stringaris *et al.* (2007) used a novel cognitive paradigm and ER-fMRI to investigate the neural substrates involved in processing three different types of sentences. Participants read either metaphoric, literal or non-meaningful sentences and had to decide whether they made sense or not. This study found that activation of the left thalamus appeared to be specifically involved in deriving meaning from metaphoric sentences and their results do not support the view the right hemisphere is involved. Lee *et al.* (2006) interested in the role of the two hemispheres in metaphor comprehension investigated normal adults using fMRI. Subjects listened to sets of three adjectives and decided whether the last two had a similar meaning. Condition one required accessing the literal meaning of the middle word (e.g., hot-cold-chilly), whereas the other condition required accessing its nonliteral, or metaphorical, meaning (e.g., hot-cold-unfriendly). Results showed that reliable activity only in left prefrontal and temporo-parietal regions. These findings suggested that the increased complexity of figurative language rather than an RH specialization for understanding metaphors. The fifth most cited article was published by Mashal *et al.* (2005). Fifteen normal adults participated in a block designed fMRI experiment that compared the patterns of brain activation induced by processing the meanings of literal, conventional metaphoric, novel metaphoric and unrelated word pairs. The subjects performed a semantic judgment task. Researchers applied the Principal Components Analysis (PCA) technique in order to find different functional networks corresponding to the different stimuli. Results obtained from PCA of the fMRI data indicate that the right homologue of Wernicke's area has a special role in processing novel metaphors. Researchers concluded that a unique network, consisting of the right homologue of Wernicke's area, right and left premotor areas, right and left insula and Broca's area, is recruited for the processing of novel

metaphors but not for the processing of conventional metaphors.

The top five cited articles are all interested in the role of the left and right hemispheres in metaphor processing. Some studies have found a special role of the right hemisphere in metaphor comprehension, others show no difference of these two hemispheres in processing metaphor. Based on studies above, we can see that the metaphor type and language complexity have crucial influence on this dispute. Further studies need to be done in this dispute.

(3) Cluster interpretation

The 249 articles generated 8 clusters in total. According to the narrative summary of CiteSpace, cluster #0 and cluster #1 have the highest citation bursts, indicating that these two clusters are the important domain on the figurative language processing. Figure 3 presents important clusters.

Cluster #0 is labeled as brain laterality, with more attention being focused on the role of the two hemispheres in metaphor comprehension. There are totally 44 articles in this cluster. The five most cited articles include Coulson & Petten (2002), Giora *et al.* (2000), Zaidela *et al.* (2002), Gagnon *et al.* (2003) and Faust & Weisper (2000). Coulson & Petten (2002) investigated the processing of metaphor with ERPs. 18 adults read sentences that ended with words used literally, metaphorically, or in an intermediate literal mapping condition which means that the literal sense of the word was used in a way that prompted readers to map conceptual structure from a different domain. Results showed that literal endings elicited the smallest N400, metaphors the largest N400, whereas literal mappings elicited an N400 of intermediate amplitude. Metaphoric endings also elicited a larger posterior positivity than did either literal or literal mapping words. Consistent with conceptual blending theory, the results suggest that the demands of conceptual integration affect the difficulty of both literal and metaphorical language. Giora *et al.* (2000) integrated and improved the experimental tasks of Brownell & Gardener (1986). Participants need to describe figurative meaning of the metaphorical phrase orally. It was found that the difference between RBD patients and normal people in metaphor comprehension did not reach significance, but there was a significant disadvantage to LBD patients relative to both RBD patients and normal controls. The results are interpreted in terms of the recently proposed graded salience hypothesis (Giora, 1997, 1999). Gagnon *et al.* (2003) further validated Giora's study (2000) that the right brain is responsible for the processing of broad semantics. In order to compare the more complex semantic processing of metaphor with simple semantic processing, the experiment selected the left and right brain impaired subjects as subjects. Two tasks were used. One was a word-triad task where they had to associate alternative metaphoric and non-metaphoric words to a target word and a word-dyad task where they had to decide whether or not there was a semantic relationship between two words. The two tasks aimed at differentiating between the subjects' preference for a given semantic meaning versus a genuine semantic deficit for a particular meaning. Results revealed that both right-and left-hemisphere-damaged groups presented a genuine semantic deficit for the processing of metaphoric meaning. The absence of a double dissociation between the two brain-damaged groups does not support the hypothesis of a specific contribution of the right-hemisphere to the processing of metaphoric meaning of words. Faust *et al*. (2000) investigated hemispheric asymmetries in comprehending metaphoric word meanings within a sentence context. Participants were presented with incomplete priming sentences followed by (literally) true, false, or metaphoric lateralized target words and were asked to decide whether each sentence is literally true or false. Results showed that responses to metaphoric sentences were slower and less accurate than to false sentences when target words were presented to the right visual field (RVF)-LH as well as to the left visual field (LVF)-RH. This suggests that the understanding of lexical metaphors within a sentence context involves LH as well as RH processing mechanisms and that the role of each hemisphere in processing nonliteral language is flexible and may depend on the linguistic task at hand.

Cluster #1 is labeled as abstraction which meant that researchers tended to investigate the arbitrariness of the process in figurative language. There are 43 articles on this cluster. The top three most cited articles include Mashal *et al.* (2005), Rapp *et al.* (2004) and Mashal *et al.* (2007). The three articles also are the top five most cited article and

we have reviewed it above.

Cluster #2 is labeled as emotion. There are 35 articles on this cluster. The top three most cited articles include Forgács *et al.* (2012), Bambini *et al.* (2011) and Bohrn *et al.* (2012). Forgács *et al.* (2012) investigated the right hemisphere's role in language comprehension. This event related fMRI experiment researchers aimed at assessing the extent of semantic distance processing in the comprehension of figurative meaning to clarify the role of the right hemisphere. Four categories of German noun and noun compound words were presented in a semantic decision task: a) conventional metaphors; b) novel metaphors; c) conventional literal, and; d) novel literal expressions, controlled for length, frequency, imageability, arousal, and emotional valence. Conventional literal and metaphorical compounds increased bold signal change in right temporoparietal regions, suggesting combinatorial semantic processing, in line with the coarse semantic coding theory, but at odds with the graded salience hypothesis. Both novel literal and novel metaphorical expressions increased activity in left inferior frontal areas, presumably as a result of phonetic, morphosyntactic, and semantic unification processes, challenging predictions regarding right hemispheric involvement in processing unusual meanings. Meanwhile, both conventional and novel metaphorical expressions induced bold signal change in left hemispherical regions, suggesting that even novel metaphor processing involves more than linking semantically distant concepts. Bohrn *et al.* (2012) combined data from 354 participants across 22 fMRI studies and one positron emission tomography (PET) study to identify the differences in neural correlates of figurative and literal language processing, and to investigate the role of the right hemisphere (RH) in figurative language processing. Studies that reported peak activations in standard space contrasting figurative vs. literal language processing at whole brain level in healthy adults were included. The left and right IFG, large parts of the left temporal lobe, the bilateral medial frontal gyri (medFG) and an area around the left amygdala emerged for figurative language processing across studies. Conditions requiring exclusively literal language processing did not activate any selective regions in most of the cases, but if so they activated the cuneus/precuneus, right MFG and the right IPL. No general RH advantage for metaphor processing could be found. On the contrary, significant clusters of activation for metaphor conditions were mostly lateralized to the left hemisphere (LH). Subgroup comparisons between experiments on metaphors, idioms, and irony/sarcasm revealed shared activations in left frontotemporal regions for idiom and metaphor processing. Irony/sarcasm processing was correlated with activations in midline structures such as the medFG, ACC and cuneus/precuneus. To test the graded salience hypothesis (GSH, Giora, 1997), novel metaphors were contrasted against conventional metaphors. In line with the GSH, RH involvement was found for novel metaphors only. Here we show that more analytic, semantic processes are involved in metaphor comprehension, whereas irony/sarcasm comprehension involves theory of mind processes.

Table 2 The top most cited articles in figurative language processing

Citation Counts	Author(year)	Title	Journal
34	Mashal et al. (2007)	An fMRI investigation of the neural correlates underlying the processing of novel metaphoric expressions	Brain and Language
32	Rapp et al. (2004)	Neural correlates of metaphor processing	Cognitive Brain Research
28	Stringaris et al. (2007)	Deriving meanings: Distinct neural mechanisms for metaphoric, literal, and non-meaningful sentences	Brain and Language
28	Lee et al. (2006)	Metaphorical vs. literal word meanings: fMRI evidence against a selective role of the right hemisphere	Neuroimage
28	Mashal et al. (2005)	The role of the right hemisphere in processing nonsalient metaphoric meanings: Application of Principal Components Analysis to fMRI data	Neuropsychologia

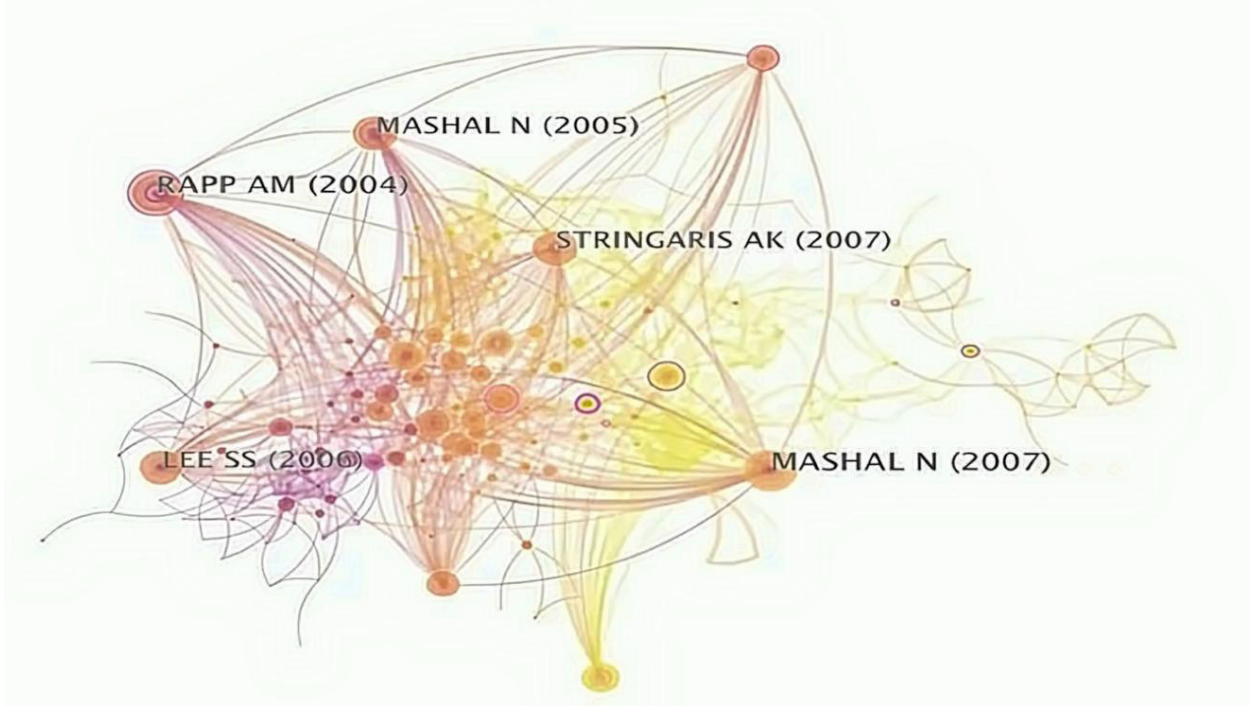

Fig. 1 Critical articles in figurative language processing

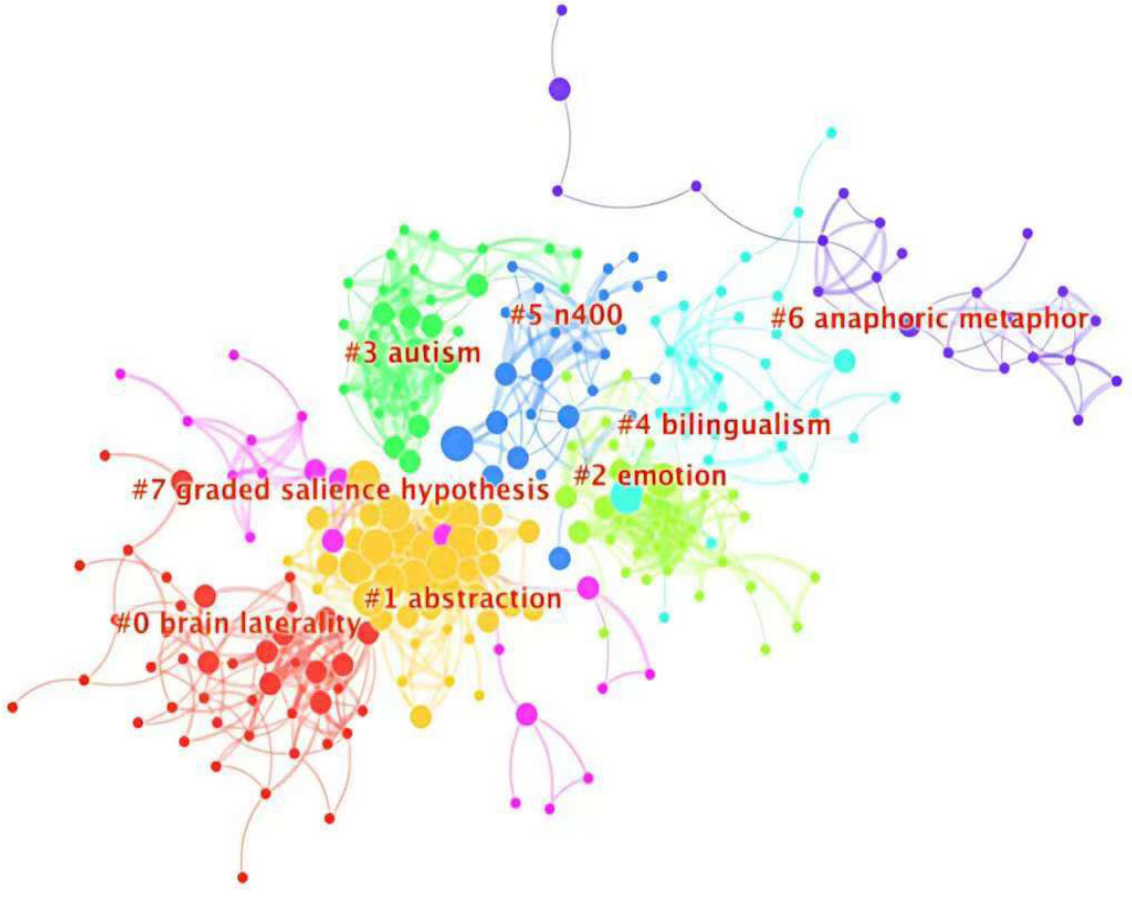

Fig. 2 Cluster view of the figurative language processing

4. Discussion and Conclusion

The present study collected 286 bibliometric recordings ranging from 1900 to 2019 and CiteSpace software was adopted to quantitatively and visually review these papers. Based on the results of co-citation analysis, cluster interpretations, and co-occurring terms, studies on the cognitive processing of figurative language primarily focus on the role of the left and right hemispheres in metaphor processing and brain laterality, bilingual figurative language processing, the difference of processing different type of metaphors such as anaphoric metaphor and metaphor related to emotion, the relationship between processing figurative language and autism.

To conclude, the current paper has manifested a quantitative scientometric approach to investigate the development of the collective knowledge of figurative language processing by entering the literatures published within this field. Through document co-citation analysis, cluster interpretations and co-occurring terms analysis, it can be found that effects of hemisphere's role, bilingualism, anaphoric metaphor and autism, which can contribute to the understanding of the research patterns and hotspots in the knowledge domain of figurative language processing visually and efficiently. However, due to the interdisciplinary feature of figurative language processing, it is difficult to acquire a comprehensive profile of the research field. In future studies, three directions are worth considering: (1) examining figurative language processing in sentence context; (2) dissociating the processing mechanisms between native speakers and non-native speakers; (3) innovating research methods such as the combination of ERP, eye tracking and fMRI in figurative language processing.

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