

From Self-Regulated Learning to Metacognitive Therapy: A Mapping Knowledge Doamains Analysis

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ABSTRACT: *Metacognition has become an important topic in the fields of cognitive psychology and attracted much attention from educational psychology, clinical psychology and other fields. The study used mapping knowledge domain, and selected 3268 papers of SSCI and SCIE citation database in the Web of Science Core Collection, in order to intuitively, dynamically and quantitatively reveal the progress of metacognitive research, and provide reference for the research on metacognitive related topics. The results showed that self-regulated learning, metacognitive therapy, metamemory, schizophrenia, and confidence were the focus of metacognitive research. Retrieval practice, metacognitive therapy and persecutory delusion were the frontier fields of metacognitive research. And there were three important papers (i.e. Flavell, 1979; Nelson, 1990; Wells & Matthews, 1996). Lysaker PH, Wells A, Moritz S, Dunlosky J and so on were important authors in recent metacognitive research.*

KEYWORDS— *Metacognition, Self-regulating learning, Metacognitive therapy, Mapping knowledge domain, Visualization*

I. INTRODUCTION

Since Flavell's proposal in 1976, "metacognition" has been tested for more than 40 years and has been concerned and attached great importance by scholars and relevant institutions [1]-[2]. In fact, people engage in metacognitive activity every day. Metacognition is related to memory, learning, planning and decision making [3]. It has not only become a bridge between cognitive psychology and educational practice [4], but also an important topic in clinical psychology, cognitive neuroscience and other fields [5].

The so-called metacognition refers to a person's cognition of his or her own cognitive process and results, and the active monitoring, adjustment and coordination of the cognitive process [6]. It refers to any knowledge targeted at the cognitive process and results, or any cognitive activities that regulate the cognitive process [7]. In cognitive psychology, metacognition is usually defined as a form of executive control involving monitoring and self-regulation [8]. Some researchers not only described metacognition as a multidimensional set of general skills [9], but also defined metacognition as "cognition of cognition" [10] and "thinking about my own thinking" [11] based on the concept of "meta". From the perspective of thinking, metacognition is the monitoring and control of thoughts [12], and responds to thoughts through monitoring and control [13]. It is a high-level thinking process, which implies active control over the cognitive process in the learning process [14]. Metacognition has two basic characteristics which are self-evaluation of cognition and self-management of cognition [15]. Among them, the self-evaluation of cognition involves answering questions about what to know, how to think, and when and why to apply knowledge strategies. While cognitive self-management is a psychological process conducive to problem solving and task completion, which mainly includes pre-task planning, adjustment during task and modification after task.

A review of metacognitive research shows that in the 1970s, the focus was mainly on metacognitive knowledge and experience, while in the 1980s, the focus shifted to emphasis on metacognitive control and strategy use [16]. Since then, metacognition has been a topic of interest in cognitive psychology, especially in the study of meta-memory. At present, cognitive psychology, cognitive developmental psychology and social developmental psychology are the basis of metacognitive research [17]. Moreover, different disciplines have different emphases on the concepts of metacognitive knowledge, metacognitive strategies and metacognitive experience, which are often involved in metacognitive research. Specifically, metacognitive experience is most mentioned in developmental psychology and educational psychology. In experimental cognitive psychology, most studies are related to metacognitive strategies. In clinical psychology, personality psychology and social psychology, the proportion of the three concepts is fairly uniform. In neuroscience and animal psychology, metacognitive knowledge attracts more attention [5].

Generally speaking, most of the analysis on the research progress of metacognition is based on the overview of the field, concept and method of metacognition research, and lack of intuitive and dynamic description of the development process and structural relationship of the knowledge involved through quantity. Yet, Knowledge map, as a visualization technology, can present many implicit complex relationships between knowledge units or knowledge groups, such as network, structure, interaction, crossover, evolution or derivation [18], thus pushing new research directions in the field of metacognition. As Web of Science (WoS) Core Collection is an important database for obtaining global academic information, it contains more than 12,400 authoritative and high-impact academic journals in the world, covering natural science, social science and other fields. Since 1976, the number of literatures related to metacognition has been increasing. In order to uncover the recent research trends in this field, this study attempts to apply knowledge mapping to analyze the literature on metacognition research in the SSCI (Social Sciences Citation Index) and SCIE (Science Citation Index Expanded) citation databases in the WoS core collection, expecting to reveal the research process in this field visually, dynamically and quantitatively, and to provide reference and reference for subsequent research in the field of metacognition.

II. METHODS

1.1 Data Sources

This study takes the WoS core Collection as the data source, takes "Metacognition" or "Metacognitive" as the keyword, and restricts the publication period of the literature to 2015-2019. The literature type is article or review, and the language is English. A total of 3317 literatures included in SSCI and SCIE citation databases were retrieved. Repetitive literatures were excluded and publication time of literatures was determined. Finally, 3268 literatures were included in the study. As shown in Figure 1, the publication of metacognitive literature presents a trend of linear growth.

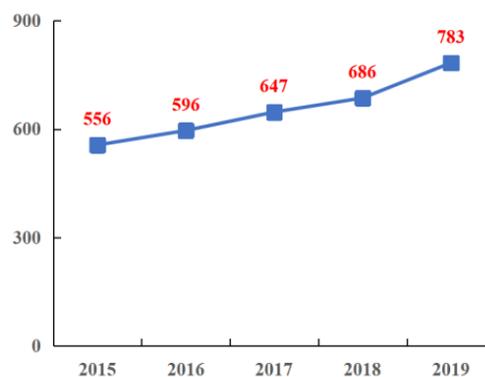


Figure 1 Publication of metacognitive literature

1.2 Data processing

Use Citespace5.6.R5 and VOSviewer1.6.15 to analyze data and plot. When using CiteSpace to divide the time zone, carry out a yearly division. And then, analyze the cited literatures from four aspects: keywords, authors, institutions and cited literatures.

III. RESULTS

1.1 Keywords

Research shows that among the keywords (except "metacognitive") in metacognitive literature, the top three are "performance", "knowledge" and "memory" (see Table 1). The result of keyword cluster analysis shows that five clusters are mainly formed, the cluster module value (Q) is 0.5474, and the average cluster contour value (S) is 0.7034. Generally speaking, $Q > 0.3$ means the clustering structure is significant, $S > 0.5$ means the clustering is reasonable. Therefore, the clustering structure of keywords in this study is significant and reasonable. Among them, cluster 1 is "self-regulated learning", $S=0.701$, including self-regulation, motivation, knowledge, cooperative learning and other keywords; Cluster 2 was metacognitive therapy ($S=0.750$), including worry, depression, anxiety, metacognitive belief and other keywords. Cluster 3 was "meta-memory", $S=0.811$, including memory, extraction practice, monitoring, processing fluency and other keywords; Cluster 4 was "schizophrenia", with $S=0.857$, including social cognition, psychosis, neuro-cognition, cognitive bias and other keywords. Cluster 5 is "confidence", $S=0.853$, including decision-making, consciousness, perception, introspection and other keywords.

Table 1 Top 50 high-frequency keywords

SN	keywords	frequency	SN	keywords	frequency	SN	keywords	frequency
1	performance	406	18	meta-analysis	173	35	psychosis	122
2	knowledge	317	19	metamemory	169	36	disorder	118
3	memory	303	20	symptom	161	37	education	116
4	student	269	21	awareness	160	38	behavior	113
5	model	263	22	achievement	159	39	social cognition	110
6	schizophrenia	255	23	information	156	40	validation	108
7	self-regulation	229	24	anxiety	154	41	psychotherapy	108
8	judgment	228	25	decision making	151	42	instruction	102
9	strategy	227	26	self-regulated learning	147	43	comprehension	99
10	confidence	225	27	attention	144	44	intervention	98
11	motivation	224	28	working memory	142	45	scale	97
12	cognition	220	29	individual difference	139	46	classroom	96
13	depression	214	30	skill	137	47	association	96
14	children	207	31	perception	133	48	efficacy	95
15	belief	193	32	self	130	49	insight	94
16	accuracy	189	33	questionnaire	130	50	deficit	92
17	executive function	175	34	experience	129			

In addition, the results of keyword breakout analysis (the duration of breakout is at least one year) show (See Figure 2) that recall has the largest burst value (5.22), and the duration of breakout is one year (2016). However, keywords such as retrieval practice, metacognitive therapy, persecutory delusion and other keywords not only have large occurrence value, but also have a long duration of occurrence, and the expiration year of occurrence is 2019. Because professional terms with rapidly increasing frequency can be identified as frontier

terms [19], extraction exercise, metacognitive therapy, victimization delusion, etc., can be regarded as frontier fields of metacognitive research.

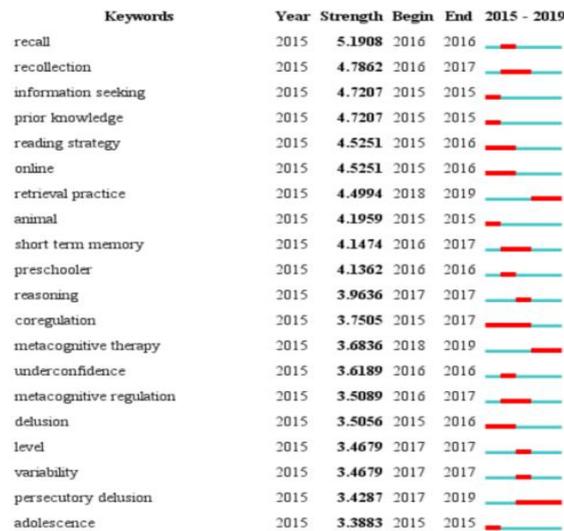


Figure 2 The top 20 keywords in breakout value

1.2 Author

The study shows that among authors of metacognitive literature, the most prolific authors are Lysaker PH and Wells A (see Figure 3A). The results of author cooperation network analysis of cited literatures (See Figure 4) show that there are 9 author communities: (1) Represented by Moritz S, Andreou C, Hauschildt M, etc.; (2) Lysaker PH, Buck KD, Leonhardt BL, etc.; (3) Wells A, Solem S, Hjemdal O, etc.; (4) Represented by Carcione A, Nicolo G, Colle L, etc.; (5) Represented by Spada MM, Sassaroli S, Caselli G, etc.; (6) Represented by Fleming SM, Garfinkel SN, David AS, etc.; (7) Represented by Morrison AP, Sellers R, Gumley A, etc.; (8) Represented by Fisher PL, Salmon P, Capobianco L, etc.; (9) Represented by Dimaggio G, Popolo R, Schweitzer RD, etc.

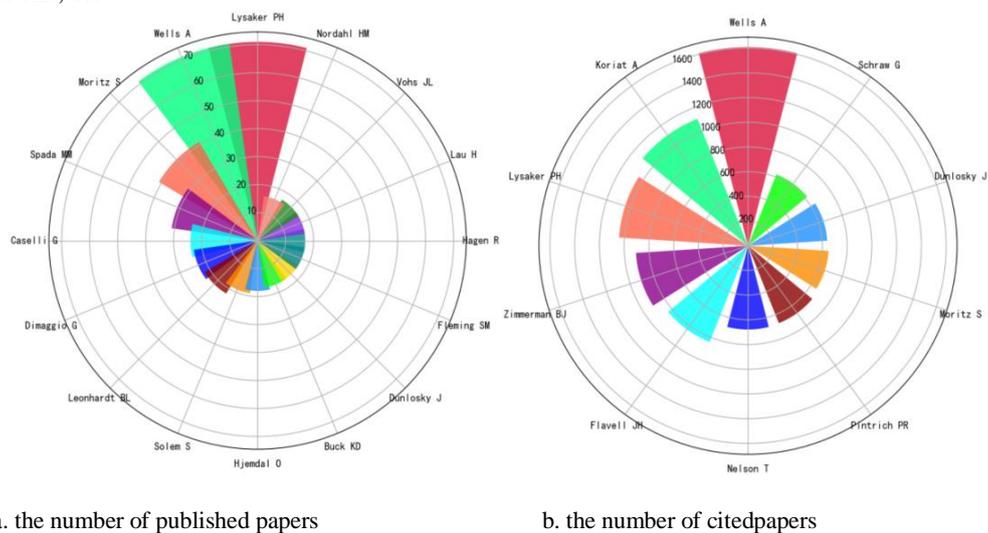


Figure 3 Top 10 authors

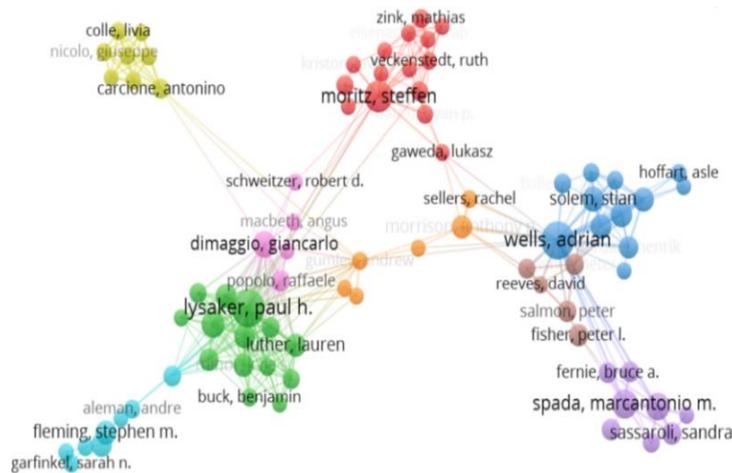


Figure 4 Network diagram of authors' cooperation in cited literatures

In addition, from the perspective of cited authors, Wells A was cited the most frequently (see Figure 3b). The results of author co-citation analysis (see Figure 5) show that five author co-citation groups are mainly formed. (1) represented by Zimmerman BJ, Flavell JH, Schraw G, etc.; (2) Represented by Fleming SM, Schneider W, Kiani R, etc.; (3) Represented by Koriat A, Kornell N, Dunlosky J, etc.; (4) Represented by Wells A, Spade MM, Solem S, etc.; (5) Represented by Lysaker PH, Moritz S, Morrison AP, etc.

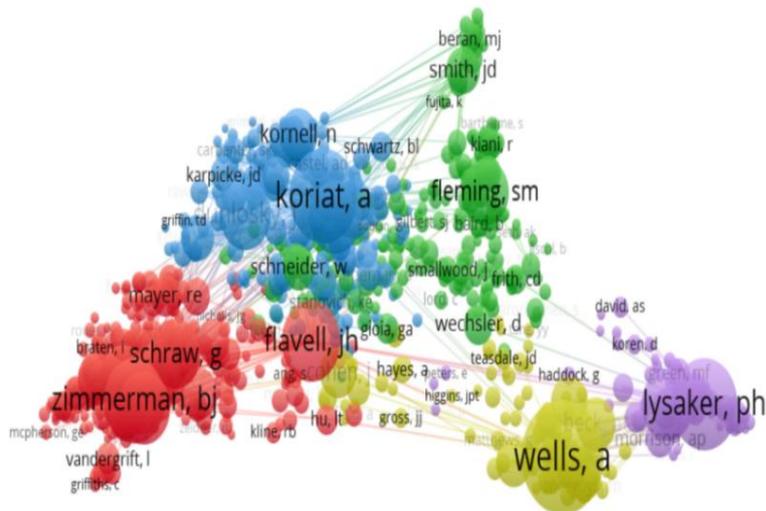


Figure 5 Author co-citation analysis

1.3 Institutions

According to the research, among the international institutions conducting metacognitive research in recent years, the University of Manchester in the UK has published the most papers. Most of the top 10 institutions are from European and American countries, including 3 in the UK, 2 in each the US and the Netherlands, and 1 in each Germany, Australia and Norway (see Table 2). However, in terms of the most published countries, the top three are the United States (1,212), the United Kingdom (475) and Germany (302).

Table 2 Top 10 institutions by publications

SN	Institution	country	Posts/ Average annual posts
1	University of Manchester	Britain	92/18.4
2	University College London	Britain	75/15
3	Indiana University School of Medicine	United States of America	71/14.2
4	University Medical Center Hamburg-Eppendorf	Germany	55/11
5	University of Sydney	Australia	46/9.2
6	Norwegian University of Science and Technology	The Norwegian	45/9
7	University of California Los Angeles	United States of America	44/8.8
8	Maastricht University	the Netherlands	41/8.2
9	University of Amsterdam	the Netherlands	39/7.8
10	Kings College London	Britain	38/7.6

The results of institutional cooperation network analysis (See Figure 6) show that there are seven institutional communities: (1) represented by University of California Los Angeles, Columbia University and McGill University in Canada; (2) Represented by Maastricht University and University of Amsterdam in the Netherlands and University Medical Center Hamburg-Eppendorf in Germany; (3) Represented by University College London, University of Oxford and University of Sussex in the UK; (4) Represented by Indiana University School of Medicine, University of North Carolina Chapel Hill and Rudbush Medical Center; (5) Represented by university of Manchester, University of Liverpool in the UK and Norwegian University of Science and Technology in Norway; (6) Represented by the University of Sydney and the University of Queensland in Australia and Pennsylvania State University in the United States; (7) Represented by Kings College London, London South Bank University and University of Padua in Italy.

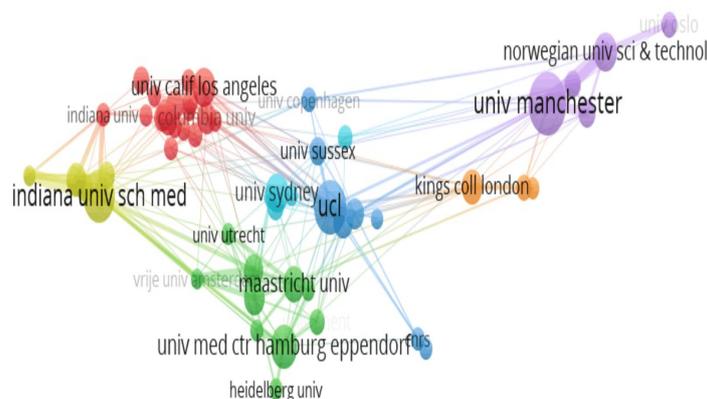


Figure 6 institutional cooperation networks

1.4 Cited literature

According to the study, the most frequently cited document is Flavell' s Metacognition and Cognitive Monitoring, published in American Psychologist: A new area of cognitive-developmental inquiry published on American Psychologist in 1979. The mediating centrality of this literature was 0.21, greater than 0.1. Among the top 10 cited literatures (excluding works), Wells alone has 2, and all published in journal Behaviour Research and Therapy (see Table 3). Among them, the mediating centrality of the paper in 1996 (0.23) was greater than

0.1. In addition, the mediating centrality of the second literature (first author: Nelson) (0.60) was also greater than 0.1, which was also very important. Among the excluded works, the Handbook of Self-Regulation written and published by Boekaerts in 2000 has two articles (one is Pintrich's The Role of Goal Orientation in Self-regulated Learning, another article is Attaining Self-Regulation: A Social Cognitive Perspective by Zimmerman) has mediating centrality (0.14 and 0.11, respectively) greater than 0.1 and should also be valued. As shown in Figure 7, the citations of these five papers in recent years showed an overall upward trend.

Table 3 Top 10 cited literature

	First author (year)	Title of literature/Subordinate to the clustering 1 to 5	Journal	citation/annual average citation
1	Flavell (1979)	Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry/1	American Psychologist	482/96.4
2	Nelson (1990)	Metamemory: A theoretical framework and new findings/2	Psychology of Learning and Motivation	232/46.4
3	Wells (2004)	A short form of the metacognitions questionnaire: properties of the MCQ-30/4	Behaviour Research and Therapy	204/40.8
4	Wells (1996)	Modelling cognition in emotional disorder: The S-REF model/4	Behaviour Research and Therapy	162/32.4
5	Koriat (1997)	Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning/2	Journal of Experimental Psychology: General	156/31.2
6	Veenman (2006)	Metacognition and learning: Conceptual and methodological considerations/1	Metacognition and Learning	128/25.6
7	Schraw (1994)	Assessing metacognitive awareness/1	Contemporary Educational Psychology	123/24.6
8	Kay (1987)	The Positive and Negative Syndrome Scale (PANSS) for Schizophrenia/5	Schizophrenia Bulletin	119/23.8
9	Feming (2010)	Relating introspective accuracy to individual differences in Brain structure/3	Science	117/23.4
10	Maniscalco (2012)	A signal detection theoretic approach for estimating metacognitive sensitivity from confidence ratings/3	Consciousness and Cognition	112/22.4

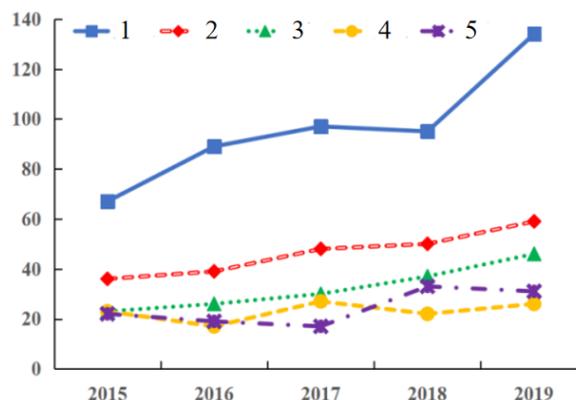


Figure 7 The number of citations of important literature

Note: 1 is Flavell (1979); 2 is Nelson (1990); 3 is Wells and Matthews (1996); 4 is Pintrich (2000); 5 is Zimmerman (2000).

IV. DISCUSSION

1.1 Hot spots and frontiers of international metacognitive research

In recent years, self-regulated learning, meta-memory therapy, meta-memory, schizophrenia confidence and so on are the hot spots of international metacognitive research.

The First one is self-regulated learning. Self-regulated learning is an active and constructive process in which learners set goals for learning and then monitor, regulate and control their own cognition, motivation and behavior, guided and constrained by goals and environment [20]. It includes three stages: pre-consideration, performance or volitional control and self-reflection [21]. Research in this field can be traced back to Flavell. Flavell [22] proposed a cognitive monitoring model, believing that the monitoring of various cognitive activities is achieved through the actions and interactions of four kinds of phenomena: metacognitive knowledge, metacognitive experience, goal (or task) and action (or strategy). However, metacognitive knowledge and metacognitive experience are often associated with learning strategies, self-regulation and other concepts [23]. Studies have pointed out that metacognition, especially metacognition monitoring, is the key to self-regulated learning [24]. In order to understand complex scientific topics, learners need to apply self-regulating learning skills including metacognitive monitoring, especially in hypermedia learning environments [25]. Nowadays, the research in this field is deepening to online learning, cooperative learning and other directions. For example, some studies examined the influence of metacognitive inquiry group model on students' metacognitive performance in cooperative learning environment supported by computer, and found that individual metacognitive support affects students' online metacognitive performance, while social metacognitive support increases students' participation in peer learning process [26]. Other studies have found that improving learners' metacognition can help enhance their interest in online learning and promote their continuous MOOCs learning [27]. Due to the COVID-19 pandemic in 2020, online learning has received greater attention. Future research can compare students' metacognitive performance in online learning environment and face-to-face learning environment, and explore whether the embedding of metacognitive support in online learning environment can improve students' performance at different levels.

The second one is metacognitive therapy. Metacognition is an important factor in the development and maintenance of psychological disorders [28]. Metacognitive therapy has been applied in the treatment of depression, generalized anxiety disorder, post-traumatic stress disorder and other disorders, with both adults, children and adolescents [29]-[32]. In order to better understand and deal with psychological disorders, researchers have constructed different theoretical models. Wells et al. [33] proposed a Self-Regulatory Executive Function Model (S-REF Model) for mood disorders based on the integration of information processing research and Beck's schema theory. The model suggests not only what cognitive therapy should do, but also how to accomplish cognitive change most effectively. Papageorgiou et al. [34] proposed a Clinical Metacognitive Model of Rumination and Depression based on the S-REF Model. The model includes positive beliefs, negative beliefs, and metacognitive efficiency, suggesting that the vicious cycle of rumination, depression, and metacognitive might be responsible for the persistence of depressive experiences. In addition, Bernstein [35] put forward such as Metacognitive Processes Model of Decentering. The model includes three metacognitive processes: meta-consciousness, separation from internal experience and reduction of response to thought content, which further confirms the important role of metacognitive ability in mental health. Based on the integration and development of metacognitive therapy models, future studies will explore the mechanism of metacognitive beliefs in different age levels and groups with different psychological disorders through longitudinal studies.

The third one is meta-memory. Research on meta-memory focuses on the core issues of people's belief in memory, memory monitoring and memory control [36]. To solve these problems, researchers used different methods, asking subjects to make judgments about their memories or to control different stages of learning. Nelson [37] established three principles of meta-memory analysis: a) the cognitive process is divided into two or more special levels related to each other; b) the meta-level contains the dynamic model of the object level; c) there are two dominant relationships, monitoring and control, which are defined in terms of the direction of information flow between the meta-level and the object level. However, Koriat [38] distinguished three kinds of

cues for learning judgment (internal cues, external cues and mnemonic cues) and proposed a method of using cues for learning judgment. Although many studies have focused on how a single cue affects meta-memory judgment, a recent study found that multiple cues affect people's prediction of future memory performance [39]. In fact, the research of metacognition involves not only human beings but also other animals. For example, monkeys' uncertain responses reflect their possible ability to monitor their mental states [40]. Coping with uncertainty requires resources, and with sufficient training, humans can cope with uncertainty by using minimal working memory resources or sharing resources effectively [41]. Future studies will further explore the effects of monitoring precision on control effectiveness, the effects of multiple cues on meta-memory, and the differences in meta-memory performance between humans and other animals, especially primates.

The fourth is schizophrenia. Metacognitive deficits were found in both the early and late stages of schizophrenia [42]-[43]. Furthermore, metacognitive deficits are associated with objective and subjective indicators of health, independent of symptom severity [44]. It controls the self-expectation of neuro-cognition, affective cognition and goal realization, and predicts the level of future negative symptoms of schizophrenia [45]-[46]. Research in this area involves both cognitive distortion and conceptual confusion. The most consistent findings on cognitive distortions in schizophrenia are associated with a specific data-collection bias known as jumping to conclusions, in which patients prematurely terminate data collection and weigh the evidence when drawing strong conclusions [47]. However, the conceptual confusion of schizophrenics weakens the connection between neuro-cognition and metacognition [48]. Metacognitive training or metacognitive intervention has been paid more and more attention in the treatment of schizophrenia [49]. For example, Metacognitive Reflection and Insight Therapy (MERIT) has been applied to the treatment of schizophrenia in recent years [50] - [51]. In the future, patients' metacognition and psychological ability should be continuously evaluated in the treatment of schizophrenia, and the relationship among metacognition, cognitive empathy and affective empathy as well as how they are affected by specific interventions should be further explored.

The last one is confidence. The cited literature can be traced back to the Signal Detection Theory and Psychophysics by Green and Swets (1966). In psychological tasks, an interesting measurement is how observers' confidence rating predicts the accuracy of stimulus judgment, and signal monitoring theory provides an effective measurement method [52]. A recent eye movement study identified a new near-threshold feature of sensory-perception involving the interaction between eye activity and visual information decision making, and suggested that perceptual decisions and confidence judgments can be processed independently [53]. In addition to confidence, introspection is also an important concept in this field. The researchers explored the neural mechanisms underlying these aspects. It has been found that introspection is associated with gray matter volume in the prefrontal cortex, and individual differences in introspection are also associated with white matter microstructure in this area of the prefrontal cortex [54]. Other studies have applied transcranial magnetic stimulation to manipulate reaction-specific representations in the premotor cortex, and found that specific action information in the premotor cortex contributes to the perception of confidence [55]. Future research will further explore the relationship between confidence judgment and perceptual decision making and their neural mechanism, further confirm the view that the brain represents a multi-level confidence system, and explore how the improvement of introspection ability will lead to changes in brain structure and function.

Among the above five research hotspots, self-regulating learning which has always been concerned by researchers is not only the largest keyword cluster in frontier literatures, but also the largest cluster in cited literature. Confidence is the smallest keyword cluster in frontier literatures, but the time span of citation is the largest. This indicates that although the discussion on confidence in metacognitive research started very early and spanned many subdomains of psychology and neuroscience [56], it has received less attention in recent years. In fact, these research hotspots are not completely independent, but related to each other. For instance, self-regulated learning, meta-memory, and confidence can be focused on educational psychology, developmental psychology and so on, while metacognitive therapy and schizophrenia can be focused on clinical psychology, cognitive neuroscience and other fields. Furthermore, this study also found that recent advances in metacognitive research focused on extraction exercises, metacognitive therapy and persecutory delusions. First, extract exercises. Retrieval exercise is an important keyword in the third research hotspot (meta-memory) identified in this study. Knowing whether information can be extracted can provide diagnostic information for

self-adjustment of subsequent learning activities [57]. Retrieval exercises are good for improving memory accuracy [58] and can benefit individuals with ADHD in learning [59]. Moreover, students' use of extraction exercises varies according to age and field of study [60]. As for metacognitive therapy, it is not only a research hotspot, but also the research frontier. In recent years, researchers have been exploring new metacognitive therapies. Take group-based metacognitive therapy [32] and family-based metacognitive therapy [61] as examples. Paranoia of persecution is also on the cutting edge. Metacognition is at the core of the subjective reality of delusional concepts and lost self-direction [62]. Researchers continue to explore metacognitive intervention approaches or metacognitive training methods, such as individualized metacognitive training. It specifically targets delusional beliefs of psychiatric patients and works by cultivating awareness of the unbelievable content of delusional beliefs, as well as the cognitive biases that lead to the formation and development of delusional beliefs [63].

1.2 The main body of international metacognitive research

From the perspective of frontier authors and cited authors, Lysaker PH, Wells A, Moritz S and Dunlosky J are remarkable authors in the field of metacognitive research ranking among the top 10 in terms of publication volume and citation volume in recent five years, with the average annual publication volume ranging from 3.4 to 14.2 and the average annual citation volume ranging from 128.2 to 321.6. Lysaker PH of Indiana University School of Medicine in the United States has conducted in-depth research on metacognitive deficits and corresponding metacognitive interventions in schizophrenia. Wells A, from the University of Manchester in the UK, introduced the concept of metacognitive therapy, carried out a large number of relevant studies, and established a theoretical model to support positive changes in mental health. Moritz S, from the Eppendorf Medical Center at the University of Hamburg in Germany, focuses on metacognitive research in psychiatric disorders, such as memory and metacognitive memory in people with schizophrenia. Dunlosky J, from Kent State University in the US, has carried out extensive research in areas such as meta-memory and self-regulated learning. Much of his work is closely related to these subjects. For example, *Metacognition in educational theory and practice* (1998), *Metacognition* (2008), *Hand book of meta-memory and memory* (2013) and *The Oxford handbook of meta-memory* (2016), etc.

This study finds that five author co-citation groups have gradually formed in recent years. Each co-cited population has a relatively close academic relationship, and the "distance" is relatively close. For example, in the largest author co-citation group, the main research topic is self-regulating learning. In addition to Flavell JH, Zimmerman BJ and Schraw G are also representatives of this group. Among them, Zimmerman BJ from the Graduate School and University Center of the City University of New York carried out a large number of fruitful researches in the field of self-regulated learning, proposed the famous three-stage model of self-regulated learning, and published books like *Self-regulated learning: From teaching to self-reflective practice* (1998), *Self-regulated learning and academic achievement: Theoretical perspectives* (2001) and *Handbook of self-regulation of learning and performance* (2011). Schraw G from the University of Nevada in the United States compiled the *Metacognitive Awareness Inventory (MAI)* and carried out a large number of studies on *Metacognitive Awareness, Metacognitive measurement and other fields*.

Conducting academic research requires teamwork. This study found that nine author communities have gradually formed in international metacognitive research. Their works focus on different issues. For example, the authors represented by Moritz S et al have made great achievements in metacognitive training of schizophrenia and depression. The authors represented by Lysaker PH et al mainly discussed metacognitive ability in the psychotherapy of schizophrenia. A community of authors represented by Fisher PL et al mainly focused on metacognitive therapy of emotional distress in cancer patients. These communities of authors are both relatively independent and related to each other, such as Moritz S in the first community and Lysaker PH in the second. The collaboration between research institutions is behind the authors' collaboration. At present, the research institutions engaged in metacognitive research are mainly concentrated in European and American countries, but the strength of Australia cannot be underestimated. From the perspective of the community of seven major institutions, there is cooperation between national and transnational research institutions. It's not

difficult to foresee that metacognitive research will be promoted to a new level in the future with the strengthening of cooperation among authors, institutions and countries.

To sum up, the role of metacognition in learning, memory and clinic has promoted the research in related fields. Neuroscientists also see metacognition as a topic worth exploring. For instance, an important question is whether metacognitive ability is a domain general skill supported by a core neuroanatomical basis, or whether region-specific neural structures are the basis for accurate reflection in different cognitive domains [64]. For example, in the process of understanding the neural mechanisms of confidence, it is important to manipulate the confidence system through specific tasks to make it independent from decision making. This includes more careful design of experimental stimuli and more rigorous application of tools for psychophysical modeling. In addition, the application and innovation of statistical methods also promote the continuous and in-depth development of metacognitive research. The diversity of methods requires researchers to clearly and specifically choose their own perspectives in any given study. In the future, metacognitive research will continue to make new breakthroughs in content, methods and means centering on self-regulating learning and meta-memory therapy.

V. CONCLUSION

In conclusion, we can draw three conclusions from the current research. (1) Self-regulating learning, metacognitive therapy, meta-memory, schizophrenia and confidence are the hot spots of international metacognitive research. Extraction exercises, metacognitive therapy, and persecutory delusions are the frontiers. (2) Flavell (1979), Nelson (1990), Wells and Matthews (1996) are important literatures in the field of metacognitive research. (3) Lysaker, Wells, Moritz and Dunlosky are important authors in the field of international metacognitive research in recent years. The close cooperation between authors and institutions engaged in metacognitive research gradually formed a community of nine authors and a community of seven institutions.

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