Research on the Application of Retrieval Practice in Clinical Populations: A Systematic Review*

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Abstract

Retrieval Practice is a strategy that improves memory efficiency by retrieving information from the memory system through testing, free recall, and other methods. Some clinical patients may have deficits in memory or cognitive abilities. This article is the first to systematically review studies on Retrieval Practice in clinical populations from January 2020 to July 2025, ultimately including 22 publications. The results show that Retrieval Practice demonstrates good applicability in clinical populations and can improve cognitive impairments such as memory and language disorders. Based on existing research, this review preliminarily proposes that the effects of Retrieval Practice may be moderated by the following three factors: (1) the type of core cognitive deficits associated with the disease; (2) the complexity and ecological validity of learning materials; and (3) whether other treatments are involved. Future research can further examine these moderating factors while also focusing on comorbid populations, the indirect effects of Retrieval Practice, and individual differences. In terms of clinical translation, the clinical applicability of Retrieval Practice can be enhanced through three measures: clarifying intervention goals, strengthening guidance and education, and adopting a progressive implementation strategy.

Full Text

Research on the Application of Retrieval Practice in Clinical Populations: A Systematic Review*

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Abstract Retrieval practice is a strategy for improving memory efficiency by retrieving information from the memory system through testing, free recall, and other methods. Some clinical patients may have deficits in memory or cognitive abilities. This article first systematically reviewed studies of retrieval practice in clinical populations from January 2020 to July 2025, ultimately including 22 papers. The results show that retrieval practice demonstrates good applicability in clinical populations and can improve cognitive impairments such as memory and language disorders. Based on existing research, this review preliminarily proposes that the effects of retrieval practice may be moderated by the following three types of factors: (1) the type of core cognitive deficit associated with the disease; (2) the complexity and ecological validity of the learning materials; and (3) whether other therapeutic approaches are present. Future research may further verify the above moderating factors, while also attending to issues such as comorbid populations, the indirect effects of retrieval practice, and individual differences. In terms of clinical translation, the clinical applicability of retrieval practice can be enhanced by clarifying intervention goals, strengthening guid-

ance and psychoeducation, and adopting gradual implementation strategies.

Keywords retrieval practice, clinical, memory, cognitive rehabilitation

1 Introduction

Retrieval practice is a long-term memory-enhancement strategy based on the process of memory retrieval. It refers to repeatedly retrieving learning materials through testing, free recall, and other means (Roediger & Butler, 2011). Compared with simple repeated study, retrieval practice can more effectively improve memory retention and knowledge transfer. This phenomenon is known as the retrieval practice effect or testing effect (Ma Xiaofeng, Li Tiantian, et al., 2022; Roediger & Karpicke, 2006). As an efficient learning strategy, retrieval practice has been shown to improve memory or learning outcomes in healthy populations (Ma Xiaofeng, Wen Meiqi, et al., 2022; Zhang Lijuan, et al., 2025; Aslan & Kubik, 2024; Carpenter, 2023; Ophuis-Cox et al., 2023).

However, for clinical populations with cognitive impairments, the prospects for applying retrieval practice remain a key question that warrants systematic answers. Many neurological diseases (such as Alzheimer' s disease) and psychiatric disorders (such as schizophrenia) are often accompanied by significant memory dysfunction (Knopman et al., 2021; Sumiyoshi et al., 2021), which seriously affects patients' lives

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quality. Therefore, exploring effective strategies for improving cognitive or memory deficits in such patients is of important clinical significance. Retrieval practice is a cognitive intervention with considerable applied potential. First, retrieval practice may induce elaborative encoding and thereby enhance memory ability (Liao Chenchen & Zhang Jinkun, 2024). Second, studies have found that the retrieval-practice effect is closely associated with brain regions such as the medial prefrontal cortex, ventrolateral prefrontal cortex, inferior frontal gyrus, ventral striatum, and midbrain (Van den Broek et al., 2013; Ye et al., 2020; Zhuang et al., 2022). Notably, these brain regions not only play key roles in memory consolidation and retrieval; their dysfunction is also closely related to the pathological mechanisms of memory deficits in diseases such as Alzheimer' s disease and schizophrenia (Liu et al., 2021; Williams et al., 2023). Therefore, on the basis of the shared neural foundations described above, retrieval practice may not only improve memory performance through elaborative encoding, but may also regulate the neural circuits underlying functional abnormalities in clinical populations, thereby providing an intervention pathway for improving their cognitive deficits at the neural-mechanistic level. Although existing studies

have shown that retrieval practice has the potential to improve vocabulary learning and semantic comprehension in specific clinical populations—such as patients with aphasia and children with developmental language disorder (Leonard et al., 2019; Middleton et al., 2022)—the current evidence remains highly fragmented. In particular, conclusions drawn across different clinical conditions and different experimental designs are not entirely consistent. Thus, key questions such as whether retrieval practice is applicable to clinical populations, as well as the conditions and boundaries of its effects, still require systematic investigation.

Existing reviews have addressed this field, but their scope has mostly been limited to specific types of acquired disorders; they have not covered populations with developmental disorders, nor have they synthesized the newer evidence from recent years involving a broader range of conditions (de Lima et al., 2020). Given that the heterogeneity and complexity of clinical populations far exceed the scope of previous reviews, a more comprehensive and in-depth discussion is urgently needed. Therefore, this review focuses on the broad category of clinical populations, examining whether retrieval practice can serve as an effective cognitive intervention strategy, what heterogeneity and effect boundaries characterize its outcomes, and further identifying weaknesses in existing research as well as directions for future work. Finally, it proposes guiding recommendations for the implementation of clinical intervention programs.

2 Methods

2.1 Literature Search

The present study searched Chinese- and English-language literature published from January 2020 to July 2025 on retrieval practice in which the participants were clinical populations. Chinese-language literature was searched mainly in CNKI, the VIP Database, and the Wanfang Database. English-language literature was searched mainly in Web of Science, ScienceDirect, and Wiley Online Library. After referring to the settings used in previous studies and making certain improvements, the final English search keywords used in this study were: “Retrieval Practice,” “Testing Effect,” “Clinical,” “Treatment,” “Rehabilitation,” and “Patient.” The Chinese search terms were: “提取练习” (“retrieval practice”), “提取练习效应” (“retrieval-practice effect”), “测试效应” (“testing effect”), “临床” (“clinical”), “治疗” (“treatment”), “康复” (“rehabilitation”), “患者” (“patient”), and “病人” (“patient”) (de Lima et al., 2020). The above Chinese and English search terms were combined using Boolean operators (OR/AND) according to the rules of each database. For example, the English search string was: (“Retrieval Practice” OR “Testing Effect”)

AND (“Clinical”OR “Treatment”OR “Rehabilitation”OR “Patient”). Meanwhile, the publication period was restricted to January 1, 2020, through July 1, 2025. After screening, 407 records were initially obtained. Subsequently, supplementary manual searches were also conducted, mainly in two respects. First, the reference lists of the included studies were traced backward to identify potentially

missed relevant studies. Second, the research outputs of relevant researchers or teams in this field were searched manually. Through manual searching, an additional 15 records were obtained. After duplicate records were removed, 313 records were ultimately obtained.

2.2 Literature Inclusion and Exclusion Criteria

The inclusion criteria for this review were as follows: 1) the article should be an empirical study published in a peer-reviewed journal. 2) The study sample should come from a clinical population (meeting the diagnostic criteria for a particular clinical disorder, except for control groups). 3) In the experimental design, a retrieval-practice paradigm should be adopted, including learning, retrieval, and final-test phases. 4) For the variable of learning method, there should be two or more different levels (e.g., retrieval practice and restudy), or different forms of retrieval practice should be compared (e.g., delayed retrieval and immediate retrieval). The exclusion criteria were as follows: 1) the language of writing was neither Chinese nor English. 2) The full text could not be obtained. 3) The article was not an empirical study, such as a review or meta-analysis. 4) The article was not published in a peer-reviewed journal, such as conference papers, dissertations, and so forth.

2.3 Literature Screening and Information Extraction

The literature screening process in this study followed the PRISMA standard (Moher et al., 2009). Two authors independently conducted literature screening and information extraction. After completion, the two cross-checked each other' s screening results and extracted information. The extracted information included: title, author, publication time, participants, learning materials, learning method, final-test time point, and conclusion. The classification consistency between the two authors during title-and-abstract preliminary screening, full-text screening, and information extraction was 0.98, 0.93, and 0.92, respectively (Xu Jianping, Zhang Houcan, 2005). In cases of disagreement, the third author was consulted, who made the final decision.

The specific screening process and changes in the number of records were as follows (Figure 1): after 109 duplicate records were removed, 313 records remained and entered the title-and-abstract preliminary screening stage. At this stage, according to the inclusion and exclusion criteria, 277 records not relevant to the topic, 6 review articles, and 6 dissertations were excluded, leaving 24 records for full-text screening. In the full-text screening stage, a further 1 record with a duplicate sample and 1 record that did not conform to the retrieval-practice paradigm were excluded. Ultimately, after full-text screening, a total of 22 records were included.

2.4 Quality Assessment

2.4.1 Assessment Methods and Process

To assess the methodological quality of the included studies, this study conducted a risk-of-bias assessment. According to de Lima et al. (2020), the assessment was carried out using a seven-domain checklist developed based on the templates of Higgins et al. (2019) and Ding et al. (2015). The checklist contained seven domains, assessing: randomization process (Domain 1), missing outcome data (Domain 2), outcome measurement (Domain 3), scoring (Domain 4), selective reporting (Domain 5), multiple final tests (Domain 6), and initial learning (Domain 7). This tool evaluates dimensions such as randomization, missing data, scoring, and reporting, and conforms to the general standards of psychological research. Among these domains,

Domains 6 and 7 targeted the experimental design of retrieval-practice studies and were applicable to research in this field. Two authors independently assessed the risk of bias for all included studies; the agreement of the bias assessments was 93.51% (Flight & Julious, 2015). Any disagreements in the assessment were discussed with the third author, who made the final decision.

Figure 1. Literature-screening flowchart

- Records obtained through database searches, $n = 407$
  Chinese databases:
  CNKI $n = 5$
  Wanfang $n = 7$
  VIP $n = 80$
  English-language databases:
  Web of Science $n = 82$
  ScienceDirect $n = 216$
  Wiley Online Library $n = 17$
- Records obtained through manual searching, $n = 15$
- Total records obtained, $n = 422$
  - Duplicate records removed: 109 articles
- Records obtained after removing duplicates, $n = 313$
  - Removed after reading titles and abstracts:
    Articles not relevant to the topic: 277
    Existing review articles: 6
    Theses/dissertations: 6
- Records obtained after reading titles and abstracts, $n = 24$
  - Removed after full-text reading:
    Articles with duplicate samples: 1
    Article not conforming to the retrieval-practice paradigm: 1

- Articles ultimately included in the analysis, $n = 22$
  They were:
  Developmental language disorder $n = 5$
  Attention-deficit/hyperactivity disorder $n = 3$
  Alzheimer' s disease $n = 2$
  Aphasia $n = 2$
  Hearing impairment $n = 2$
  Stroke $n = 1$
  Schizophrenia $n = 3$
  Early psychosis $n = 1$
  HIV infection $n = 1$
  Down syndrome $n = 1$
  Developmental dyslexia $n = 1$

2.4.2 Evaluation Results

Referring to the similar evaluation methods and criteria in Wei Yiting et al. (2024), among the studies included in this article, high-quality articles (with low risk in 6–7 domains) accounted for 27.27% (6/22), medium-quality articles (with low risk in 3–5 domains) accounted for 68.18% (15/22), and low-quality articles (with low risk in 1–2 domains) accounted for 4.55% (1/22). The final evaluation results showed that the overall quality of the 22 included studies was moderate. Among them, regarding the randomization process, 21 studies were rated as low risk, and 1 study had unclear risk. Regarding final testing, no studies were rated as high risk, but 9 studies had unclear risk because of insufficient reporting of details. All studies were rated as low risk in terms of selective reporting.

The uncertainty of the evidence is mainly reflected in the following aspects. First, with respect to repeated final tests, there were 12 high-risk studies; because the tests themselves constituted additional practice, this may have overestimated the long-term effects of retrieval practice. Second, with respect to scoring bias, 10 studies had an unclear risk, likely because electronic automatic scoring was used and the studies did not specify whether scoring was blinded or report scorer reliability. Third, with respect to missing data, 1 study was at high risk and 6 had an unclear risk; some studies did not report systematic differences between dropouts and completers. Fourth, with respect to information on initial learning, 2 studies were at high risk and 2 had an unclear risk; insufficient reporting of the learning phase may affect attribution of the effects of retrieval practice.

Overall, the above results indicate that the conclusion that retrieval practice has positive effects in clinical populations is relatively robust. The included studies were generally of good quality in core methodological dimensions such as randomization, outcome measurement, and selective reporting, thereby strengthening the credibility of the evidence. However, the certainty of the long-term effects of retrieval practice in clinical populations may be constrained by repeated testing. Future studies should control for interference from repeated testing and

report in detail the scoring procedures, missing data, and performance during the learning phase.

3 Results

This review included a total of 22 studies, mainly examining the application effects of retrieval practice as a cognitive intervention strategy in different clinical populations. Overall, these studies showed the following characteristics (Table 1). First, in terms of disease distribution, the studies were highly concentrated on neurological disorders (16 articles in total), among which studies on Developmental Language Disorder (DLD) predominated (5 articles). There were also 3 articles on Attention Deficit/Hyperactivity Disorder (ADHD); 2 articles each on Alzheimer Disease (AD), People with Aphasia (PWA), and Deaf and Hard of Hearing (DHH); and 1 article each on Stroke Survivors (SS) and Developmental Dyslexia (DD). In the field of Schizophrenia (SP), there were 3 articles. Another article focused on Early Psychosis (EP), but its participants still mainly belonged to the schizophrenia spectrum. In addition, 1 article each involved people with HIV infection and Down Syndrome (DS). Second, in terms of research design, all 22 studies used experimental or quasi-experimental designs: 16 adopted mixed experimental designs, 3 were between-subjects designs, and 3 were within-subjects designs. Sample sizes ranged from 11 to 92 participants (excluding healthy control groups). All studies included a retrieval-practice condition or different forms of retrieval practice, such as spaced retrieval and generative retrieval. The intervention targets were mostly the promotion of declarative memory, while a small number of studies examined episodic memory and complex cognitive tasks. The dependent-variable indicators were mainly accuracy in immediate or delayed recall/recognition, with testing intervals ranging from immediate testing to 3 months. Most studies demonstrated that retrieval practice, or its different forms, had advantages over control learning conditions; some studies also compared the differential effects of different forms of retrieval. This finding preliminarily confirms the application potential of this intervention in clinical populations. The following sections will elaborate on the research findings by disease category.

Table 1. Basic characteristics of the included studies

Study	Participants	Materials	Final test time point	Learning approach and main comparative results
Boundy et al., 2025	Children with Down syndrome (n=11)Healthy control group (n=11)	Novel nouns andtheir pictures and meanings	5 minutes, 1 week	Repeated immediate retrieval > repeated study
de Diego-Lázaro, 2025	Children with hearing impairment (n=16)Healthy control group (n=26)	Meaningless words andcor-responding pictures	Immediate, 1 day, 1 week	Immediate retrieval > no re-trievalSpaced retrieval > no retrieval-Immediate retrieval = spaced retrieval
Evans et al., 2020	Stroke patients (n=20)Healthy control group (n=20)	Name–face pairs	30 minutes, 1 week	Retrieval practice > spaced repeated studyRe-trieval practice > massed study
Knouse et al., 2020	Patients with attention-deficit/hyperactivity disorder (n=58)Healthy control group (n=121)	Psychological concepts	1 week	Fixed-criterion retrieval > self-regulated retrieval
Leonard et al., 2020	Children with develop-mental language disorder (n=13)Healthy control group (n=13)	Novel nouns andtheir pictures and meanings	5 minutes, 1 week	More retrieval and less restudy > more restudy and less retrieval

Study	Participants	Materials	Final test time point	Learning approach and main comparative results
Leonard et al., 2023	Children with developmental language disorder (n=11)Healthy control group (n=12)	Novel inanimate and animate verbs andtheir videos	5 minutes, 1 week	Repeated spaced retrieval > repeated study
Leonard, Deevy et al., 2024	Children with developmental language disorder (n=14)Healthy control group (n=13)	Novel transitive verbs andmultiple videos	5 minutes, 1 week	Repeated spaced retrieval > repeated study
Leonard, Christ et al., 2024	Children with developmental language disorder (n=14)Healthy control group (n=14)	Novel nouns andtheir pictures and meanings	5 minutes, 1 week	Expanded-interval retrieval = equal-interval retrieval
Li et al., 2024	Patients with schizophrenia (n=92)	3D spatial routes	Immediately after a distractor task	Interim test > repeated study
Middleton et al., 2022	Patients with aphasia (n=12)	Semantic minimal word pairs andpictures	1 day, 1 week	Generative retrieval practice > errorless learningComprehension-based retrieval practice = repeated study

Study	Participants	Materials	Final test time point	Learning approach and main comparative results
Minear et al., 2023	Patients with attention-deficit/hyperactivity disorder (n=36)Healthy control group (n=36)	Swahili-Englishword pairs	2 days	Retrieval practice > repeated study
Pan et al., 2025	Patients with schizophrenia (n=52)	Two-character words	Immediate, 1 day	Retrieval practice > repeated study
Ragland et al., 2020	Patients with early psychosis (n=20)Healthy control group (n=20)	Knowledge about psychosis	7 to 10 days	Retrieval practice > repeated study

Note: ">" indicates that the intervention effect of the former is superior to that of the latter; "=" indicates no significant difference in intervention effects between the two. The same applies below.

Continued table

Study	Participants	Materials	Final test time point	Learning method and main comparative results
Reimer et al., 2024	Children with hearing impairment (n=16)	Novel nouns and their pictures	2 days	Retrieval practice > repeated study
Small & Cochrane, 2020	Patients with Alzheimer' s disease (n=15)	Details of recent events(including videos and cues)	1 week, 1 month,3 months	Spaced retrieval > unspaced retrieval

Study	Participants	Materials	Final test time point	Learning method and main comparative results
Souto et al., 2025	Children with developmental language disorder (n=13)Healthy control group (n=14)	Novel nouns and their meanings	5 minutes, 1 week	Repeated spaced retrieval > repeated study
Stamate et al., 2020	Patients with Alzheimer' s disease (n=33)Healthy control group (n=42)	Fable stories	1 month	Multiple tests > single test
Stern & Halamish, 2023	Patients with attention-deficit/hyperactivity disorder (n=36)Healthy control group (n=36)	Prose	2 days	Whole-text recall > segmented recallWhole-text recall = repeated studySegmented recall = repeated study
Tan et al., 2024	Patients with schizophrenia(Experiment 1: n=64; Experiment 2: n=60)Healthy control group(Experiment 1: n=64; Experiment 2: n=60)	Experiment 1:2D planar routeExperiment 2:3D spatial route	Immediately after a distractor task	Interim testing > repeated study

Study	Participants	Materials	Final test time point	Learning method and main comparative results
Wang et al., 2020	Patients with aphasia (n=11)Young healthy control group (n=18)Older healthy control group (n=18)	Word pairs, picture pairs	10 minutes, 2 days	Spaced retrieval > massed retrieval
Wilschut et al., 2025	Patients with reading disorder (n=57)Healthy control group (n=61)	Swahili-Englishword pairs	Immediate	Verbal retrieval > typed retrieval
Woods et al., 2021	HIV-infected individuals (n=41)	Knowledge of a fictional disease	20 minutes	Spaced retrieval practice with self-generation enhance-ment> massed study

3.1 The Role of Retrieval Practice in Populations with Neurological Disorders

3.1.1 Developmental Language Disorder

Compared with age-matched healthy children, children with developmental language disorder (DLD) show significantly lower abilities in language comprehension and expression (Freudenthal et al., 2021). Multiple studies by Leonard' s team have shown that retrieval practice can effectively improve vocabulary learning outcomes in children with DLD (Leonard et al., 2019, 2020, 2022, 2023; Haebig et al., 2019; Souto et al., 2025). In learning novel pseudowords (e.g., /bog/), repeated spaced retrieval (e.g., a 0-3-3 schedule) is superior to repeated study (Leonard et al.,

2019). Moreover, compared with "more restudy and less retrieval" (continuing to restudy after initial mastery, with no further retrieval), children with DLD

showed better memory outcomes under "more retrieval and less restudy" (continuing to retrieve after initial mastery, with no further restudy) (Leonard et al., 2020).

In addition, integrating retrieval practice into picture-book reading activities can significantly improve children with DLD in recalling word forms and word meanings, providing an operationally feasible practical approach for DLD intervention (Souto et al., 2025). In sum, DLD is currently the area with the strongest body of evidence. However, optimizing retrieval intervals remains a core challenge: in long-term memory retention, the learning effect of expanding retrieval (e.g., 0-1-1-3-3) has not been shown to be significantly superior to that of equal-interval retrieval (0-3-3-3-3) (Leonard, Christ et al., 2024). Although the advantage of spaced retrieval practice is still maintained after one week, the effect size decreases slightly (Leonard et al., 2021). Furthermore, verb learning is more complex and more difficult for children with DLD. Although retrieval practice can improve verb-learning performance on immediate tests, the effect size is moderate, and its effects on verb morphological transformation (e.g., ing) and syntactic transfer are limited (Leonard et al., 2023). Retrieval practice may play a positive role in the learning and memory of children with DLD by enhancing encoding or improving retrieval precision. However, its specific cognitive mechanisms remain unclear, and its intervention effects on verb morphological transformation and flexible use remain insufficient (Leonard et al., 2021; Leonard, Deevy et al., 2024). Future research should continue to investigate these limitations in depth.

3.1.2 Attention-Deficit/Hyperactivity Disorder

The working memory and long-term memory of individuals with attention-deficit/hyperactivity disorder (ADHD) are significantly impaired (Yu Xue, 2020; Skodzik et al., 2017). Three studies preliminarily indicate that the application of retrieval practice in individuals with ADHD has begun to receive attention, but the conclusions are not yet fully consistent. Knouse et al. (2020) showed that individuals with ADHD performed better under fixed-criterion retrieval practice (with a minimum criterion for the number of successful retrievals) than under self-regulated retrieval practice (self-determining the number and timing of retrieval attempts). Although this study reported patients' medication status, it did not examine the influence of pharmacological treatment on retrieval practice. Further, Stern and Halamish (2023) did not observe a retrieval practice effect, which may have been related to participants' discontinuation of medication before the experiment. Minear et al. (2023) further examined the influence of patients' medication status on retrieval practice. This study showed that retrieval practice was more effective when patients were medicated than when they were unmedicated. This suggests that although retrieval practice is effective, it may not compensate for basic encoding problems, and its effects may be moderated by patients' encoding ability. Therefore, future research could further clarify the interaction among retrieval practice, patients' basic encoding

function, and medication status.

3.1.3 Alzheimer' s Disease

Existing studies have shown that spaced retrieval practice training is an effective means of improving semantic memory in Alzheimer' s disease (AD) (Oren et al., 2014). Recent studies have also demonstrated that spaced retrieval practice can improve the decline of episodic memory in patients with AD, with more pronounced effects when cues are provided (Small & Cochrane, 2020). In addition, although patients with AD already show obvious deficits at the memory-encoding stage, the repeated-retrieval group still performs better than the single-retrieval group, suggesting that retrieval practice may partially compensate for their encoding and storage deficits (Stamate et al., 2020). Current evidence indicates that spaced retrieval practice may enhance immediate episodic recall by strengthening cue associations, whereas repeated retrieval may alleviate long-term accelerated forgetting by consolidating memory traces. However, research on this disease

Further work should explore more training sessions and denser training intervals, and should combine imaging evidence to investigate its sustained effects and neural mechanisms in depth.

3.1.4 Aphasia

Existing studies have demonstrated that retrieval practice has a positive effect on vocabulary learning in patients with aphasia (PWA) (de Lima et al., 2020; Nunn & Vallila-Rohter, 2023). In addition, evidence from Wang et al. (2020) indicates that spaced retrieval practice is significantly more effective than massed retrieval practice, and that retrieval practice is more effective for word materials than for picture materials. This reveals the application potential of spaced retrieval in promoting word-association learning among PWA patients. Middleton et al. (2022) found that generative retrieval practice (e.g., picture naming) has additional advantages over errorless learning, and that retrieval practice has a certain positive effect on improving lexical-semantic comprehension deficits. Although these findings are insightful, the subtypes of PWA patients are diverse and interindividual differences are substantial, which may limit the scope of applicability of the conclusions and increase the difficulty of clinical translation. At the same time, the intervention effects of retrieval practice on cross-domain associative learning in this population, as well as its cognitive mechanisms, remain weak links in current research.

3.1.5 Other Neurological Diseases

Two studies on hearing impairment (DHH) both support the positive effects of retrieval practice. The experiment by de Diego-Lázaro (2025) found that DHH children's vocabulary recognition performance under both immediate and spaced retrieval conditions was superior to that under passive learning (no-retrieval)

conditions. Reimer et al. (2024) pointed out that comorbidities (such as Waardenburg syndrome) are important factors affecting the effectiveness of retrieval practice in DHH children. Although the above findings provide preliminary evidence for vocabulary intervention in DHH children, research in this field remains relatively insufficient, and future work needs to systematically evaluate its application effects in clinical and educational practice. At present, there are only a small number of studies in the field of stroke (SS) (Evans et al., 2020). Preliminary evidence suggests that retrieval practice may enhance SS patients' memory for name–face associations, and that it has advantages in both short-term and long-term retention. Future studies need to verify its effects across different cognitive tasks. Research on developmental dyslexia (DD) has found that verbal retrieval practice can alleviate the learning disadvantage caused by typing in patients with DD; the problem lies mainly in delays in encoding and production rather than in memory itself (Wilschut et al., 2025). However, research on this population still has considerable room for expansion.

3.1.6 Evidence and Limitations of Retrieval Practice in Populations with Neurological Diseases

Overall, existing evidence demonstrates that retrieval practice can improve memory function in some patients with neurological diseases, especially showing a certain facilitative effect in vocabulary learning and declarative memory tasks. Current evidence is highly concentrated on vocabulary-learning tasks, with a small number of studies involving face–name associative memory, episodic memory, and semantic memory. The operational form of retrieval practice is mainly spaced retrieval. However, the following research limitations remain. First, disease coverage is uneven. Evidence is relatively sufficient for developmental language disorder, aphasia, and Alzheimer' s disease, whereas there are only a small number of studies on attention-deficit/hyperactivity disorder, stroke, and developmental dyslexia. Second, the disease specificity of cognitive mechanisms remains unclear. Whether retrieval practice improves memory outcomes by compensating for encoding deficits, strengthening retrieval pathways, or consolidating memory traces may vary across diseases, but cross-disease comparative research is currently lacking. Third, ecological validity and transfer effects are limited. Most studies use pseudowords or laboratory tasks, and evidence regarding complex tasks and long-term effects

(such as the application of grammatical rules and improvements in everyday functioning) remains weak. Fourth, guidance is lacking for personalized intervention parameters. There are as yet no clear disease-type-specific recommendations regarding the optimal retrieval interval, task format, or whether retrieval practice should be combined with medication or encoding strategies.

3.2 The role of retrieval practice in schizophrenia

Previous studies have shown that retrieval practice can produce the forward testing effect (The Forward Testing Effect) in patients with schizophrenia, im-

proving their memory for newly learned spatial information (Li et al., 2024; Tan et al., 2024). Continuous periodic transcranial direct current stimulation (Transcranial Direct Current Stimulation, tDCS) targeting the left dorsolateral prefrontal cortex (Left Dorsolateral Prefrontal Cortex, L-DLPFC) can promote the elaborative organization of semantic information, thereby enhancing the interventional effects of retrieval practice (Pan et al., 2025). Together, these findings reveal a hierarchical intervention model: retrieval practice at the behavioral level can optimize memory retrieval outcomes, while neuromodulation techniques may provide supportive conditions for memory retrieval and consolidation by influencing neural networks and cognitive organizational strategies. However, the intrinsic neural mechanisms underlying their synergistic effects remain to be explored in depth—for example, how tDCS can more precisely modulate the cognitive and neural circuits related to retrieval practice. This may provide an important direction for developing more individualized combined intervention programs.

In addition, one study focused on early psychosis (EP), including schizophrenia, bipolar I disorder with psychotic symptoms, and major depressive disorder (Ragland et al., 2020). The study found that retrieval practice significantly improved long-term retention of clinically relevant information in patients with EP, and that individuals with milder negative symptoms benefited more substantially. However, because there is only a single report and the sample was highly heterogeneous, the effects of retrieval practice across different symptom dimensions and diagnostic subtypes remain unclear, and future studies should replicate these findings in larger samples.

Overall, the existing evidence supports the ability of retrieval practice to improve memory function in patients with schizophrenia. The studies have mainly used spatial memory tasks and semantic memory tasks, and have also combined retrieval practice with transcranial direct current stimulation to explore the neural mechanisms of cognitive enhancement. In addition, one study examined the role of retrieval practice in declarative memory among patients with early psychosis. However, current research still has the following limitations. First, disease coverage is insufficient. Apart from schizophrenia, there has been no systematic research on the effects of retrieval practice in other psychiatric disorders associated with memory deficits, such as bipolar disorder and major depressive disorder. Second, the range of task types is relatively narrow. Existing studies have mostly focused on spatial memory tasks and verbal memory tasks, while examinations of complex memory tasks or highly ecologically valid memory tasks remain relatively lacking. Finally, research on intervention interactions is insufficient. Multimodal treatment is often used in the clinical treatment of psychiatric disorders such as schizophrenia, but the synergistic effects of retrieval practice with conventional interventions such as pharmacotherapy and physical therapy still need to be verified.

3.3 The role of retrieval practice in individuals with HIV infection and children with Down syndrome

Woods et al. (2021) found that spaced retrieval practice with self-generation booster (Spaced Retrieval Practice with Self-Generation Booster) can effectively improve memory for and retention of health-related information in individuals with HIV infection, providing a feasible pathway for clinical intervention. Children with Down syndrome (DS) have significant difficulties in language acquisition (Filipe et al., 2022; Peter et al., 2025). Boundy et al. (2025) found that, compared with restudying, retrieval practice could more significantly improve the new

word recall rate, and the testing effect lasted for 1 week. This study extended the application of retrieval practice to hereditary diseases. Overall, retrieval practice has shown preliminary positive effects among people with HIV infection and children with Down syndrome; however, the number of relevant studies and sample sizes are both small, the evidence is concentrated on health-information memory or vocabulary-memory tasks, and evidence for long-term transfer effects and improvements in daily functioning remains lacking.

4 Discussion

This review systematically integrated studies published from January 2020 to July 2025 on the application of retrieval practice in clinical populations, covering multiple domains including neurological diseases, schizophrenia, infectious diseases, and hereditary diseases. The results indicate that retrieval practice shows substantial intervention potential for cognitive impairments such as memory deficits and language disorders in clinical populations, but its effects are moderated by multiple factors, including disease characteristics and task design.

4.1 Applicability of Retrieval Practice in Clinical Populations

The evidence included in this review suggests that, as a learning strategy, retrieval practice has demonstrated positive memory-enhancing effects across a variety of clinical populations. In populations with developmental disorders, its positive effects are reflected in promoting vocabulary memory in DHH children, DLD children, and patients with DD (de Diego-Lázaro, 2025; Leonard et al., 2023; Wilschut et al., 2025), as well as full-text recall in patients with ADHD (Stern & Halamish, 2023). In populations with acquired and neurodegenerative diseases, this strategy helps improve long-term episodic memory in patients with AD (Stamate et al., 2020), lexical-semantic comprehension in PWA (Middleton et al., 2022), memory performance for names in SS (Evans et al., 2020), and enhances new-information encoding efficiency in patients with SP and memory retention in patients with EP (Ragland et al., 2020; Tan et al., 2024). In addition, retrieval practice also has a certain facilitative effect on health-information memory in people with HIV infection and vocabulary memory in children with DS (Boundy et al., 2025; Woods et al., 2021).

These findings suggest that the memory-enhancing effect of retrieval practice may show a certain degree of application potential across heterogeneous clinical populations. Its potential mechanisms may involve modulation of the functions of core memory-related brain regions such as the hippocampus (Wiklund-Hörnqvist et al., 2021), but this inference still requires further validation in future studies targeting different clinical populations. Overall, the existing evidence preliminarily suggests that retrieval practice, as a cognitive intervention strategy, has certain cognitive intervention effects and clinical application potential, providing a basis for its subsequent movement toward broader standardized clinical application.

4.2 Population Specificity and Effect Boundaries of Retrieval Practice

Taken together, the existing evidence suggests that the role of retrieval practice in clinical populations may be that of a conditional cognitive compensation strategy. Its potential specificity and effect boundaries are preliminarily reflected in the following three aspects. These three aspects constitute a preliminary framework based on existing research and are intended to provide testable hypotheses for future studies.

4.2.1 Types of Core Cognitive Deficits in Disease

Existing studies suggest that the clinical effects of retrieval practice may be modulated by the type of core cognitive deficit associated with a disease. This inference is mainly based on comparative analyses of patients with AD and SP, and still requires supporting evidence from a wider range of disorders.

Stamate et al. (2020) pointed out that the real challenge for patients with AD lies in encoding difficulties. In view of this feature, retrieval practice can partially compensate for memory deficits, but preliminary evidence indicates that its compensatory effect may have an upper limit, or may require external support such as cues in order to maintain long-term effects (Small & Cochrane, 2020). By contrast, the cognitive impairment of patients with SP may be manifested more as a decline in interference-inhibition function (Weisbrod et al., 2000). Studies by Tan et al. (2024) and Pan et al. (2025) found that retrieval practice can improve memory by reducing proactive interference and promoting semantic organization. This suggests that, for patients with SP, the effectiveness of retrieval practice may lie in optimizing information representation and resistance to interference, thereby helping to mobilize cognitive-control resources that are still preserved but relatively inefficient.

On the basis of the above analysis, the following hypothesis is proposed for subsequent verification: when the impairment is concentrated at the encoding level, retrieval practice may require external support in order to exert lasting effects. When the impairment is concentrated at the level of retrieval and interference control, retrieval practice itself may serve as a relatively effective means of rehabilitation. Future research may broaden its scope by examining the applicability

of this hypothesis to other similar cognitive-disorder diseases.

4.2.2 Complexity and Ecological Validity of Learning Materials

Preliminary evidence from studies of children with DLD and patients with ADHD suggests that the complexity and ecological validity of materials may modulate the intervention effects of retrieval practice. With respect to complexity, when children with DLD learn verbs, retrieval practice can promote learning outcomes; however, compared with noun learning, its effect size is smaller, and retrieval practice does not improve their ability to convert grammatical forms (Leonard et al., 2023). This may be related to the cognitive load required when learning verbs and carrying out morphological conversion. This finding suggests that when material complexity exceeds the range that patients' cognitive load can bear, the additional cognitive cost of retrieval practice may outweigh its memory-consolidation effect (Zheng et al., 2023). However, systematic manipulation studies on material complexity remain limited, and the optimal difficulty ranges for different diseases are still unclear.

In terms of ecological validity, Stern and Halamish (2023) found no advantage of retrieval practice when using highly ecological text materials among patients with ADHD, whereas Souto et al. (2025) showed favorable effects when retrieval practice was embedded in picture-book reading. These preliminary findings suggest that retrieval practice may be more likely to exert a facilitating role in contexts consistent with everyday learning modes; however, the conditions under which ecological materials weaken or enhance the retrieval-practice effect still require further clarification through additional research.

4.2.3 Support from Multiple Treatment Modalities

Preliminary studies on patients with ADHD and SP suggest that the effects of retrieval practice may be modulated by other therapeutic approaches. First, in terms of pharmacological treatment, Stern and Halamish (2023) required participants with ADHD to discontinue medication before the experiment, which may be one reason why retrieval practice did not show an intervention effect. Conversely, the study by Minear et al. (2023) demonstrated that patients taking medication

performed better on the final test. This may be because medication improved the attention, motivation, and effort levels of patients with ADHD during the learning phase, thereby influencing their memory-encoding ability and indirectly enhancing the intervention effect of retrieval practice (Addicott et al., 2019; Rubinson et al., 2019). This comparison suggests that the cognitive readiness state provided by pharmacological treatment may be one of the important prerequisites for retrieval practice to take effect.

Second, the involvement of physical therapy suggests that the intervention effect of retrieval practice depends, to some extent, on the effectiveness of specific neural-circuit functions. Pan et al. (2025) used tDCS to stimulate the L-DLPFC

cortex in patients with schizophrenia and significantly enhanced the intervention effect of retrieval practice. This facilitative effect may arise from two mechanisms: on the one hand, tDCS provides a more favorable neural environment for retrieval practice by affecting the inhibitory function of γ-aminobutyric acid and promoting long-term potentiation (Long-term Potentiation). On the other hand, the L-DLPFC brain region stimulated and activated by tDCS may correspond to the neural mechanisms involved in retrieval practice (Zhuang et al., 2022). This finding suggests that optimizing the function of specific brain regions through external physical means may provide a favorable neural environment for retrieval practice. However, its reproducibility, mechanisms of action, and applicability across different diseases all require further examination.

In summary, existing evidence has preliminarily outlined the possibility of retrieval practice as a conditional cognitive compensation strategy. Its effectiveness may partly depend on the cognitive and neural foundational support provided by other therapeutic approaches. However, this conclusion remains an exploratory hypothesis and needs to be further validated across a broader range of disease categories.

5 Future Research Directions and Clinical Translation

5.1 Research on Retrieval Practice in Comorbid Populations

Comorbidity refers to an individual having two or more diseases. Compared with a single disease, the treatment of comorbidity faces more challenges (Lü Xiaoyan et al., 2022). In the studies covered by the present review, comorbidity was mostly treated as an exclusion criterion, or only the comorbidity rate of participants was reported. This situation may affect the clinical translation of retrieval practice.

The potential influence of comorbidity on the intervention effect of retrieval practice can be manifested in multiple ways. For example, patients with schizophrenia have a relatively high incidence of comorbid anxiety disorders (Veras et al., 2025), and anxiety disorders affect the accuracy and reaction time of working memory (Nguyen et al., 2025); this negative influence may weaken the effect of retrieval practice. When ADHD is accompanied by substance use disorder, addictive substances may have harmful effects on neural circuits related to learning and memory, such as the hippocampus (Meda et al., 2018; Ribeiro & França, 2025; Valeri et al., 2024). Only one study of DHH children has explored the role of retrieval practice in comorbid populations (Reimer et al., 2024), but existing research has not yet clarified whether retrieval practice can ameliorate such superimposed impairments. Moreover, in broader comorbid populations, the intervention effect of retrieval practice also remains unclear. In addition, the treatment environment for comorbid populations is more complex—for example, they may need to receive antidepressant and antipsychotic medication simultaneously—and the interactions between retrieval practice and these therapeutic approaches have not yet been explored.

Future research may focus on the following aspects. First, it should prioritize clinically prevalent comorbid combinations (e.g., schizophrenia comorbid with anxiety disorders), systematically verify the effectiveness of retrieval practice, and clarify its ameliorative effects on comorbidity-related cognitive deficits (e.g., memory impairment shared by the two disorders). Second, comorbid characteristics can be used to guide the optimization of intervention programs, specifically in two directions: one is to dynamically adjust retrieval intervals in response to memory decline in comorbid populations; the other is to improve the clinical fit of intervention measures by targeting the overlap in cognitive impairments associated with comorbidity. The value of research on comorbid populations lies not merely in expanding the coverage of research samples, but more importantly in making intervention programs better aligned with real clinical settings, thereby providing scientific support and practical guidance for the application of retrieval practice in complex cases.

5.2 Indirect Effects of Retrieval Practice

Existing studies have mostly focused on the direct effects of retrieval practice on declarative memory or language learning. However, the experiences generated during the retrieval process can also strengthen metacognitive monitoring and regulation. This ability can help individuals effectively distinguish known from unknown information, thereby optimizing learning decisions (Carpenter et al., 2020; Rivers, 2021; Endres et al., 2023). Such influences are defined as the indirect effects of retrieval practice (Endres & Renkl, 2022).

Compared with healthy populations, some clinical populations are often accompanied by multidimensional cognitive deficits. These may specifically manifest in metacognitive judgment, metacognitive monitoring, self-efficacy, sustained attention, and other domains (Drueke et al., 2023; Lai et al., 2024; Lehmann & Ettinger, 2023; Olsson et al., 2024). Retrieval practice shows potential for indirect intervention in these factors. For example, experiences of success or failure obtained during and after the retrieval process itself are important factors influencing individuals' subsequent retrieval or learning behaviors (Carpenter et al., 2020). Some clinical patients (such as those with anxiety or depression) have relatively high psychological sensitivity, manifested as being highly concerned about others' opinions and negative experiences (Fan et al., 2021). Therefore, using retrieval practice may allow patients to gain successful experiences, thereby improving deficits in metacognitive judgment among clinical patients (Drueke et al., 2023; Kubik et al., 2022), and further enhancing confidence and a sense of efficacy in learning and daily life. In addition, retrieval practice helps reduce proactive interference (Li et al., 2024; Mulligan & Buchin, 2025; Mulligan et al., 2022). This may enable patients to allocate fewer attentional resources to suppressing interfering information during subsequent learning or recall, thereby indirectly alleviating competition for attentional resources and ultimately improving the ability to concentrate.

In summary, given the complexity of cognitive deficits in clinical populations and

the potential of retrieval practice to indirectly intervene in cognitive functioning, future research may further explore the indirect effects of retrieval practice in clinical populations, providing new ideas for clinical cognitive intervention.

5.3 The Role of Individual-Difference Variables in Retrieval Practice among Clinical Populations

Although retrieval practice has shown application potential in clinical populations, existing studies have generally neglected in-depth examination of individual-difference variables within this group. Individuals' unique traits give rise to individual differences in the learning process, and such differences may influence the extent to which individuals benefit from retrieval practice (Smith-Peirce & Butler, 2025). For example, cognitive ability facilitates encoding and retrieval processes (Unsworth, 2019), and personality traits affect task engagement, quality of execution, and persistence (Smith-Peirce & Butler, 2025). In addition, retrieval practice consumes substantial working-memory resources, and its effects are influenced by individuals' working-memory capa-

capacity and the demands placed on working memory by the task (Zheng et al., 2023). Thus, individual differences in psychological characteristics may also influence the effects of retrieval practice.

Therefore, future research could shift perspective by placing these individual-difference factors at the core of the research framework and systematically examining their moderating effects in clinical populations. For example, patients with schizophrenia may have deficits in working-memory capacity (Yao et al., 2024). According to the Source of Activation Confusion model, when individuals have insufficient working-memory resources, the post-retrieval re-encoding process cannot proceed adequately, and the retrieval-practice effect may be weakened or disappear (Zheng et al., 2023). However, this mechanism has not been sufficiently studied in clinical patients. In addition, variables such as fluid intelligence and degree of effort may likewise play important moderating roles. Studies should directly quantify the influence of these factors by designing group comparisons within clinical populations, thereby providing empirical evidence for developing individualized intervention programs adapted to patients' cognitive characteristics.

5.4 Clinical Translation and Implementation of Intervention Programs

The clinical translation and implementation of retrieval-practice intervention programs require systematic thinking and multidimensional integration. Attention should be paid to the following aspects.

First, intervention goals should be clearly specified, and appropriate intervention materials should be selected accordingly. For example, the experimental goal of Middleton et al. (2022) directly targeted lexical-semantic comprehen-

sion impairments in patients with aphasia; therefore, semantically similar and easily confusable word pairs were selected as materials. Each set consisted of two semantically similar but distinct concepts and their corresponding pictures, such as a spider and a scorpion. Guided by this goal, the study designed two intervention conditions: production-based retrieval practice and comprehension-based retrieval practice. By comparing retrieval practice with a non-retrieval control condition, the study demonstrated the advantages of retrieval practice in improving lexical-semantic comprehension deficits.

Second, strategy instruction should be incorporated into the intervention process to improve adherence. Some research has suggested that people may be reluctant to use retrieval practice as a strategy (Karpicke et al., 2009), but direct guidance can effectively increase individuals' willingness and ability to use retrieval-practice strategies (Ariel & Karpicke, 2018). The above phenomenon and mechanism may also exist in clinical populations. Accordingly, the design of retrieval-practice interventions needs to go beyond simple task training and construct an integrated guidance system that includes explanation of principles (knowledge transmission), firsthand experience (skills training), and positive reinforcement (motivational regulation). This design is intended to help patients internalize the learning strategy, thereby increasing their willingness to actively apply retrieval practice in daily life and ultimately achieving generalization of the intervention effects.

Finally, a progressive implementation strategy should be adopted. Retrieval-practice training can be divided into the following three stages. First is the introduction stage. Retrieval practice is used as a supplement to patients' existing cognitive training or psychoeducation sessions. For example, before the end of each treatment session, 5 to 10 minutes of retrieval practice can be arranged, requiring patients to recall core knowledge points or events that occurred that day. This stage does not pursue training intensity; rather, it focuses on establishing an initial practice habit. Second is the expansion stage. As patients become more adapted, the intervention dose and task challenge can be gradually increased. On the one hand, the duration of retrieval practice can be extended; on the other hand, more functional individualized materials can be used, such as remembering new names or life information such as medication timing and dosage. At this point, retrieval practice has become the core component of the intervention program. Third is the generalization stage. The focus of this stage lies in the transfer of strategies. Patients begin to learn how to autonomously apply retrieval practice to

in daily life, such as spontaneously recalling events that occurred that day before going to sleep. Through this process, patients are helped to internalize retrieval practice as an autonomous, self-regulated learning tool, thereby achieving the goals of clinical intervention.

6 Shortcomings and Limitations of This Study

This study has the following main shortcomings and limitations. First, the literature should be included more extensively. Only 22 studies were included in this review, which is not comprehensive enough; the reasons may lie in the following two aspects. (1) Search strategy and time constraints. Relevant literature before 2020 had already been examined in a similar review (de Lima et al., 2020), so this study searched only the relevant literature from 2020 to 2025. In addition, this study searched only six databases, did not include preprints or contact relevant researchers to obtain potentially existing nonsignificant results, and did not make full use of truncation symbols in setting the search formulas; therefore, some relevant studies may have been missed. (2) According to the inclusion and exclusion criteria, among the included literature, the learning-method variable needed to have two or more different levels (such as retrieval practice and repeated learning), or different forms of retrieval practice needed to be compared (such as spaced retrieval and immediate retrieval); therefore, studies that examined only retrieval practice were excluded (e.g., Smith et al., 2024). Second, quantitative meta-analysis can be conducted. This study is a systematic review of the current research field and a prospect for future research. Future studies can conduct a meta-analysis of the effects of retrieval practice in related research to further analyze the magnitude of its effect in clinical populations. Third, the clinical scope of application of the conclusions should be treated with caution, for the following two possible reasons. (1) The included studies and diseases are highly heterogeneous. Different studies differ significantly in disease type and stage, learning materials, and dependent-variable indicators. (2) Laboratory tasks differ from real clinical contexts. Most tasks involve word or sentence learning under laboratory conditions, which differs to some extent from functional memory in real clinical situations (such as medication scheduling and daily planning), and long-term follow-up data are lacking.

7 Research Conclusions and Contributions

This study systematically reviewed applied research on retrieval practice in clinical populations from 2020 to 2025 and reached the following conclusions: retrieval practice has a certain degree of applicability to clinical populations. In some groups—such as patients with neurological disorders, schizophrenia, HIV infection, and Down syndrome—it can effectively improve cognitive impairments such as memory deficits and language disorders. However, its effects show specificity and boundaries of applicability. In some diseases, its effectiveness may be influenced by the type of core cognitive deficit, the complexity and ecological validity of the learning materials, and whether it is combined with other therapeutic methods. This study also identifies weak points in existing research, such as comorbid patients, the indirect effects of retrieval practice, and individual differences, thereby providing directions for subsequent research. In addition, from three aspects—clarifying intervention goals, strengthening guidance and psychoeducation, and adopting progressive implementation strategies—this

study proposes ideas and principles for the clinical translation of retrieval practice, aiming to promote its translation and application in real clinical settings.

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Retrieval practice in clinical populations: A systematic review

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Abstract: Retrieval practice is a learning strategy that improves memory efficiency by actively retrieving information from memory, typically through testing or free recall. Some clinical populations often present with memory or other cognitive impairments. This paper provides the first systematic review of research on retrieval practice in clinical populations. It covers studies published between January 2020 and July 2025 and includes 22 studies in total. The findings show that retrieval practice appears applicable to various clinical groups and alleviates cognitive deficits including memory and language impairments. However, for certain conditions, its effectiveness may be moderated by the core cognitive deficits inherent to these disorders, the complexity and ecological validity of the learning materials, and the presence of concurrent therapeutic interventions. Future studies could further explore these moderating factors and examine interventions for comorbid conditions, indirect benefits, and the role of individual differences. To advance clinical translation, it is recommended to clarify intervention goals, enhance guidance and education, and adopt a stepwise implementation strategy, thereby strengthening the clinical applicability of retrieval practice.

Keywords: retrieval practice, clinical, memory, cognitive rehabilitation

Note: Figure translations are in progress. See original paper for figures.