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Beyond Forgetting: Applying Information Processing Theory to Enhance English Language Learning Engagement in Children with Neurocognitive Impairment

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ABSTRACT

Children struggling with neurocognitive impairment frequently experience limitations in attention, working memory, and information retrieval. These conditions contribute to low learning engagement and difficulty retaining material in learning English as a Foreign Language (EFL) within inclusive classroom settings. This conceptual review applies Information Processing Theory (Atkinson & Shiffrin, 1968; Baddeley, 2017) to examine these cognitive challenges through three core stages: encoding, storage, and retrieval. Using a descriptive-qualitative approach, the study reviews 20 sources published predominantly between 2015 and 2025, comprising Scopus-indexed international research and relevant Indonesian studies. The synthesis identifies practical EFL strategies that can support students with neurocognitive impairment: (1) multisensory input combined with schema activation to strengthen encoding; (2) chunking paired with spaced repetition to improve storage and consolidation; and (3) retrieval practice using children's songs with missing lyrics and pictures and pragmatic contexts to boost retrieval and engagement. These strategies are feasible for inclusive settings. The review highlights the need for empirical intervention studies and targeted teacher training to effectively bridge cognitive psychology and inclusive EFL education.

1. INTRODUCTION

Differences in how the brains of children with neurocognitive impairment process information make English language learning in inclusive classrooms a challenge that cannot be addressed through conventional approaches. Neurocognitive impairment refers to neurological conditions affecting cognitive functions such as attention, memory, perception, and problem-solving (Sachdev et al., 2014; Gazzaniga et al., 2019; Cicerone et al., 2022). Children with neurodevelopmental impairment commonly experience difficulties in attention, working memory, and language processing, which directly impact their ability to comprehend and retain linguistic information (Helland & Morken, 2021; Conti-Ramsden et al., 2022). In Indonesia, the prevalence of children with neurocognitive barriers among school-aged children is with an upward trend in recent years (Sari & Sari, 2020). These conditions highlight the need of developing learning strategies that are more adaptive and grounded in cognitive needs, particularly in EFL contexts where linguistic input is novel and demanding.

In this study, neurocognitive impairment refers to developmental difficulties in children's cognitive processing, particularly in attention, working memory, and language-related functions (Helland & Morken, 2021). This scope excludes acquired neurological conditions and instead emphasizes neurodevelopmental profiles commonly encountered in inclusive primary classrooms. In inclusive primary EFL contexts, instructional approaches are therefore expected to align with children's developmental cognitive characteristics and support early language learning needs.

The Information Processing Theory proposed by Atkinson and Shiffrin (1968) explains that learning occurs through three primary stages: encoding, storage, and retrieval. Disruptions in any of these stages may hinder students' ability to retain vocabulary or linguistic structures over the long term (Baddeley, 2017; Kong et al., 2021). Contemporary research shows that strategies such as schema activation, retrieval practice, chunking, spaced repetition, and multisensory approaches can enhance information retention and learning engagement, particularly for students with attention and memory challenges (Adesope et al., 2017; Handayani, 2021; Roediger & Butler, 2011). For instance, schema-based instruction improves encoding (Julaid & Khaghaninejad, 2025), chunking and spaced repetition strengthen storage (Handayani, 2021), and retrieval practice through low-stakes testing or contextual tasks (e.g., children's songs with missing lyrics and pictures) significantly boosts long-term recall (Adesope et al., 2017; Sari & Sari, 2020).

The State of the Art (SotA) indicates that global research on EFL learning for children with neurocognitive impairment has largely focused on general challenges related to language development and memory, without fully exploring the specific application of Information Processing Theory in instructional practice (Helland & Morken, 2021; Conti-Ramsden et al., 2022; Kong et al., 2021). Key studies, such as Roediger and Butler (2011), emphasize retrieval practice's role in overcoming storage deficits, while Handayani (2021) highlight chunking's efficacy in EFL for neurodiverse learners. Other studies have contributed meaningfully to English language pedagogy through approaches such as flipped learning to enhance student engagement (Azhari & Yuniko, 2024), visual memory stimulation such as 4D flashcards, for young learners through classroom language (Azhari, 2022), and engaging vocabulary retrieval through children's songs with pictures and missing lyrics (Sari & Sari, 2020). These findings enrich pedagogical practices and provide a valuable foundation for innovation and can be adapted to inclusive classrooms. Positioned as a logical continuation of these contributions, this descriptive qualitative literature-based study seeks to extend the discussion. However, there remains an open space for examining how Information Processing Theory is operationalized specifically in English language learning for children with neurocognitive impairment in inclusive classrooms. This area has been minimally explored in prior research, offering opportunities for developing new perspectives.

Based on this gap, the present study aims to:

1. Analyze how Information Processing Theory is applied in EFL learning for children with neurocognitive impairments; and
2. Identify the most effective, practical strategies for enhancing engagement and retention in inclusive EFL classrooms.

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2. RESEARCH METHOD

This study employs a descriptive qualitative research design. It adopts a conceptual, library-based approach to examine the application of Information Processing Theory in EFL instruction for children with neurocognitive impairment in inclusive classrooms. As a conceptual study, the research does not involve primary data collection, experimental intervention, classroom observation, or human participants. Instead, it draws on secondary data to synthesize theoretical perspectives and pedagogical strategies, allowing for a systematic interpretation of cognitive challenges and instructional implications in inclusive EFL contexts.

The data sources consist exclusively of secondary materials, including peer-reviewed journal articles, books, book chapters, and conference proceedings published between 2015 and 2025. These sources were drawn from reputable national and international publications, including Scopus-indexed journals as well as selected Indonesian studies to ensure contextual relevance. The population of the literature included all academic publications addressing at least one of the following themes: (1) Information Processing Theory or related cognitive models, (2) EFL learning and teaching strategies, (3) neurocognitive impairments in children, and (4) inclusive education settings.

From this population, 20 publications were purposively selected as the sample of the literature. The selection was guided by clearly defined inclusion criteria to ensure methodological rigor and consistency. Specifically, the selected sources were required to (1) be published between 2015 and 2025, (2) demonstrate explicit or implicit relevance to cognitive processing stages—encoding, storage, and retrieval, (3) relate directly to EFL or foreign language learning contexts, particularly for children, and (4) be peer-reviewed and published by reputable national or international journals or academic publishers. The final number of sources was determined based on their conceptual relevance and the recurrence of key theoretical and pedagogical insights across the reviewed literature.

The literature review was intentionally delimited to 20 key publications to maintain conceptual depth and analytical coherence in synthesizing Information Processing Theory within inclusive EFL contexts. It represents foundational cognitive models, empirical studies on neurodevelopmental cognitive profiles, and pedagogical research on EFL instruction. The selected literature is aligned with the stages of encoding, storage, and retrieval. This delimitation enabled focused cross-study comparison and reduced redundancy across overlapping findings. Within this scope, each stage of the information processing framework was adequately represented, ensuring sufficient theoretical and empirical coverage relevant to inclusive primary education.

Data collection was conducted through a manual literature search between October and November 2025 using four major databases: Google Scholar, Garuda Portal, Scopus, and ERIC. Keywords used in the search included "information processing theory," "neurocognitive impairments," "working memory," "inclusive EFL learning," "learning engagement," "multisensory," "retrieval practice," and "chunking," along with their Indonesian equivalents such as "teori pemrosesan informasi," "hambatan neurokognitif," and "pembelajaran EFL inklusif." The process involved initial screening of titles and abstracts to assess relevance, followed by full-text reading of potentially

suitable sources. Selected references were systematically recorded in a summary table containing author(s), year of publication, main findings, target population, and relevance to the stages of information processing.

Data analysis was carried out using descriptive qualitative content analysis. This involved close reading of the selected sources, identification of key findings related to encoding, storage, and retrieval processes, and categorization of EFL instructional strategies relevant to learners with neurocognitive impairment. The findings were then synthesized to generate theoretically grounded and practically oriented recommendations for inclusive primary EFL classrooms.

3. RESULTS

The synthesis of 20 selected sources reveals that Information Processing Theory provides a robust framework for addressing cognitive challenges in EFL learning for children with neurocognitive impairment in inclusive classrooms. Findings are organized thematically by the three core stages of processing: encoding, storage, and retrieval. Primary insights derive from Scopus-indexed studies directly linking the theory to neurocognitive deficits in language acquisition, supplemented by local EFL strategies for contextual applicability.

3.1. Encoding Stage: Enhancing Initial Attention and Sensory Input

Children with neurocognitive impairment often face barriers in selective attention and sensory processing, impeding the transformation of linguistic input into mental representations (Helland & Morken, 2021; Conti-Ramsden et al., 2022). Scopus-indexed research highlights schema activation and multisensory input as key strategies to bolster encoding, with evidence showing reduced attentional overload and improved initial retention (Kong et al., 2021).

1. Schema activation in pre-reading: Juliad and Khaghaninejad (2025) demonstrated that cognitive reading strategies based on schema activation (pre-reading activities such as personal experience questions, picture-based prediction, and thematic brainstorming) enhances cognitive engagement in EFL learners with low proficiency (including those with neurocognitive impairment such as developmental language disorder), fostering theory of mind development and reducing sensory distractions for children with neurocognitive impairment. This aligns with Information Processing Theory by providing cognitive frameworks for input integration.
2. Multisensory classroom language: Azhari (2022) illustrated that visual-supported classroom instructions (e.g. 4D Flashcard with pictures that can move and produce a sound) clarify EFL input for young learners, minimizing ambiguity and supporting encoding in diverse classrooms.

These strategies mitigate encoding failures rooted in unbalanced sensory filters (Atkinson & Shiffrin, 1968), where schema activation serves as a modulator to lower cognitive load (Baddeley, 2017). Kefallinou et al. (2020) further notes that in inclusive EFL environments, multisensory approaches promote interaction and tolerance, bridging neurocognitive differences. For Indonesian inclusive classrooms, integrating schema activation with visual aids like 4D flashcards (Azhari, 2022) offers a way to transform

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passive input into active processing, potentially enhancing early retention by leveraging familiar cultural contexts.

3.2. Storage Stage: Managing Working Memory and Consolidation

Working memory limitations in children with neurocognitive impairment led to information leakage before consolidation into long-term memory (Alloway & Gathercole, 2018). These studies emphasize chunking and spaced repetition as effective interventions, indicating improved consolidation through distributed practice (Cepeda et al., 2006).

1. Chunking for vocabulary retention: Handayani (2021) found that chunking EFL vocabulary into thematic units (3–5 items) reduces working memory overload in children with learning disabilities, facilitating storage and rehearsal in inclusive settings.
2. Spaced repetition in flipped models: Azhari & Yuniko (2024) showed that flipped classroom reviews—pre-lesson exposure followed by distributed practice—strengthen EFL consolidation, aligning with spaced repetition principles for neurocognitive barriers.

Storage disruptions stem from low working memory capacity (Baddeley, 2017), where chunking compresses information for rehearsal (Cepeda et al., 2006), and spaced repetition exploits sleep-dependent consolidation Handayani (2021). In EFL, these strategies outperform massed practice for neurodiverse learners, as per Handayani (2021). Furthermore, Azhari & Yuniko (2024) adapt flipped models without technology, making them feasible for Indonesian inclusive classrooms and addressing resource gaps.

3.3. Retrieval Stage: Facilitating Access and Application

Retrieval deficits in children with neurocognitive impairment result in inconsistent recall despite successful storage (Roediger & Butler, 2011). Scopus research underscores retrieval practice and contextual cues as catalysts, with testing effects strengthening neural pathways for linguistic recall (Fazio & Marsh, 2019; Adesope et al., 2017).

1. Retrieval practice in reading tasks: Adesope et al. (2017) revealed that low-stakes retrieval (e.g., quizzes on EFL texts) boosts long-term recall in children with learning disabilities, enhancing access through repeated activation.
2. Contextual song-based retrieval: Sari & Sari (2020) demonstrated that inserting pictures in missing lyrics of children's songs significantly enriched elementary EFL vocabulary retrieval. The activity combines visual cues and contextual recall, making it highly engaging and effective for young learners in inclusive settings.

Retrieval failures arise from weak executive cues (Atkinson & Shiffrin, 1968), where testing effects reinforce synaptic strength (Roediger & Butler, 2011), and contextual cues reduce interference (Fazio & Marsh, 2019). Locally, Sari & Sari (2020) provide a practical, low-cost, and fun example: children's songs with missing lyrics and pictures stimulate active recall and reinforce vocabulary in a meaningful, multimodal context — ideal for Indonesian inclusive EFL classrooms.

3.4. Integrated Cognitive Processing in Inclusive EFL Learning

Rather than operating as isolated instructional techniques, the strategies discussed across the encoding, storage, and retrieval stages demonstrate an interconnected cognitive process in inclusive EFL learning. The analysis of theory-driven empirical and contextual studies cited in this article indicates that learning difficulties experienced by children with neurocognitive impairment often reflect cumulative disruptions across processing stages, rather than deficits at a single point of instruction.

Difficulties observed during retrieval, for instance, are frequently rooted in earlier challenges during encoding, such as attentional overload or insufficient sensory clarification (Helland & Morken, 2021; Conti-Ramsden et al., 2022). From an Information Processing perspective, retrieval failure should therefore be understood as a downstream effect of incomplete or fragile mental representations, rather than as an isolated memory weakness. This reinforces the importance of early instructional support that ensures input is meaningfully encoded before being rehearsed or assessed.

Instructional sequencing emerges as a critical factor in supporting this continuity. Schema activation and multisensory input do not merely enhance initial attention, but also organize linguistic information into coherent cognitive structures that facilitate subsequent storage (Kong et al., 2021). When these structures are reinforced through chunking and spaced review, the cognitive demands placed on working memory are reduced, allowing information to be consolidated more effectively (Baddeley, 2017; Cepeda et al., 2006). As a result, retrieval practices—such as low-stakes quizzes or contextual recall activities—become more accessible for learners with attention and executive function difficulties.

Learner engagement represents another cross-stage pattern identified in this integrated analysis. Multisensory materials, song-based activities, and low-pressure retrieval practices were consistently associated with sustained attention and reduced learning anxiety in inclusive classrooms (Adesope et al., 2017; Fazio & Marsh, 2019; Sari & Sari, 2020). In this sense, engagement functions not only as an affective outcome but also as a cognitive facilitator that supports the smooth transfer of information across processing stages.

From an inclusive education standpoint, Information Processing Theory provides a unifying framework that accommodates learner variability without lowering instructional expectations. The strategies discussed do not simplify linguistic content; instead, they restructure instructional delivery to align with learners' developmental cognitive profiles, thereby promoting equitable access to EFL learning (Baddeley, 2017; Nijakowska & Kormos, 2020).

Within the Indonesian context, local studies demonstrate that cognitively informed strategies can be effectively implemented through visual supports such as 4D flashcards and vocabulary enrichment using song media (Azhari, 2022; Sari & Sari, 2020). Furthermore, innovations in instructional delivery models, such as flipped learning, indicate a capacity to restructure English language teaching to be more adaptive (Azhari & Yuniko, 2024). These strategies hold significant potential for adaptation within inclusive classrooms to meet the specific requirements of students with special needs, while ensuring that the teacher's role remains central in providing structured and impactful English instruction (Azka et al., 2025).

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Table 1
EFL Strategies Aligned with Information Processing Theory Stages (Synthesized from 20 Sources).

No	Stage	Strategy	EFL Application Example	Key Sources
1.	**Encoding**	Schema activation and multisensory input	Pre-reading brainstorming and visual anchors	Julaid and Khaghaninejad (2025); Kong et al. (2021); Azhari (2022)
2.	**Storage**	Chunking and spaced repetition	Thematic vocabulary groups, weekly review, flipped exposure	Handayani (2021); Cepeda et al. (2006); Azhari & Yuniko (2024)
3.	**Retrieval**	Retrieval practice and contextual cues	Low-stakes quizzes and children's songs with missing lyrics and pictures	Adesope et al. (2017); Roediger & Butler (2011); Sari & Sari (2020)

Note: The table present the most representative strategies and sources from the full set of 20 references. Complete references are provided in the reference list.

The proposed integrated learning cycle:
1. Begin with schema activation and multisensory input (Julaid and Khaghaninejad, 2025; Kong et al., 2021; Azhari, 2022)
2. Continue with chunking and spaced review (Handayani, 2021; Cepeda et al., 2006; Azhari & Yuniko, 2024)
3. End with contextual retrieval practice (Adesope et al., 2017; Roediger & Butler, 2011; Sari & Sari, 2020)

This model not only bridges the gap between cognitive theory and inclusive EFL practice in Indonesia but also has the potential to promote equitable educational access, with teacher training identified as the key to successful implementation.

4. CONCLUSION

This conceptual review concludes that Information Processing Theory offers a robust and practical framework for enhancing EFL learning among children with neurocognitive impairment in inclusive classrooms. The synthesis of 20 sources (2015–2025) reveals that effective instruction requires a holistic approach, as learning difficulties often represent cumulative disruptions across the entire processing cycle–not isolated deficits at single stages.

Key evidence-based strategies identified address core cognitive challenges in an integrated sequence:
1. Encoding is strengthened through schema activation and multisensory input, which builds necessary cognitive structures and manages attentional load.
2. Storage is improved by chunking and spaced repetition, reducing working memory overload and facilitating seamless consolidation of information.
3. Retrieval and long-term retention are significantly boosted by contextual practice, utilizing the strong neural pathways established in earlier, integrated stages.

These strategies are not only aligned with Indonesian's context, culturally appropriate, and immediately applicable in resource-limited inclusive settings, but they

also promote sustained learner engagement across all stages. This engagement functions as a key cognitive facilitator, supporting the smooth transfer of information and transforming the EFL classroom into a supportive "cognitive scaffold". The study's relevance lies in providing teachers with clear, theory-driven tools to transform EFL from a source of frustration into an achievable and engaging subject for neurodiverse learners, promoting equitable educational access.

Limitations include the conceptual design and absence of primary empirical data from Indonesian classrooms, which restricts claims of localized effectiveness.

Future research should prioritize intervention studies and action research to test the proposed integrated cycle in real inclusive EFL contexts, alongside the development of targeted teacher-training programmes grounded in Information Processing Theory.

In brief, this review delivers actionable guidance for achieving more equitable and successful EFL education for children with neurocognitive impairment in Indonesia by emphasizing an integrated instructional sequence rooted in cognitive science principles.

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