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Theoretical Argumentation on the Application of AI in Bilingual Reading Teaching

Han Bo

Northwest Normal University, Lanzhou, 730071, China

Abstract: *The rapid advancement of Artificial Intelligence (AI) technologies has expanded their application in education, notably in second language (L2) reading instruction. This paper examines the feasibility of using AI to enhance brain plasticity in L2 reading, focusing on personalized learning paths, real-time feedback, and multisensory interaction. Case studies and empirical data demonstrate AI's effectiveness in improving language comprehension and learning motivation by facilitating neural network reorganization. Challenges and future research directions are also discussed.*

Keywords: *Artificial Intelligence; Second Language Reading Teaching; Brain Plasticity*

1. Introduction

Brain plasticity refers to the ability of brain structure and function to change in response to external stimuli or learning experiences. In recent years, the application of artificial intelligence (AI) technology in education has gradually increased, especially in reading teaching. The goal of this study is to theoretically explore and verify the feasibility of using AI technology to enhance brain plasticity in reading teaching.

2. Research Methods

This paper adopts a literature review and theoretical analysis method, first reviewing the basic theories of brain plasticity and reading learning, then analyzing the application status of AI in education, especially how it optimizes and applies based on the characteristics of brain plasticity. In addition, this paper will analyze the functions of existing AI educational tools to explore their application effects and theoretical basis in actual teaching.

3. Theoretical Basis and Literature Review

3.1 The basic theory of brain plasticity

3.1.1 Brain plasticity, or neuroplasticity, refers to the ability of the brain to adjust its structure and function according to experience throughout life

This plasticity is achieved by changing neural connections or forming new ones, allowing the brain to respond and adapt to the external environment. During the learning process, when an individual repeatedly practices a skill, the neural network involved becomes more powerful and efficient. For example, learning a new language or musical instrument increases the density of gray matter in brain regions associated with these tasks. Learning affects not only the structure of the brain, but also its function. Long-term learning and cognitive activity can increase the strength of synaptic connections, which are key mechanisms for memory formation and long-term memory retention. In addition, the impact of emotions can not be ignored, positive emotional experience can enhance learning and memory. In short, brain plasticity enables the brain to have the ability to optimize its structure and function with learning experience, and is an important basis for individuals to adapt to complex and changing environments[1] .

3.1.2 Brain plasticity and reading: exploring how brain structure and function change during learning to read

In the process of reading learning, the structure and function of the brain change significantly,

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reflecting the plasticity of the brain. Learning to read involves multiple brain regions, including language processing and visual recognition. Here are some of the key changes: First, structural changes: During reading, the structure of the brain changes, especially in areas related to language and visual processing. For example, studies have shown that dyslexic people have structural abnormalities in specific brain regions that are often involved in decoding language and processing visual information. Secondly, functional changes: the improvement of reading ability is accompanied by adaptive changes in brain function. For example, second language learning has shown that brain function shifts from right-sided dominance to bilateral or left-sided differentiation during learning, suggesting that language learning can lead to a reorganization of brain function. Third, synaptic plasticity: In reading and other cognitive activities, synaptic connections between neurons are strengthened, and this synaptic plasticity contributes to the storage of information and the formation of memories. Repetitive reading exercises can enhance the connection strength of specific neural circuits, thereby improving reading skills and language comprehension. Through continuous reading practice, the brain is able to adapt its structure and function to cognitive needs, thereby optimizing learning and memory processes.

3.2 Literature review: The brain mechanisms of second language learning in English

The first is the problem of brain activity. Learning English as a second language initially relies on the right superior temporal gyrus and right inferior frontal gyrus, and as mastery increases, activity may shift to the left language area, showing changes in brain adaptability. Second, both long-term bilingual experience and short-term language training have shown that second language learning can significantly affect brain function and structure. This brain plasticity is achieved through continuous language practice and cognitive challenges, which in turn promote the neural mechanisms of language acquisition. Bilingual code switching issues are also included. When bilingual individuals perform language switching, multiple brain regions work together, including the prefrontal regions associated with executive function and attention regulation. These findings are supported by the use of neuroimaging techniques such as MEG.

Basic research on brain mechanisms shows that, firstly, the process of second language learning involves the cooperative work of multiple brain regions, including but not limited to the temporal lobe, frontal lobe and parietal lobe. These regions are involved in processing language input, syntactic structure, and semantic understanding. Second, in terms of research methods, using neuroimaging techniques such as functional magnetic resonance imaging (fMRI) and event-related potentials (ERP), researchers were able to more accurately delineate patterns of brain activity in second language learning. These studies shed light on the key role of brain plasticity in language learning. Third, a key research area is about metaphor and semantic processing. The study of second language metaphor comprehension shows that language metaphor and direct meaning processing may have different neural pathways in the brain. This problem of processing order and lateralization is the key to understanding the cognitive complexity of the second language. Fourth, in terms of influencing factors, the individual's second language learning ability is affected by many factors, including the learners' first language background, learning strategies, speech discrimination ability and differences in brain structure. Future research needs to explore the relationship between these factors and brain mechanisms from more perspectives. Fifth, in the study of sentence processing, the study of two-sentence sub-processing shows that there are significant differences between the brain activity patterns of second language learners and native speakers when dealing with complex sentence patterns. These differences reflect the brain plasticity of language processing and its adaptability to second language learning.

4. Theoretical analysis

4.1 The application of AI in education

Artificial intelligence (AI) technology plays an important role in the field of education, especially reading teaching, through core functions such as data analysis, pattern recognition and adaptive learning systems. Data analytics allow AI to assess student progress and understanding, providing personalized feedback. Pattern recognition helps identify learning behaviors and common errors, providing guidance for teaching. The adaptive learning system dynamically adjusts the teaching content and difficulty according to the students' performance to adapt to the needs of individual learners and effectively promote the plastic development of the brain. These features make AI a powerful tool for improving reading instruction[2].

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4.2 AI and Personalized Learning: Analyze how AI can provide customized learning paths based on learners' specific needs

First, data-driven personalized learning: By analyzing learners' behavior and performance, AI is able to create personalized learning plans. This involves using machine learning algorithms to identify the learner's strengths and weaknesses, thereby adjusting the content and difficulty of the teaching. Second, the model-centered classification framework study proposes the use of time series analysis based models to analyze the progress of learners, which helps to predict the future performance of learners and adjust teaching strategies based on these predictions. Third, the LLM agent framework proposes an AI agent framework based on a large language model (LLM), which is divided into three parts: brain, perception and action, which can be customized according to different learning needs to adapt to various educational applications. Fourth, in terms of data transformation and policy planning, AI technology can help policy makers formulate education policies based on empirical data, and design more effective teaching strategies and personalized paths by analyzing large amounts of learning data. Fifth, event management and causal analysis have shown broad application prospects. In AI operations management, by analyzing the causal relationship between events and behaviors, AI can help educators understand potential problems in the learning process and provide solutions. Sixth, AI-assisted rapid literature reading is promising for educators. AI is used to support educational research, helping educators quickly access the latest advances and related theories in educational research through automated literature analysis and abstract generation. AI technology has important potential and broad application prospects in adapting to the needs of learners.[3]

4.3 Interaction between AI and brain plasticity in second language reading teaching

4.3.1 Interaction between AI and brain plasticity

The study of the interaction between artificial intelligence (AI) and brain plasticity has become an important research topic at the intersection of neuroscience and computing technology. Here are a few key findings and discussion points. First, simulation and enhancement of brain function: AI technology, especially artificial neural networks, is widely used to simulate the neural mechanisms of the human brain, such as basic data processing and complex neural dynamics. These simulations help scientists gain a deeper understanding of the structure and function of the brain, and thus explore ways to improve cognitive function and neuroplasticity. Second, brain-inspired learning algorithms: The field of AI draws on discoveries in brain science, particularly synaptic plasticity, to develop brain-inspired learning algorithms that can mimic the human learning process. These algorithms optimize the learning process by simulating the tuning mechanisms of neurons and synapses, making AI systems more efficient in dealing with complex and changing environments. Third, the development of brain-like intelligence: Exploring AI from a neuroscience perspective, especially by understanding how the brain processes information at the macro and micro levels, scientists are trying to design AI systems that can mimic this advanced intelligence. This includes studying how the brain maintains stability and adaptability, and how to design more advanced AI models by simulating these properties. Fourth, information processing and cognitive systems: The way the brain processes information provides important insights into the design of AI systems. Studying how the brain breaks down and integrates information can help develop new AI algorithms that can more effectively process and interpret complex data and mimic human cognitive processes. In short, these studies show that the interaction between AI and brain plasticity not only helps us understand and enhance the function of the human brain, but also provides a theoretical basis and technical path for the development of more advanced and natural AI systems[4].

4.3.2 The interaction between AI and brain plasticity has important application potential in second language reading teaching

First, personalized learning experience: using the ability of AI technology to analyze the behavior and performance of learners, teaching systems can adjust the content and difficulty of teaching in real time to match the current level and learning speed of learners. This personalized adaptive learning environment not only responds to the immediate needs of the learner, but also promotes the growth and reorganization of the brain's neural network, thereby strengthening the learner's language ability and cognitive flexibility. Second, brain-inspired learning algorithms: By simulating the way the brain processes information, AI systems can provide a learning path that mimics the process of natural language acquisition. For example, algorithms that use the principle of synaptic plasticity can simulate how the human brain adjusts neural connections when learning a new language. In this way, AI teaching tools can help language learners strengthen language structure and vocabulary through continuous practice. Third, reinforcement learning and feedback mechanisms: AI teaching systems can provide immediate feedback

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and reinforcement learning opportunities, which are critical factors in promoting brain plasticity. By instantly correcting errors and confirming correct language use, learners are able to establish correct language patterns more effectively, and repeated practice can strengthen the neural pathways of these patterns in the brain. Fourth, multi-modal learning experience: AI technology can integrate visual, auditory and tactile inputs to create a rich learning environment. This fusion of multi-sensory input not only mimics the environment of natural language acquisition, but also activates multiple areas of the brain and promotes the development of neuroplasticity, thereby deepening and consolidating learning effects. In short, through these methods, the interaction between AI and brain plasticity can greatly improve the reading comprehension and language use ability of second language learners, so that they can adapt and master the new language faster.

5. The combination of theoretical and empirical data

5.1 Case study

The following selects several specific AI reading teaching tools to analyze how they specifically achieve the teaching goal of promoting brain plasticity in second language reading. In the teaching of second language reading, AI teaching tools can effectively promote the brain plasticity of learners by providing personalized learning experience and adaptive learning strategies. Here are a few typical AI reading teaching tools and how they can promote L2 reading skills. First, Scientific Learning: Science Learning, as mentioned, uses software developed based on neuroscience research to improve language and reading skills through audio and visual training. These training activities are designed to tune and strengthen the brain's neural networks to improve the flexibility and efficiency of language processing areas through repetitive exercises, thereby improving language comprehension and reading fluency. Second, OpenCSG: This platform enables AI systems to adapt to changing environments and information through continuous learning models. In the teaching of second language reading, this technology can be used to adjust the teaching content and update the teaching materials according to the progress and feedback of students. Such dynamic adjustment is helpful to the plasticity of brain and nerve, so that learners can better adapt to and master the new language structure and vocabulary. Third, personalized learning path: multiple AI teaching platforms automatically adjust teaching content and speed to adapt to students' learning ability and preferences by analyzing learners' behavior and learning history. This kind of personalized learning not only enables learners to learn at their own pace, but also promotes brain plasticity through appropriate challenges, thereby enhancing learning effects. In short, through these AI reading teaching tools, second language learners are able to develop their language skills in a supportive and adaptive environment, while strengthening the brain's neural plasticity, which is essential for language learning[5].

5.2 Effect evaluation

In evaluating the practical effectiveness of AI teaching tools in improving English as a second language (L2) reading skills, empirical research provides insight. First, in terms of enhancing understanding and engagement, AI teaching tools can significantly improve learners' reading comprehension by providing personalized reading materials and real-time feedback. These tools utilize natural language processing techniques to analyze student responses and adjust instructional strategies to meet the needs of individual learners, thereby increasing learning motivation and engagement. Second, in terms of automated feedback and assessment, a major advantage of AI tools is the ability to provide immediate, personalized feedback, which is especially critical for language learning. For example, AI-driven assessment tools can instantly identify students' reading weaknesses and provide targeted exercises to improve these weaknesses, thereby speeding up the learning process and improving efficiency. Third, in terms of promoting metacognitive skills, some studies have pointed out that AI tools help students develop metacognitive skills, that is, understanding about their own learning processes, by providing visual progress tracking and feedback. These skills are essential for self-regulation and lifelong learning, especially in language learning. Fourth, in terms of technology integration and learning outcomes, while AI tools show potential for improving reading skills, research also highlights the impact of the quality of technology integration on learning outcomes. In summary, success stories often involve well-designed teaching activities that are tightly integrated with AI capabilities to ensure that the use of technology is consistent with educational goals.

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6. Discussion

In second language reading teaching, AI application faces multiple challenges and restrictions. These challenges mainly involve technical implementation, educational policy support and resource allocation.

6.1 In terms of technical challenges

6.1.1 The complexity of natural language processing

AI systems need advanced natural language processing capabilities to understand and generate language, which is particularly complex in a bilingual environment because it must handle linguistic diversity and complexity.

6.1.2 The realization of personalized learning

Although AI can provide a personalized learning experience, this requires complex algorithms and large amounts of learning data, which puts high demands on technology.

6.2 Education policy challenges

6.2.1 Lack of clear norms and standards

The application of AI in second language teaching lacks unified educational policies and practical standards, which may limit the effective integration and application of AI tools.

6.2.2 Ethical and privacy issues

When using AI to process student data, it is necessary to consider data protection, privacy rights and ethical issues, all of which need to be properly managed through policies.

6.3 Resource allocation challenges

6.3.1 Economic resources

High costs are one of the main barriers to implementing AI solutions. Especially in resource-limited educational environments, investing in AI technology may not be feasible.

6.3.2 Teacher training

To effectively use AI tools, teachers need to have corresponding technical knowledge and skills. This requires systematic training and continuous professional development support.

6.4 Future research directions and solution strategies

6.4.1 Interdisciplinary research

Educational institutions and research organizations should encourage researchers in fields such as computer science, linguistics, psychology, and educational technology to work together to develop AI teaching tools that adapt to multilingualism and cultural diversity.

6.4.2 Policy and standardization

Educational institutions and policy makers should establish clear AI application policies and teaching standards to ensure transparent and fair use of AI tools while protecting students' data privacy.

6.4.3 Optimize resource allocation

Governments and private sectors should cooperate to provide necessary funds and technical support for educational institutions to ensure that all students can access AI teaching resources fairly.

6.4.4 Continuous teacher development

Educational institutions should establish a continuous teacher professional development plan to help teachers master the latest developments and teaching applications of AI technology, so as to more effectively integrate them into teaching practice.

In conclusion, by overcoming these challenges and adopting appropriate strategies, AI has the potential to significantly improve the effectiveness of second language reading instruction and help

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students better master a second language[6].

7. Conclusion

This paper provides a theoretical and empirical analysis framework to demonstrate the feasibility of the application of artificial intelligence in the teaching of brain plasticity reading. The depth and expansion of the specific content needs to be further enriched and verified in future research. AI shows great potential in promoting brain plasticity and reading instruction.[7] AI simulates complex cognitive functions, supports language learning, and promotes neuroplasticity. In practice, AI adapts to students' needs through personalized learning, providing immediate feedback and reinforcing learning effects. However, to realize its potential, continuous research and technical improvements are needed, especially in natural language processing and personalized learning strategies. Future research should focus on developing efficient algorithms, improving the adaptability of AI tools and teacher training, and ensuring ethical and privacy protection. These steps are critical to the optimization of AI teaching tools for more effective learning outcomes.[8]

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