Language Testing in Asia

RESEARCH Open Access

The development of reading comprehension ability of Chinese Heritage Language (CHL) learners in Indonesia

Qinling Zhou[1], Fengjiao Du[1], Yueli Lu[1*], Hanwei Wang[1], Herman[2] and Shunzhi Yang[3]

*Correspondence:
2296527992@qq.com

[1] College of Chinese Language and Culture, Jinan University, Guangzhou 510610, Guangdong, China
[2] Faculty of Education, Language, and Culture, Universitas Universal, Riau Islands, Batam 29444, Indonesia
[3] Institute of Applied Artificial Intelligence of the Guangdong-Hong Kong-Macao Greater Bay Area, Shenzhen Polytechnic University, Shenzhen 518055, Guangdong, China

Abstract

This study investigates the evolution of reading comprehension abilities in Indonesian learners of the Chinese Heritage Language (CHL), by comparing their scores on the Chinese Proficiency Test, a test specifically designed for CHL learners. A total of 275 candidates, divided into early adolescent (M_{age} = 13.56), late adolescent (M_{age} = 15.78), and adult (M_{age} = 22.83) groups, were evaluated on four dimensions of reading comprehension: orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension. A detailed cross-sectional and longitudinal analysis of these four dimensions was conducted across the three groups. The results indicate that horizontally, the order of the four dimensions is orthographic knowledge > vocabulary knowledge > syntactic awareness > discourse comprehension, with significant differences observed in all dimensions. During adolescence, orthographic knowledge is significantly higher than vocabulary knowledge, while in adulthood, vocabulary knowledge is significantly higher than syntactic awareness, and syntactic awareness is significantly higher than discourse comprehension. Longitudinally, reading comprehension abilities appear to stall across adolescence in three dimensions (vocabulary knowledge, syntactic awareness, and discourse comprehension), with a decline in one dimension (orthographic knowledge) occurring in late adolescence. However, the adult group shows improvement in all four dimensions compared to the late adolescence group. Considering both longitudinal and cross-sectional results, the developmental order of reading skills in Indonesian CHL learners is orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension. The main developmental peak for orthographic knowledge to vocabulary knowledge occurs in adolescence, while the major developmental peak for vocabulary knowledge to syntactic awareness and for syntactic awareness to discourse comprehension occurs in adulthood. The results suggest that reading comprehension improves significantly upon reaching adulthood in Indonesian. By understanding the trajectory of reading comprehension abilities in Indonesian CHL learners, this study can provide effective suggestions for Indonesian CHL learners and educators, and may also serve as a reference for other heritage languages.

Keywords: Reading comprehension, Indonesian, Chinese Heritage Language, Chinese Proficiency Test

Introduction

Heritage Language (HL) has gained significant traction in the fields of Language Policy and Language Education since the 1990s (Cummins, 2005). The phenomenon of HL has been a constant throughout human history, as immigrant families have always navigated across language boundaries (Polinsky, 2018). Polinsky (2018) defines HL as the family language of a bilingual individual who primarily speaks the mainstream language of society. This definition sets HL learners apart from general foreign language learners. HL learners exhibit the following characteristics: (1) They have already been exposed to and used the language within their families before formal learning, and they can speak or understand the family language. (2) They are bilingual and possess bilingual abilities to varying degrees in both the mainstream and HL within society.

HL learners occupy a unique position between first language (L1) and second language (L2) learners (Montrul, 2010). Researchers have increasingly recognized the distinction between HL learners and native language or general foreign language learners (Carreira & Kagan, 2018; Montrul, 2010). Despite this recognition, HL learners have often been overlooked and grouped with either L2 or L1 learners in instructional practices. There are significant gaps in our understanding of HL learners, particularly in the context of reading comprehension ability. Previous research has predominantly focused on L1 (Hjetland et al., 2019) or L2 (Kuperman et al., 2023; Namaziandost et al., 2022) learners, with limited information on HL learners (Cain et al., 2004). Extensive research exists on the reading comprehension ability of L1 or L2 learners at various ages, including childhood (Kendeou et al., 2009; Oakhill & Cain, 2012; Oakhill et al., 2005), adolescence (Oakhill & Cain, 2012; Perfetti, 2007), and adulthood (Elbro & Buch-Iversen, 2013; Kendeou et al., 2009). However, there has been less emphasis on studying the developmental characteristics of reading comprehension in HL learners across different age groups.

While some studies have explored the impact of vocabulary knowledge, morphological awareness (Zhang & Koda, 2018a, 2018b), and early oral language (Zhang & Koda, 2021) on the reading comprehension ability of Chinese Heritage Language (CHL) learners, they have not approached this from a developmental perspective. Additionally, assessments for CHL learners often rely on Chinese as a second language (CL2) exam materials (Zhang & Koda, 2018a). Recent reviews emphasize the significant influence of age on CHL learners' language abilities (Carreira & Kagan, 2018; Montrul, 2010, 2018, 2023; Ortega, 2020). Paris (2005) suggests a focus on the developmental trajectories of various reading skills, considering the onset and duration of different reading skills. To comprehensively understand the development of reading comprehension among CHL learners, this study delves into Indonesian CHL learners and thoroughly examines the development of different reading skills.

The choice of Indonesian CHL learners is due to its complex language and cultural background, which provides a unique research scenario that helps gain a deeper understanding of the development of reading comprehension abilities of CHL learners. There are several specific reasons: (1) Chinese are the 15th largest ethnic group in Indonesia, where there are more than 600 ethnic groups which are smaller than the Chinese (Arifin et al., 2017). At present, Chinese education in Indonesia is booming and developing (Luli & Budiman, 2017). (2) Education in the Chinese language in Indonesia has transformed

from a long period of closure (1966–1998) to initial recovery (1998–1998) (Kuntjara & Hoon, 2020). These specific educational or language policies either support or impact the learning of CHL learners in Indonesia. (3) Given the increasing trade and cultural exchange between China and Indonesia, the demand for the Chinese language is likely to continue to grow. Studying Indonesian CHL learners can provide relevant language education strategies and methods to meet societal needs. Therefore, it is crucial to conduct research and analysis on current Indonesian CHL learners. The present study is exploring a new area where previous research is lacking and understanding is limited.

In our research, we utilized the Chinese Proficiency Test (HC) specifically designed for CHL learners, created by the Chinese Language Examination Institute at the College of Chinese Language and Culture, Jinan University (Wang, 2016, 2018). It is an officially developed standardized examination and is recognized for its high reliability and validity (Wang et al., 2023). This test's database, which includes real examination scores on the reading test for CHL learners, served as the primary source of our data. These data, exclusively obtained from real exam scenarios involving Indonesian test takers under rigorous supervision, were used with permission from Jinan University's College of Chinese Language and Culture. Throughout our study, we maintained the utmost confidentiality of this data.

Our analysis leverages these authentic examination records and the structure of the test papers to explore the progression of various reading comprehension skills. This study ranges from basic abilities like orthographic knowledge to more complex skills such as discourse comprehension. We have conducted both horizontal and vertical analyses by sorting Indonesian candidates into different age categories. The cross-sectional component of our analysis primarily focused on the developmental sequence of diverse reading comprehension abilities. In contrast, the longitudinal aspect concentrated on tracking the change of these abilities across different age groups. The objective of this research is to deepen our understanding of the growth patterns in reading comprehension abilities among Indonesian CHL learners, thereby providing crucial insights for educators and decision-makers in this educational sector.

Literature review

Reading comprehension ability of CHL learners

For learners of foreign language or L2, reading is often considered the most fundamental skill, or as Grabe (1991) puts it, "the mother of all skills." Reading skills are not only crucial for navigating contemporary life, but they also play a significant role in learning and demonstrating proficiency in other disciplines (Nortvedt et al., 2016; OECD, 2019; Yang et al., 2018). For instance, individuals with superior reading abilities often perform better in tasks such as writing (Mart, 2012; Mermelstein, 2015). Meanwhile, for HL learners, reading and writing skills are often areas of weakness (Montrul, 2010). This highlights the importance of studying the reading comprehension abilities of HL learners. By doing so, we can develop effective strategies and interventions to help these learners improve their reading comprehension skills in the HL, thereby contributing to the preservation and continuation of the language.

The academic community holds diverse views regarding the definition of reading comprehension, with several interpretations put forth over the years. For instance, Davis

(1968) posits that reading comprehension refers to the ability to critically understand written texts, emphasizing aspects such as text meaning, concluding, identifying writing skills, identifying emotions, and answering questions. Grabe (1991), on the other hand, suggests that reading encompasses recognition skills, vocabulary and textual knowledge, content comprehension, and evaluation abilities. Keenan et al. (2008) view reading comprehension as an overall process involving the interaction between paragraph meanings, emphasizing the understanding of the entire text rather than individual words and sentences. Newton et al. (2018) describe reading comprehension as a combination of cognitive and visual tasks that extract meaning from written discourse by understanding written text, processing data, and associating it with background knowledge. Similarly, Hoover and Tunmer (2018) define reading comprehension ability as the ability to extract and construct literal meanings and infer word meanings from the language discourse represented by the printed version. From these definitions, it is evident that reading comprehension is a complex process, involving multiple sub-skills, including orthographic knowledge, vocabulary knowledge, syntactic awareness, discourse comprehension, and so on. This complexity underscores the importance of a multifaceted approach in teaching and assessing reading comprehension, particularly among CHL learners.

To comprehend this complex process, the academic community has proposed several theoretical analysis frameworks. One such framework is the simple view of reading (SVR), which posits that the two main components of reading comprehension skills are decoding and language comprehension (Gough & Tunmer, 1986). Decoding refers to the ability to translate written symbols into spoken language, encompassing the skills required for accurate recognition and pronunciation of words. Language comprehension is the ability to understand spoken language and the meaning of words and sentences, involving vocabulary knowledge, grammar, and the ability to construct meaning from sentences and texts. The applicability of the SVR has been confirmed in studies on learners of different languages (de Jong & van derLeij, 2002; Protopapas et al., 2007; LARRC, 2015; Joshi et al., 2012; Tobia & Bonifacci, 2015; Kim, 2020a, 2020b), including Chinese (Joshi et al., 2012; Yan et al., 2021; Yeung et al., 2016).

However, the SVR mentions the core skills of reading comprehension, decoding, and language comprehension, which may not be enough to understand the complex reading process. Kim (2017, 2020b) proposed the direct and indirect effects model of reading (DIER), integrating the SVR with various other reading theories. This model includes not only the core components of the SVR, such as decoding and language comprehension skills, but also discourse reading fluency, background knowledge, reading emotions or social emotions (such as motivation, attitude, self-concept, self-efficacy, and anxiety), higher-order cognition and rules (such as reasoning, viewpoint adoption, inference, and monitoring), basic oral skills (vocabulary and grammar knowledge), phonetics, morphemes, orthography, and domain-general cognition (such as working memory and attention control) (Kim, 2020a, 2020b). These component skills have both direct and indirect effects on reading. This comprehensive model underscores the complexity of reading comprehension and the multitude of factors that influence it.

Prior research on the development of reading comprehension has predominantly focused on L1 or L2 learners (Verhoeven & Van Leeuwen, 2008; Florit & Cain, 2011; Lonigan et al., 2018; Tobia & Bonifacci, 2015; Joshi et al., 2012). For instance, Verhoeven

and Van Leeuwe (2008) conducted a longitudinal study examining the specific effects of word decoding, vocabulary, and listening comprehension skills on the development of reading comprehension in Dutch children throughout primary school. Their findings indicated that the impact of word decoding on reading comprehension diminished progressively with each increasing grade level. Similarly, Joshi et al. (2012) discovered that Chinese character recognition accounted for 22% and 32% of the variation in reading comprehension among second- and fourth-grade Chinese children, respectively. Furthermore, their study suggested that for an opaque orthography like Chinese, word decoding plays a more significant role in early reading comprehension, compared to a transparent orthography like Italian (Lonigan et al., 2018). But they did not pay attention to the development and changes of reading ability of HL learners.

HL learners are a unique group compared with L2 and L1 ones (Carreira & Kagan, 2018; Montrul, 2008, 2018, 2023; Ortega, 2020). Previous studies have drawn comparisons between the reading comprehension abilities of HL learners and those of L1 and L2 learners. The disparities in reading and writing abilities between HL learners and L2 learners are linked to the context of acquisition (Montrul, 2010). Early language experience differentiates the development of reading and writing abilities in CHL learners from L2 learners, as L2 learners typically develop initial language knowledge in the classroom. Through extensive exposure to formal printed language in university language classrooms, CHL students enhance their initial morphological awareness and develop sensitivity to mapping functional elements (morphological cues) to graphic symbols (printed text and phrases) (Zhang & Koda, 2018a). Compared to L1 students, CHL college students with early language input exhibit stronger morphological awareness, which appears to be an additional resource that can be leveraged to enhance CHL reading comprehension (Zhang et al., 2016). In the acquisition of CHL reading comprehension, existing vocabulary knowledge lays a semantic foundation for further utilization of morphological awareness, thereby contributing to reading comprehension (Zhang & Koda, 2018a). For instance, CHL adult students may develop early vocabulary knowledge through exposure to varying degrees of spoken and printed language, and early oral input helps to form initial morphological awareness, including fragment and structural awareness (Zhang & Koda, 2018a, 2018b). Moreover, CHL learners outperform non-CHL learners in terms of oral vocabulary knowledge, morphological awareness, and vocabulary reasoning ability, but not in terms of printed vocabulary knowledge (Zhang & Koda, 2018b). Therefore, to fill the gap in existing research, our research focuses on unraveling the mysteries of reading comprehension development in HL learners.

Research on CHL has also found that vocabulary knowledge and morphological awareness significantly impact reading comprehension. For instance, Zhang and Koda (2018a) investigated the effects of vocabulary knowledge and morphological awareness on the reading comprehension ability of CHL learners. Their study revealed that vocabulary knowledge contributes both directly and indirectly to CHL reading comprehension ability, with morphological awareness serving as a mediating factor. In addition, several studies have mainly explored the role of morphological awareness in the reading comprehension of CHL learners, highlighting it as a crucial factor in predicting reading comprehension among CHL students (Wang et al., 2006), and a key link between language ability and reading skills in young CHL learners (Zhang & Koda, 2018a). Due to

exposure to both English (the majority language) and Chinese (the minority language) in different contexts, CHL children have developed initial morphological awareness of both languages. Despite strict limitations on print resources, CHL learners have managed to develop initial vocabulary knowledge and morphological sensitivity to some extent during childhood (Pasquarella et al., 2011). Morphological awareness is also strongly associated with the reading comprehension of CHL learners (Pasquarella et al., 2011; Wang et al., 2006). Given that lexical compounding is a primary method of word formation in Chinese, the language-specific aspects of morphological awareness (cross-linguistic composite awareness) can be shared among different languages to enhance Chinese reading comprehension (Pasquarella et al., 2011).

In the previous studies on the reading comprehension of CHL learners, they focused on the influencing factors of reading comprehension, such as vocabulary knowledge and morphological awareness, but neglected the development of reading comprehension itself. The dynamic attention to the development of reading comprehension of CHL will help to understand the development trajectory of reading comprehension of HL learners, thereby further providing beneficial guidance for the teaching of HL. Therefore, this study adopts a test specifically targeting learners of CHL to study the dynamic development trajectory of their reading comprehension abilities.

Testing the reading comprehension ability of CHL learners

The testing of Chinese as L1 and L2 has been the subject of extensive study and practice. From a testing perspective, there are oral and written language tests, as well as comprehensive tests that combine both oral and written language. Currently, there are two influential Chinese language tests: HC and the Hanyu Shuiping Kaoshi (HSK). HSK is a standardized international Chinese language proficiency test for L2 learners that plays a significant role in the field of international Chinese language education. As a crucial component of the HSK, reading tests primarily assess the comprehensive reading ability of learners of CL2.

However, in existing studies, the test materials for assessing the reading comprehension ability of CHL learners predominantly come from the HSK developed for CL2 learners (Zhang & Koda, 2018a, 2018b, 2021). For instance, Zhang and Koda (2018a) selected reading comprehension questions from HSK levels 3–5 based on the CHL level of participants (intermediate students) when investigating the vocabulary knowledge and morphological awareness of CHL reading comprehension ability. Similarly, Zhang and Koda (2021) randomly selected 5 lexical items from each level in HSK when examining Chinese reading vocabulary, resulting in a total of 30 lexical items selected as target words.

There is a mismatch in testing CL2 learners with tests that test CHL learners, which may affect the accuracy of the study results because the two groups are significantly different. Recognizing this, we used a test specifically designed for CHL learners, namely HC. Wang (2018) proposed HC, specifically designed to measure linguistic competence of CHL learners. Wang (2018) specifically explained the concept of CHL reading comprehension tests, encompassing aspects such as morpheme sampling, basic principles, paper structure, question types, and sample design. HC fully takes into account the characteristics of the Chinese language and examines the reading comprehension ability

of CHL learners from four dimensions: Chinese characters, words, sentences, and discourse. Wang et al. (2023) conducted a quality analysis on the HC test paper measuring reading comprehension, and the results showed that the test paper was of better quality.

It can be seen that HC also draws on the DIER theoretical analysis framework, which proposed that reading comprehension consists of multiple component skills (Kim, 2017, 2020b). From the characteristics of Chinese, to master reading comprehension, we need to master some basic ingredient skills, like Chinese characters, vocabulary, sentences, and discourse (Gough & Tunmer, 1986; Kim, 2017, 2020b). Firstly, Chinese characters are the foundation of reading comprehension. There are various types of Chinese characters, such as close-form characters and homophones, which are easy to confuse. Therefore, we need to start with the pronunciation, form, and meaning of each character, and gradually grasp the meaning and usage of each character (Share, 2008; Tong et al., 2009; Yeung et al., 2011, 2016). Secondly, vocabulary is the basic unit that makes up sentences. Mastering the pronunciation, meaning, and usage of commonly used vocabulary is crucial for improving reading comprehension ability (Nation & Snowling, 1998). In Chinese, the subject-verb-object structure, definite complement, and other components of a sentence have their specific positions and functions. By analyzing the structure of a sentence, we can better understand its meaning and function (Cain et al., 2003; Nation et al., 1999). Finally, discourse is the foundation of a complete article. Based on mastering Chinese characters, vocabulary, and sentences, we need to understand the overall structure, theme, and author's intention of the article from a macro perspective. By analyzing the logical relationships and transitional ways between paragraphs, we can better understand the overall framework and meaning of the article. Mastering reading comprehension ability requires mastering the four dimensions of Chinese characters, vocabulary, sentences, and discourse in sequence, and the difficulty of these four dimensions gradually increases (Cain & Oakhill, 2007; Perfetti et al., 2005).

In summary, the HC reading comprehension test is tailored to the characteristics of the Chinese language and the framework of DIER, exploring four types of questions, with all test paper types based on textual comprehension. The HC primarily sets four types of questions from the perspectives of orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension, aiming to assess the reading comprehension ability of CHL learners. It is worth noting that the HC measures orthography knowledge and vocabulary knowledge by giving a sentence and also examines the understanding of this sentence. These four question types are both relatively independent and integrated. This approach underscores the complexity of reading comprehension and the multitude of factors that influence it, providing a comprehensive assessment tool for educators and policymakers in the field.

Orthography knowledge

Orthographic knowledge is defined as an understanding of the principles and rules governing how written symbols represent spoken words in a given language (McBride, 2016). Orthography knowledge in Chinese refers to the rules and customs of spelling in Chinese characters. Chinese is a form of ideographic writing, with each Chinese character having an independent pronunciation, form, and meaning. The Chinese orthography is mainly determined based on the form of Chinese characters, including the following

aspects: phonological rules (the phonological rules of Chinese characters mainly include initial consonants, vowels, tones, etc.), glyphic rules (the glyphic rules of Chinese characters mainly include strokes, radicals, etc.), and semantic rules (the semantic rules of Chinese characters mainly include the relationship between glyphs and meanings, the evolution of meanings, etc.). The orthography knowledge in Chinese is a language knowledge that people must rely on when recognizing Chinese characters. It provides the internal redundancy of Chinese character recognition and has a top-down impact on Chinese character recognition. The orthography knowledge in Chinese is particularly crucial for CHL learners, as it directly impacts their reading comprehension abilities.

Numerous studies have explored the role of orthographic knowledge in reading comprehension. For instance, within the SVR framework, representing the meaning of retrieved words through orthography is crucial for reading comprehension (Perfetti & Stafura, 2014). Orthographic knowledge impacts reading acquisition and reading difficulties (such as developmental dyslexia) across different languages, with the depth and transparency of orthography playing a significant role in reading development (Ziegler & Goswami, 2005; Seymour & Erskine, 2003). However, it has been observed that many reading studies and practices overly focus on the specificity of English as a spelling system, while neglecting the differences and impacts of orthography in other languages. For languages that use non-English orthography, different reading strategies and processing methods need to be considered (Share, 2008). Orthographic knowledge has been shown to have a positive connection with Chinese reading comprehension (Tong et al., 2009; Yeung et al., 2011, 2016). For example, orthographic knowledge can explain how Chinese primary school students interpret reading comprehension through Chinese character reading (Yeung et al., 2016). These findings underscore the importance of orthographic knowledge in reading comprehension and highlight the need for a more nuanced understanding of orthography's role in different languages.

Vocabulary knowledge

Vocabulary knowledge is an important component of reading comprehension skills (Rupley, 2005). It encompasses the richness of vocabulary, understanding of word meanings, and vocabulary association. These elements are integral to identifying words, understanding sentences, and inferring textual meanings. Therefore, cultivating and developing vocabulary knowledge is one of the key strategies for enhancing reading comprehension ability.

Vocabulary knowledge has consistently been identified as a powerful predictor of reading comprehension (Pasquarella et al., 2012). As early as the mid-twentieth century, studies have recognized it as one of the main factors in reading comprehension (Davis, 1944). This underscores the enduring importance of vocabulary knowledge in the realm of reading comprehension, highlighting the need for continued emphasis on vocabulary development in reading instruction and assessment.

The important role of vocabulary knowledge in reading comprehension has been proven by various studies (Protopapas et al., 2007). And, word decoding is identified as important components of reading comprehension (Gough & Tunmer, 1986; Perfetti & Hart, 2001). Young children's reading comprehension relies more heavily on decoding, while older children and early adolescents' reading comprehension depends more

on vocabulary knowledge (Braze et al., 2007; Protopapas & Skaloumbakas, 2007). Individuals with rich vocabulary knowledge can quickly recognize words and understand the meaning of sentences, leading to more accurate reading (Perfetti & Hart, 2001). This gives them an advantage in their ability to read and understand different texts (Nagy & Anderson, 1984). Vocabulary knowledge is closely related to reading comprehension ability, especially for children with reading comprehension difficulties (Nation & Snowling, 1998). Moreover, long-term follow-up studies have found that early vocabulary knowledge is a key factor in predicting subsequent reading ability (Cunningham & Stanovich, 1997).

Syntactic awareness

Syntactic awareness refers to an individual's ability to recognize and understand the relationship between sentence structure, grammar rules, and sentence components in a language (Brimo et al., 2017). This involves sensitivity and ability to the organization of sentences, the application of syntactic rules, and the correlation between sentence components. Individuals with strong syntactic awareness are more likely to handle complex sentences, accurately understand the meaning of sentences, and thus enhance their reading comprehension skills. Numerous studies have emphasized the significant role of syntactic awareness in reading comprehension performance (Cain, 2007; Kieffer & Lesaux, 2008; Low & Siegel, 2005). One of the key factors that distinguish L1 acquisition from L2 acquisition is the different syntactic structures of the two languages (Penny et al., 2002). Syntactic processing may not be transferred from a child's L1 to their L2, leading to difficulties in acquiring foreign language syntactic structures and, consequently, challenges in learning foreign language reading (Verhoeven, 1994).

Syntactic awareness is vital for reading comprehension ability (Nation & Snowling, 2000). A lack of syntactic awareness may be one of the reasons for reading comprehension difficulties and is closely related to language barriers (Nation et al., 1999). Individuals with strong syntactic awareness are more likely to process and understand complex sentence structures during the reading process (Miller & Keenan, 2009). They use sentence structure and grammatical cues to infer the meaning of words, thereby improving their reading comprehension ability (Cain et al., 2003).

Discourse comprehension

Discourse comprehension refers to the organization and correlation between sentences, paragraphs, and other language units within a text or discourse. Discourse comprehension involves comprehending the logical relationships between sentences, the organization of paragraphs, and the overall framework of the discourse. Discourse comprehension is crucial for comprehending and organizing information, inferring meaning, and constructing a coherent reading experience. In essence, discourse structure serves as the organizational framework of a text. It aids readers in understanding and constructing the meaning of the text through the logical relationships between sentences, the organization of paragraphs, and the overall organizational structure, thereby facilitating a coherent reading experience. Therefore, discourse comprehension plays a pivotal role in reading ability and comprehension (Cain & Oakhill, 2007; Kintsch, 1998; McNamara, 2001; Perfetti et al., 2005).

Numerous studies have underscored the impact of discourse comprehension on reading ability. For instance, Kintsch (1998) proposed a paradigm of discourse comprehension, emphasizing the importance of discourse comprehension in reading comprehension. Research has found that understanding the structure, logical relationships, and coherence of a discourse is crucial for effective reading. Individuals with good comprehension skills in discourse structure are more capable of extracting key information, constructing meaning, and reasoning from texts (McNamara, 2007). Sensitivity and understanding of discourse structure, paragraph organization, and logical relationships are keys to effective reading and comprehension (Cain & Oakhill, 2007; Perfetti et al., 2005).

The present study

Indonesia has the largest number of CHL learners in the world, and we used HC to study the development and changes of reading comprehension ability of Indonesian CHL learners. It is valuable to understand the strengths and weaknesses of Indonesian CHL learners in reading comprehension. Given the gaps in existing research in this regard, this study takes Indonesian CHL learners as an example to examine the development path of reading comprehension ability and the differences in reading comprehension development among different age groups of them. This study selected four question types of HC level 5 containing four dimensions of reading comprehension (orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension) as research material. This study has important guiding significance for gaining a deeper understanding of the reading comprehension process of Indonesian CHL learners and further improving their reading comprehension abilities. The following research questions guided our study:

- Research question 1: From a cross-sectional perspective, what are the differences in the four dimensions of Indonesian CHL learners' reading comprehension abilities?
- Research question 2: From a longitudinal perspective, is there any difference of the four dimensions reading comprehension ability among Indonesian CHL learners of different age groups?

Method

Design

To address the gap in literature concerning the developmental process of reading comprehension skills, our study primarily focuses on Indonesian CHL learners to investigate the developmental trajectories of different reading comprehension skills. To achieve this objective, our research employs a cross-sectional longitudinal design. Initially, participants are categorized into different age groups. We then compare the various reading comprehension skills within the same age group to discern the sequence of development of these skills. Finally, we contrast the same reading comprehension skill across different age groups to observe their developmental changes and trends.

Data collection

Our study primarily utilizes secondary data analysis for data collection. This method involves collecting key data from large databases, enabling researchers to obtain larger samples (Johnston, 2014), which allows them to pose more research questions than would be possible in smaller-scale studies (Vartanian, 2010). Secondary data analysis is widely used in fields such as education (Ho & Gan, 2023; Mercier et al., 2021) and healthcare (Tosepu et al., 2020), and is a commonly employed research method.

Our research data is mainly sourced from the Chinese Language Examination Institute of Jinan University's College of Chinese Language and Culture's confidential database, which includes examination data of over 18,000 HL learners. To protect the privacy of the examinees, this database is private and not publicly accessible. We have been granted permission to use this data by the Chinese Examination Institute of Jinan University and have ensured strict confidentiality, using it solely for this research purpose.

Demographics and grouping

Our research data is sourced from the authentic test databases of the HC. We selected data from one exam paper containing Indonesian CHL learners. After excluding the candidates who are not Indonesian learners, a total of 275 learners remain, with 180 females and 95 males, all of whom are Indonesian students mainly from local Chinese schools. The candidates took part in the test between March 2021 and April 2023, all undergoing the examination under a uniformly strict and carefully monitored process. To meet the research needs, we excluded some subjects following three procedures: (1) The data of non-heritage learners was excluded. (2) We eliminated the students who took the online test and only retained the students who took the offline test to avoid other possible interfering factors. (3) We deleted candidates over the age of 30. Through the above processes, we were left with 275 CHL learners, having excluded 6 subjects. The age span of them is 12–30 years old, with an average age of 17.79.

To examine the differences in reading ability across different age groups, we divided the participants who took the same set of tests into three groups: early adolescence group (M_{age} = 13.56, range = 12–14), late adolescence group (M_{age} = 15.78, range = 15–18), and adult group (M_{age} = 22.83, range = 20–30). The early adolescence group consisted of 62 individuals (32 females, 30 males), the late adolescence group had 115 individuals (67 females, 48 males), and the adult group included 98 individuals (81 females, 17 males).

Research material

We chose a set of papers as the research sample from level 5 of the HC reading test, which has 4 task types about reading comprehension ability, covering tests on orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension. The number of each task is 6, so the number of all question types is 24, all of which are scored by 0/1.

Measurement of orthographic knowledge

The measurement of orthographic knowledge is presented through "identifying the incorrectly use of Chinese character." The stimulus material for this type of question

is text, and the task of "identifying the incorrect Chinese character" is accomplished through reading. The comparison between "incorrectly use of Chinese characters" and "correctly use of Chinese characters" requires a certain level of Chinese character accumulation, as errors within a group of Chinese characters due to the existence of homophonic forms are based on sentence meaning and syntax (i.e., context), as well as the identification and correction of these errors based on sentence meaning and syntax (i.e., context). The specific presentation of this question type is as follows.

Read the sentence and identify a Chinese character that is used incorrectly based on its meaning.

真	没	想	到	，	我	们	的	名	字	竟	会	有	这	么	大	的	学	问	。
A	B	C	D	E	F	G	H		I	J	K	L	M	N	O	P	Q	S	

I didn't expect our name competition to have such a lot of knowledge.

In the example sentence, "竞(competition)" and "竟(unexpected)" are homophones, but according to the sentence meaning and syntax (i.e., context), only "竟(unexpected)" can be paired with "really unexpected" to express unexpected meanings. Therefore, the correct way to write "竞(competition)" is "竟(unexpected)," so blackout K on the answer sheet.

Measurement of vocabulary knowledge

The measurement of vocabulary knowledge is presented through "Fill in the missing Chinese character." Unlike other reading question types, this question type presents an abnormal text with missing information. The participants are tested based on their mastery of vocabulary knowledge, their ability to understand context, and their ability to infer based on understanding. This also means that the missing information in this question type cannot be random, but should be "special information" that must be related to the context to infer. There are two procedures for answering this question: (1) Accurately identify the missing information. (2) Fill in the missing Chinese character according to the sentence's meaning. The specific presentation of this question type is as follows.

Read the text, each question has a missing character. Please identify the Chinese character before the missing character and the missing character.

a. 愁 (worry)
b. 挂 (hanging)
c. **在** (being)
d. **多** (many)
e. 功 (success)
f. **气** (angry)

对	你	来	说	，	成	和	幸	福	是	什	么	？
A	B	C	D	E	F	G	H	I	J	K	L	

What is success and happiness for you?

In the example question, if the candidate understands the meaning of the following text, they can naturally find the "wrong" place before "**和**(and)." One can infer, based on their acquired vocabulary knowledge, that "**成果**(success)" is parallel to "幸福(happiness)." If one cannot fully understand the meaning of a sentence, there is no way to start. Therefore, this sentence should be "What are success and happiness for you?" The vacancy is after "**成**(success)," and the missing word is "功(success)," so blackout F and e on the answer sheet.

Measurement of syntactic awareness

The measurement of syntactic awareness is presented through "sentence pause." "Sentence pause" has a long history and is a "natural" question type based on the characteristics of Chinese characters and the reading training and measurement methods of Chinese text. "Sentence pause" is based on Chinese characters and vocabulary, mainly examining syntax. If learners understand, they will naturally be able to "pause." The specific question types and requirements are as follows.

Read the text below, pause four times in the middle of each question, identify the pause item, and black out the word that paused.

我	想	出	**去**	玩	**可**	**是**	**我**	**生**	**病**	**了**	**不**	**能**	出	门	**只**	**好**	**在**	家	里	**太**	无	聊	**了**	。
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	

I want to go out to play, but I'm sick and can't go out. I have to stay at home and it's too boring.

The example sentence provided requires a pause of four times, which should be "I want to go out to play/but I'm sick/can't go out/has to stay at home/it's too boring." This pause indicates that the test reader has understood the text, therefore blackout E, K, O, and T on the answer sheet.

Measurement of discourse comprehension

The measurement of discourse comprehension is presented through "delete one sentence." The advanced reading question type in this study reflects a transition to writing, representing a "cross-border" question type. This advanced reading question type requires not only understanding, but also a particularly clear grasp of Chinese characters, vocabulary, sentences, discourse, and even the meaning, details, and all aspects, to effectively achieve "slimming." Expressing understanding through "deletion" is considered "modification" or "reconstruction," that is, writing in a broad sense. This represents the combination of reading and writing abilities in slimming down. The specific presentation of HC reading comprehension questions for discourse comprehension is as follows.

Please delete one sentence. After deletion, the sentence should be smooth the meaning should be consistent with the original text to the greatest extent possible, and the answer sheet should be blacked out. Specific examples are as follows:

人可以无知	，	但不可以无趣	，	这是从旁观者的眼光看的	，	与无趣之人对坐	，	如坐牢狱	。
A		B		C		D		E	

People can be ignorant	,	but they cannot be uninteresting	,	This is seen from the perspective, of bystanders	,	sitting against uninteresting people	,	which is like sitting in prison	
A		B		C		D		E	

In the example sentence, after deleting "这是从旁观者的眼光看的(This is seen from the perspective of bystanders)," the sentence remains as close to the original meaning as possible and is smooth, therefore blackout C on the answer sheet.

We tested the quality of the test paper assessing reading comprehension ability. First, we used SPSS 22.0 to analyze the reliability of the reading ability part. Cronbach's α is 0.92, indicating excellent consistency. Secondly, we used Mplus 8.1 to conduct a confirmatory factor analysis to test its validity. We tested the second-order four-factor model. The four dimensions are the four question types mentioned before (orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension). The goodness-of-fit test shows that the main indicators are $\chi^2/df = 1.66 < 3$, RMSEA = 0.03 < 0.08, CFI = 0.98 > 0.9, TLI = 0.98 > 0.9, and SRMR = 0.06 < 0.08. The fitting index is good, which proves that the structural validity of our model is good. This demonstrates the effectiveness of our test in assessing reading comprehension ability.

Method of data analysis

For the cross-sectional contrastive analysis, we primarily employed descriptive statistical analysis and paired sample *t* tests. In the case of longitudinal contrastive analysis, we used one-way analysis of variance (ANOVA). We initially conducted a homogeneity of variance test to determine the method for post hoc multiple comparative analysis. The post hoc tests were primarily conducted using the Scheffe method and Dunnett's T3(3). All the above analyses were performed using SPSS software.

Results

Cross-sectional contrastive analysis

We conducted a descriptive statistical analysis of the four dimensions of reading comprehension to observe their developmental progression. We first compared the overall reading comprehension ability across the four dimensions, and then compared the reading comprehension ability of the four dimensions within each of the three groups, respectively. The results are shown in Table 1. From the table, we can see that the ranking of scores in the four dimensions of reading comprehension is generally consistent, with the order being orthographic knowledge > vocabulary knowledge > syntactic awareness > discourse comprehension. However, there are some exceptions. Orthographic knowledge is less than vocabulary knowledge in the adult group, and vocabulary knowledge and syntactic awareness are equal in the late adolescent group.

To determine whether there are significant differences among the four dimensions of reading comprehension, we conducted paired sample *t* tests on them in groups.

Table 1 Descriptive statistical analysis

	M	SD	Range	95% CI
Total				
OK	2.90	2.02	0–6	2.66, 3.14
VK	2.58	2.35	0–6	2.30, 2.86
SA	2.08	3.42	0–6	1.86, 2.30
DC	1.74	1.54	0–5	1.56, 1.93
Early adolescence				
OK	3.08	2.13	0–6	2.54, 3.62
VK	2.24	2.16	0–6	1.69, 2.79
SA	1.95	2.89	0–6	1.52, 2.38
DC	1.69	1.52	0–5	1.31, 2.08
Late adolescence				
OK	2.21	1.70	0–6	1.89, 2.52
VK	1.64	1.96	0–6	1.28, 2.01
SA	1.64	1.75	0–6	1.32, 1.97
DC	1.39	1.41	0–4	1.13, 1.65
Adult group				
OK	3.59	2.06	0–6	3.18, 4.00
VK	3.89	2.29	0–6	3.43, 4.35
SA	2.66	1.90	0–6	2.28, 3.05
DC	2.18	1.62	0–5	1.86, 2.51

OK Orthographic knowledge, *VK* Vocabulary knowledge, *SA* Syntactic awareness, *DC* Discourse comprehension

Table 2 Paired sample *t* test results

	t	SD	*p*	95% CI
Total				
OK-VK	0.32	2.00	0.008	0.08, 0.55
VK-SA	0.50	1.91	0.000	0.27, 0.72
SA-DC	0.33	1.88	0.003	0.11, 0.55
Early adolescence				
OK-VK	0.83	1.58	0.000	0.43, 1.24
VK-SA	0.29	1.44	0.118	− 0.65, 0.07
SA-DC	0.25	1.75	0.251	− 0.18, 0.70
Late adolescence				
OK-VK	0.56	1.81	0.001	0.23, 0.90
VK-SA	0	1.73	1	− 0.32, 0.32
SA-DC	0.25	1.88	0.153	− 0.09, 0.60
Adult group				
OK-VK	− 0.29	2.28	0.204	− 0.75, 0.16
VK-SA	1.22	2.15	0.000	1.65, 0.79
SA-DC	0.48	1.96	0.018	0.08, 0.87

OK Orthographic knowledge, *VK* Vocabulary knowledge, *SA* Syntactic awareness, *DC* Discourse comprehension

Based on the basic knowledge of Chinese linguistics and the results of descriptive statistical analysis, the order of development may be orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension. Therefore, we compared orthographic knowledge and vocabulary knowledge, vocabulary knowledge

and syntactic awareness, and syntactic awareness and discourse comprehension to ascertain their developmental order, as detailed in Table 2.

In the total data of reading comprehension, we found that orthographic knowledge is significantly higher than vocabulary knowledge ($t = 0.32$, $p < 0.01$), vocabulary knowledge is significantly higher than syntactic awareness ($t = 0.50$, $p < 0.001$), and syntactic awareness is significantly higher than discourse comprehension ($t = 0.33$, $p < 0.01$).

In the early adolescence group, orthographic knowledge is significantly higher than vocabulary knowledge ($t = 0.83$, $p < 0.001$), but there is no significant difference between vocabulary knowledge and syntactic awareness ($t = 0.29$, $p > 0.05$), nor between syntactic awareness and discourse comprehension ($t = 0.25$, $p > 0.05$).

In the late adolescence group, orthographic knowledge is significantly higher than vocabulary knowledge ($t = 0.56$, $p < 0.01$), but vocabulary knowledge and syntactic awareness are equal. Syntactic awareness is not significantly higher than discourse comprehension ($t = 0.25$, $p > 0.05$).

In the adult group, there is no significant difference between vocabulary knowledge and orthographic knowledge ($t = -0.29$, $p > 0.05$), but vocabulary knowledge is significantly higher than syntactic awareness ($t = 1.22$, $p < 0.001$), and syntactic awareness is significantly higher than discourse comprehension ($t = 0.48$, $p < 0.05$).

In summary, our research investigates the reading comprehension ability of CHL learners from the perspectives of orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension, and then analyzes their differences across three stages. In the two stages of adolescence, orthographic knowledge is significantly higher than vocabulary knowledge, and there are no significant differences in other aspects. In the adult stage, vocabulary knowledge is significantly higher than syntactic awareness, and syntactic awareness is significantly higher than discourse comprehension. However, there is no significant difference between orthographic and vocabulary knowledge.

Longitudinal contrastive analysis

We conducted an ANOVA on reading comprehension ability and its four dimensions across different age periods. Initially, we conducted a homogeneity of variance test on the data. The results showed that the *F* values of three dimensions of reading ability (syntactic awareness, orthographic knowledge, discourse comprehension) were not significant ($p > 0.05$), indicating homogeneity of variance among them, except for vocabulary knowledge. This suggests that the Scheffe method should be used for post hoc multiple comparative analysis of the three dimensions, and Dunnett's T3(3) is more suitable for vocabulary knowledge after one-way ANOVA.

As shown in Table 3, the results of the ANOVA show that there are significant differences in reading ability among participants of different age groups (F (2, 272) = 23.03, $p < 0.001$). In the dimension of orthographic knowledge, there were also significant differences among participants of different ages (F (2, 272) = 13.81, $p < 0.001$). Post-analysis results showed that the late adolescence group had significantly lower performance than

Table 3 Differences in reading comprehension ability among different age groups

Dimension	Early adolescence (M_{age} = 13.56, n = 62)		Late adolescence (M_{age} = 15.78, n = 115)		Adult (M_{age} = 22.83, n = 98)		F
	M	SD	*M*	SD	*M*	SD	
Reading comprehension ability	8.97	6.17	6.89	5.31	12.33	6.23	23.03***
Orthographic knowledge	3.08	2.13	2.21	1.70	3.59	2.06	13.81***
Vocabulary knowledge	2.24	2.16	1.64	1.97	3.89	2.30	30.28***
Syntactic awareness	1.95	1.70	1.64	1.76	2.66	1.90	8.69***
Discourse comprehension	1.69	1.52	1.39	1.42	2.18	1.62	7.29**

** $p < 0.01$; *** $p < 0.001$

the early adolescence group and the adult group, while there was no significant difference between the early adolescence group and the adult group.

In terms of vocabulary knowledge, there are also significant differences among participants in different age groups (F (2, 272) = 30.28, $p < 0.001$). Post-analysis results showed that the achievement of the adult group was significantly higher than that of the early adolescence group and the late adolescence, while there was no significant difference between the early adolescence group and late adolescence.

In the dimension of syntactic awareness, there was also a significant difference among participants in different age groups (F (2, 272) = 8.69, $p < 0.001$). Post-analysis results showed that the achievement of the adult group was significantly higher than that of the late adolescence group, while there was no significant difference between the early adolescence group and the late adolescence group, or the adult group.

In the dimension of discourse comprehension, there were also significant differences among participants at different ages (F (2, 272) = 7.29, $p < 0.01$). Post-analysis results showed that the achievement of the adult group was significantly higher than that of the late adolescence group, while there was no significant difference between the early adolescence group and late adolescence.

In the cross-sectional contrastive analysis, we examined the reading comprehension ability of CHL learners from the perspectives of orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension, and then analyzed their differences across three stages: early adolescence, late adolescence, and adulthood. This allowed us to roughly predict the development process of reading comprehension of Indonesian CHL learners. Firstly, the adolescent stage is characterized by the development of orthographic and vocabulary knowledge, as these two parts show significant differences during this stage, while there are no significant differences between vocabulary knowledge, syntactic awareness, and discourse comprehension. Secondly, in the adult stage, vocabulary knowledge, syntactic awareness, and discourse comprehension are developing. There is no significant difference between orthographic and vocabulary knowledge, suggesting that these may have been developed and matured, while there are significant differences between vocabulary knowledge, syntactic awareness, and discourse comprehension, indicating that these may still be developing.

In the longitudinal contrastive analysis, the results of the ANOVA show that reading ability differs at different age stages. Specifically, there are no differences between the late adolescence and early adolescence groups in three dimensions, other than in orthographic knowledge where the late adolescence group's performance is lower than that of the early adolescence group. The performance of the adult group is significantly higher than that of the late adolescence group in all four dimensions, while the adult group's performance is higher than that of the early adolescence group only in vocabulary knowledge, with no significant differences in the other dimensions. This suggests that after entering adulthood, Indonesian HL learners can significantly improve their reading comprehension skills through learning. However, the development of reading ability in adolescence appears to be relatively stagnant, with no significant improvements observed in most dimensions. This underscores the importance of targeted instruction and support during this critical developmental period to facilitate the growth of reading comprehension skills.

Discussion

Cross-sectional comparison of reading comprehension ability for Indonesian CHL learners

From the above research results, we can see that there are certain differences in the scores of Indonesian CHL learners in reading comprehension ability. Orthographic knowledge scored the highest, followed by vocabulary knowledge, with relatively low syntactic awareness and discourse comprehension. Reading comprehension is a complex process that manifests itself in the conversion from lower-level abilities (word recognition, etc.) to higher-level abilities (syntax, semantics, etc.) (Mckee, 2012).

Firstly, orthographic knowledge scores the highest in reading comprehension ability, indicating that CHL learners have a good grasp of the form, structure, and spelling rules of Chinese characters. Chinese characters are the written form of Chinese, and correct writing and recognition of Chinese characters are essential for reading comprehension (Pan et al., 2021). Therefore, CHL learners' advantages in orthographic knowledge lay the foundation for their reading comprehension abilities (Tong et al., 2009; Yeung et al., 2011, 2016).

Secondly, vocabulary knowledge ranks second in the overall score, indicating that CHL learners have achieved a good level of understanding of the meaning and usage of vocabulary. Vocabulary is the foundation of language and has a decisive impact on the depth and breadth of reading comprehension (Pasquarella et al., 2012). Learners need to master a certain amount of vocabulary and understand its meaning and usage in different contexts. Compared to orthographic knowledge, vocabulary knowledge may be more difficult to master, so CHL learners score slightly lower in vocabulary knowledge than orthographic knowledge. Chinese is a language based on characters, with each character typically representing a word or part of a word. Therefore, vocabulary knowledge is particularly crucial for reading Chinese, as correctly understanding the meaning of each word is crucial for overall understanding.

Thirdly, syntactic awareness is relatively low in the overall score, which means that CHL learners' ability to understand sentence structure and grammar rules is relatively weak. Chinese is a highly contextual language, and the meaning of a sentence often depends on its context. Therefore, CHL learners need to improve their understanding and application

abilities of sentence structure and grammar rules to better understand the meaning and logical relationships of the text (Cain et al., 2003; Miller & Keenan, 2009).

Finally, discourse comprehension ranks lowest in overall scores, which belongs to the most difficult part of these four dimensions. Discourse comprehension requires comprehensive consideration of various elements of the text, including themes, structures, and logical relationships, and requires learners to possess comprehensive analysis and reasoning abilities (Kintsch, 1998). Therefore, compared to other reading comprehensive ability, the mastery of discourse comprehension is more difficult.

The ranking of scores in this study indicates that the mastery of reading comprehension skills by Indonesian CHL learners is consistent with the general rules of reading comprehension (Mckee, 2012). They first have an orthographic knowledge and vocabulary knowledge, followed by an awareness of syntactic and discourse comprehension, etc. This is also in line with the natural order of language learning, which is to first master the spelling of Chinese characters, the use of words, and then a fine grasp of grammar and discourse structure.

In addition, our research examines the reading comprehension ability of CHL learners from the perspectives of orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension, and then analyzes their differences in three stages. For early adolescence, late adolescence, and adulthood, we can roughly predict the development process of reading comprehension of Indonesian CHL learners. First of all, in the adolescent stage is the development of orthographic and vocabulary knowledge, because in the adolescent stage, these two parts are significantly different, and there is no significant differences between vocabulary knowledge, syntactic awareness, and discourse comprehension. Secondly, in the adult stage, vocabulary knowledge, syntactic awareness, and discourse comprehension are developing, because in the adult stage, there is no significant difference between orthographic and vocabulary knowledge, which may have been developed and mature, while there are significant differences between vocabulary knowledge, syntactic awareness, and discourse comprehension, which may still be developing.

Combining the characteristics of Chinese and our research results, we can see that the reading comprehension learning sequence of Indonesian CHL learners is in line with the general Chinese learning rules. And, we can also see the peak development period of reading comprehension skills of Indonesian CHL learners; that is, they mainly develop low-level skills (such as characters and words) in adolescence and begin to develop high-level skills (such as chapter comprehension) in adulthood. This can reveal the general development pattern of reading comprehension among CHL learners and can also provide targeted guidance and suggestions for teaching Chinese to Chinese Indonesians.

Longitudinal comparison of reading comprehension ability for Indonesian CHL learners

According to the research results, there is an age difference in the scores of Indonesian CHL learners in reading comprehension ability. The early adolescent group ($M_{age} = 13.56$) scored higher in orthographic knowledge than the late adolescent group ($M_{age} = 15.78$). This research result is related to the characteristics of Indonesian CHL learners themselves.

HL is a language and cultural heritage beyond the language of the social subject, mainly used in the family environment (Polinsky, 2018). HL learners have a large amount of input from birth (Polinsky & Kagan, 2007), which are similar to L1 learners who have been exposed to this language since childhood in their families and input a large amount of it in natural environments (Montrul, 2010). Therefore, the language input channels for HL learners mainly come from family environment.

There is a difference in the time spent at home between the early adolescent group ($M_{age}=13.56$) and the late adolescent group ($M_{age}=15.78$), as they are in different stages of life. The early adolescent group is more subject to family supervision and care, while the late adolescent group is more independent, with more autonomy and social activities. This difference in life stages affects their time allocation within the family. In addition, as learners age, they often face more academic requirements and challenges. The late adolescence learners need more time to complete school assignments, prepare for exams, and participate in additional academic activities. These academic pressures may lead to a decrease in their time spent at home. Therefore, the early adolescent group is more exposed to HL in the family than the late adolescent group and is in an advantageous position in language input. Among the four component skills of reading comprehension, research shows that the early adolescent group ($M_{age}=15.78$) performs better in orthographic knowledge than the late adolescent group ($M_{age}=13.56$), indicating the language attrition in the late adolescence group ($M_{age}=13.56$). Language attrition refers to the process in which bilingual or multilingual users reduce or stop using a certain language due to physiological, psychological, cognitive, and social reasons, and their ability to use that language gradually decreases over time (Köpke & Schmid, 2004). As mentioned earlier, HL belongs to the family language. The late adolescence group reduced language input from families, and their contact time with CHL also decreased. Therefore, the speed of CHL attrition is faster, and the orthographic knowledge acquired by the late adolescent group has a certain degree of attrition. Therefore, human intervention can be used to prevent language erosion. For example, in Japan, to prevent the English proficiency of returning children from being eroded, organizers give them a few hours a month to participate in English communication activities. The organizers believe that theoretically, this method should help prevent the attrition of these children's English abilities (Yoshitomi, 1999).

Generally speaking, learners in the early adolescent group are still in the stage of accumulating basic language knowledge. The curriculum design and teaching methods of schools and educational institutions place more emphasis on learning characters and spelling rules, which helps improve the orthographic knowledge acquired by CHL learners in childhood. Therefore, the early adolescent group gained a deeper understanding of the writing and phonetic rules of Chinese characters and scored relatively high in orthographic knowledge.

According to the research results, the early adolescent group ($M_{age}=13.56$) scored lower in vocabulary knowledge than the adult group ($M_{age}=22.83$). It can be seen that as people age, CHL learners gradually form a richer vocabulary network. In early adolescence, learners are not exposed to sufficiently broad and complex vocabulary, and the application of vocabulary is relatively limited. The understanding and application of vocabulary is still in the development stage, requiring more time and experience to

establish rich vocabulary knowledge. In adulthood, learners may have more opportunities to come into contact with more complex and professional vocabulary and, through practical application of this vocabulary, improve their vocabulary knowledge level. The relative advantage of the adult group in this regard may be related to more language learning experience, wider reading, and practical applications. Meanwhile, multiple surveys have shown that students' learning motivation can affect differences in reading performance among learners (Becirovic, 2017; Saaty, 2022), and like L2 learners, HL learners require strong motivation to maintain and learn HL (Montrul, 2010). Indonesian adult learners may have more learning motivation, which helps them better understand and use vocabulary.

The research results also indicate that the adult group ($M_{age} = 22.83$) scored higher in orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension than the late adolescent group ($M_{age} = 15.78$). In addition to the learning motivation mentioned earlier, it is also related to the learning environment of the adult group; as with the lifting of Indonesia's China exclusion policy and the exchange and cooperation between Indonesia and China in the fields of business, culture, and education, many universities in Indonesia teach Chinese and send students to China to learn Chinese. According to data from the Indonesian Ministry of Education, a minimum of 30 universities in Indonesia offer Chinese language courses, for example Universitas Indonesia, Universitas Darma Persada, Universitas Kristen Maranatha, Universitas Muhammadiyah in Yogyakarta, and Universitas Subei in Medan (preparatory). According to statistics (Li, 2020), there were over 15,000 Indonesian students studying in universities in China, such as Beijing Language and Culture University, Jinan University, and Xiamen University. In recent years, Indonesia's attitude towards the Chinese has shifted towards a more positive direction. Many CHL learners in Indonesia have received formal Chinese education as adults and have undergone systematic training in literacy, reading, writing, and other aspects. Adult group CHL acquisition typically occurs in a classroom environment, with a focus on reading and writing, as well as grammar interpretation, practice, feedback, and evaluation of CHL skill development.

HL learners missed the opportunity to learn formal registers and the typically complex structures of written language in early language acquisition (Polinsky & Kagan, 2007; Rothman, 2007). As age increases and learners' language abilities improve, the adult group's ability and depth in learning orthographic knowledge, vocabulary knowledge, syntactic awareness, and discourse comprehension will also correspondingly increase. They have already acquired a solid foundation of language knowledge and skills, and have a deeper understanding and mastery of the handwriting and phonetic transcription rules of Chinese characters, the meaning and usage of vocabulary, the structure and grammar rules of sentences, as well as the overall structure and logical relationships of texts. Secondly, the adult group may also have more diverse reading experiences and strategies. They may have more cultural background knowledge and life experience and can better understand and analyze the meaning and logical relationships in the text.

Conclusion

This study compared the acquisition of reading comprehension skills among Indonesian CHL learners from both cross-sectional and longitudinal perspectives, revealing the reading comprehension process of Indonesian CHL learners and the development trends and differences in reading comprehension among learners of different age groups.

Cross-sectional comparison shows that in the overall reading skills, orthographic knowledge dominates the CHL learners' reading comprehension process, followed by vocabulary knowledge and syntactic awareness, while discourse comprehension is relatively low. This represents the development pattern of Indonesian CHL learners' reading comprehension ability and is in line with the patterns of linguistics. At the same time, different teaching strategies need to be adopted for HL learners of different ages. For adolescence, Indonesian CHL learners are still in the development process from orthography to vocabulary knowledge, so they need to pay more attention to understanding and mastering the meaning of the characters during the reading process. In adulthood, they can focus on the training of more complex reading comprehension skills, such as syntactic awareness and discourse comprehension, helping them better understand and master the deep structure meaning and expression of Chinese.

The longitudinal comparison emphasizes the significant impact of age on reading comprehension ability. During adolescence, the development of reading comprehension ability of Indonesian CHL learners is stagnant and even regresses in orthography knowledge. Fortunately, after adulthood, their reading comprehension ability further recover, and all four dimensions are significantly higher than those in late adolescence, and even exceeded those in early adolescence in terms of vocabulary knowledge. This inspires us to pay attention to the maintenance of HL among Indonesian CHL adolescent learners, and at the same time, it also enlightens us that although HL remains stagnant or lost in a certain period of time, it can be further passed down through some efforts in the later period.

This study guides designing personalized and phased CHL teaching. We suggest paying attention to the cultivation of orthographic knowledge in the early stages, while gradually strengthening the learning of vocabulary. As learners age, more attention should be paid to improving their syntactic awareness and discourse comprehension abilities, to achieve their comprehensive development in reading comprehension.

In future research, focusing on micro-critical reading is essential. Aloqaili (2012) highlighted the importance of critical thinking for reading comprehension. Our research primarily evaluated students' proficiency in character and word decoding, as well as their comprehension of sentences. Nonetheless, the assessment of students' critical thinking abilities was not sufficiently addressed. Future research should give more emphasis to this aspect. This method involves guiding students through detailed and critical analysis of texts, enabling them to precisely comprehend the author's intentions and the deeper meanings in the text. Micro-critical reading is more than a skill; it nurtures learners' abilities to think independently, analyze, and evaluate texts. In the context of learning CHL, this ability is especially crucial, given the complexity and nuances of Chinese that demand critical thinking. Secondly, future research could further focus on the key factors affecting the improvement of reading comprehension skills among adult CHL learners in Indonesia. By doing so, it can provide effective references for the language regain

of CHL learners in adulthood, which is crucial for the maintenance of the HL (Montrul, 2023). Thirdly, future studies could further compare the differences in reading comprehension development trajectories between CHL and CL2 learners. Such comparisons would assist educators in adopting differentiated teaching methods tailored to the distinct characteristics of different groups.

Abbreviations

CHL	Chinese Heritage Language
CL2	Chinese second language
DIER	Direct and indirect effects model of reading
HL	Heritage language
HC	Chinese Proficiency Test
HSK	Hanyu Shuiping Kaoshi
L1	First language
L2	Second language
SVR	Simple view of reading

Acknowledgements
The authors are grateful for use of the data from the Chinese Proficiency Test.

Authors' contributions
The first three authors write and approved the manuscript. The fourth and fifth author provided the data for this article. The sixth author was responsible for the formatting of the paper.

Funding
This work was supported in part by the International Chinese Language Education Research Program under Grant 23YH72D, in part by the Shenzhen Science and Technology Program under Grant 20231126112732001, and in part by the Shenzhen Polytechnic University Research Fund under Grant 6024310005 K.

Availability of data and materials
The data and materials will not be available to protect the privacy of the candidates.

Declarations

Competing interests
The authors declare that they have no competing interests.

Received: 8 December 2023 Accepted: 11 February 2024
Published online: 01 March 2024

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