# Comprehension of Quantifier Sentences in Poor Readers with Different Levels of Arithmetic Proficiency

Yang Dong [1]

Bonnie Wing-Yin Chow [2]

Jian-Hong Mo [3]

Hao-Yuan Zheng [4]

Sammy Xiao-Ying Wu [5]

Jie Yang [1]

[1]Hainan University

[2] University College London

[3] The Chinese University of Hong Kong

[4] Guangzhou Huashang College

New York University

## Abstract

This study compared the sentence hyperbole comprehension performance of Chinese poor readers with various levels of arithmetic proficiency. A total of 168 Chinese poor readers in Grade 1 were recruited, and their nonverbal intelligence, verbal working memory, Chinese receptive vocabulary, Chinese grammatical knowledge, character reading and morphological awareness were controlled. The reaction times of these students in correctly answering literal and inferential questions was selected for further comparison. Results of a mixed-effect model analysis show that the participants with good and poor arithmetic proficiency levels demonstrated similar levels of literal information comprehension, regardless of the presentation form of the quantifier construction that was built by the quantifier location of the sentences, the number of numeric characters in a single quantifier and the hyperbole function applied in the sentence quantifier. Students with good arithmetic proficiency also demonstrated faster response in comprehending quantifier inferential information. Primary school students with good arithmetic proficiency outperformed those with poor proficiency in the inferential reading of verbal numeric information. In addition, differences in arithmetic proficiency did not significantly affect the students' word/character semantic representation cognition and shallow literal information processing. Overall, the results distinguish the interaction and independent numerical information processes at the literal and inferential levels of text quantifier comprehension for young primary school students with poor reading proficiency.



*Key words*: text comprehension; hyperbole; quantifier identification; poor readers;

## Introduction

Text comprehension is a process of mental image construction that involves literal and inferential comprehension for constructing a representation from written text according to the Construction and Integration Model (Kintsch, 1988). Poor ability in identying literal or inferential meanings from text contributes to challenges in text comprehension amongst poor readers (Cain et al., 2000; Authors, 2021; Kim & Petscher, 2020; Rader & Sloutsky, 2002; Swanson et al., 2017). Comprehending text meaning is even more challenging for poor readers, especially when it involves hyperbole comprehension (Snow, 2002). Readers' prior knowledge and linguistic comprehension ability positively predict the performance of text hyperbole comprehension (e.g. Kim & Petscher, 2020). According to The Simple View of Reading theory (Hoover & Gough, 1990), text comprehension is the interactive product between readers' decoding and linguistic comprehension. However, text comprehension is a complex process that requires not only linguistic ability, but also non-linguistic skills. Quantifier comprehension, which refers to the process of constructing mental representations of numerical information when reading text, involves linguistic and numerical abilities.

Quantifier hyperbole comprehension involves the numerical domain information process of verbal forms, and the comprehension process of this verbal numerical information relies on both linguistic comprehension and numerical information decoding. Therefore, both arithmetic and reading skills (e.g. decoding) contribute to the processing of verbal numerical information in text comprehension. According to the Triple Code Model (TCM, Dehaene, 1992) of numerical processing, individuals with high arithmetic skills tend to be more effective and sensitive in processing numerical information, including Arabic numbers (e.g.

3), verbal word frames (e.g. ‘three’) and analogue nonsymbolic magnitude representations (e.g. ■■■) than those with low arithmetic skills, thus suggesting the links between arithmetic and reading abilities. However, the development of reading and arithmetic skills is not parallel (Morgan et al., 2011; Nortvedt et al., 2016; Silinskas et al., 2010), thereby leading to the emergence of a heterogeneous group of young poor language learners with different proficiency levels in terms of mathematics skills. Whether good arithmetic skills can compensate for poor decoding skills—which protect reading comprehension or at least quantifier comprehension—of poor readers warrants investigation. Therefore, this study aims to fill in this research gap by investigating the quantifier hyperbole comprehension performance of Chinese poor readers with various levels of arithmetic proficiency.

## Literature Review

### Text Comprehension in Poor Readers

Regarding the mechanism of the text comprehension process, growing evidence suggests that various internal cognitive factors determine poor readers’ text comprehension (Cain et al., 2000; Cain & Oakhill, 2006; Kim, 2020; Nation et al., 2004). Specifically, better working memory (Daneman & Merikle, 1996; Hasher & Zacks, 1988; Kim & Petscher, 2020; Schuh et al., 2016), vocabulary (Åsberg, 2010; Kim & Petscher, 2020; Schuh et al., 2016), grammatical knowledge (Mecartty, 2000; Kim, 2016; Van Dijk, 1979), inference (Kintsch, 1993; Niehaus & Young, 2014; Rader & Sloutsky, 2002), word identification (Graesser et al., 1997; Kim & Petscher, 2020; Robertson et al., 2000), metalinguistic knowledge (Åsberg & Sandberg, 2010; Bianco et al., 2010; Norris et al., 2006), content knowledge (McKeown et al., 2009; McNamara et al., 1996; Swanson et al., 2017), text category (Diakidoy et al., 2005; Wu et al., 2020; Primor, Pierce, & Katzir, 2011) and text structure (Akhondi et al., 2011; Cain et al., 2004; Roehling et al., 2017) positively predict text comprehension performance.

Two types of text comprehension processes have been widely investigated in the literature, namely, literal comprehension, which refers to processing of information explicitly provided in the text, and inferential comprehension, which refers to the understanding of what is not explicitly specified but is implied in the text (Graesser et al., 1994; Kim & Petscher, 2020; Kintsch, 1988). In text comprehension activities, one main challenge faced by early primary school children with poor reading skills is identifying the meaning of words (Authors, 2020; Kim et al., 2020; Lyster et al., 2021). The literal information process in word-level comprehension greatly depends on shallow comprehension by word outline surface coding, which is easier than the inferential information process requiring higher-order thinking cognition progress (Authors, 2020; Graesser et al., 1994; Kim, 2020). Kim (2020) suggested that during text comprehension, literal information processing is required for inferential information processing. In other words, readers cannot achieve inferential comprehension during text comprehension without literal comprehension.

**Hyperbole Comprehension**

Hyperbole is a literal approach to writing a sentence with an exaggerated function regarding an event, and the level of hyperbole identification and information process reflects readers' coherent representation of sentence contents (including causal structure) and their integration of text content into relevant content knowledge (Graesser et al.,1994; Kim & Petscher, 2020; Kreuz & Roberts, 1995; McKoon & Ratcliff, 1992). In the current study, we focused on verbal and literal hyperbole comprehension. Hyperbole comprehension is a difficult task in text comprehension that, relative to text semantic meaning comprehension, imposes higher requirements on readers' event inferential abilities. A successful hyperbole comprehension requires the processing of information from printed words and involves literal and inferential information integration processes.

Text features (e.g. inverted and causal structure) and genre (e.g. narrative and expository) affect the hyperbole comprehension of primary school students (Graesser et al., 1994; Kim & Petscher, 2020). For word-level comprehension, hyperbole comprehension performance is determined by the location of keywords in a sentence (e.g. the effect of 'part of speech', that is, the subject function at the beginning or object function at the end part of the sentence) (Beymer et al., 2007; Desai et al., 2021; McGlone, 2011; Varga, 2000), the composition of words (e.g. one or two characters in one word: bookshelf, sky) (Graham et al., 1997; Van Bon & Van Der Pijl, 1997; Zhang & Lin, 2018) and the functions/attributes of words (e.g. restrict, elaborate) (Bavelier et al., 1997; Liberman, 1992; Wen et al., 2019). However, thus far, only a few studies have investigated the hyperbole reading comprehension performance of learners in early childhood.

**Quantifier Comprehension**

Quantifier is a function word that provides information about the explicit number of an objective attribute. Quantifiers in a sentence comprise a specific number plus a unit/dimension (e.g. ten pieces, three trees, one ton, hundred times) that provides the explicit quantity information of an object. Previous studies have argued that quantifiers play various roles at the part of speech level, including object, adherent adjunct and adverbial modifier (Bott & Radó, 2009; Brasoveanu, 2011; Kurtzman & MacDonald, 1993). However, the quantifier reading performance of poor readers in the early primary grade level in terms of sentence hyperbole comprehension remains unclear.

**Text Comprehension and Arithmetic Skills**

The arithmetic operations of addition, subtraction, multiplication and division represent the main learning content for early primary grade students (Davenport, 1999; Morgan et al., 2017; Nortvedt et al., 2016). These operations require students to identify and manipulate numbers to address practical problems in visual and symbol information processing (Arsalidou & Taylor, 2011; Grimm, 2008). Interestingly, students' text comprehension performance and arithmetic skills are not always consistent. For example, students may demonstrate poor performance in terms of sentence comprehension but show high proficiency in arithmetic skills. However, previous studies have mostly focused on the effect of sentence comprehension on arithmetic skills (Cummins et al., 1988; Morgan et al., 2017; Nortvedt et al., 2016). For example, some studies have shown that skilled readers regard arithmetic questions as number problem-solving tasks (Cummins et al., 1988; Glenberg et al., 2012; Nortvedt et al., 2016). Meanwhile, only few studies have categorised students' arithmetic performance and investigated the effects of different arithmetic performance levels on their sentence comprehension. TCM (Dehaene, 1992) suggests that both semantic and asemantic information can be processed across two functionally independent yet interrelated code modules, namely, verbal and Arabic numerical information. TCM also argues that individuals with excellent arithmetic skills are likely to process verbal numerical information more efficiently than those with poor arithmetic skills. However, little is known about the interaction or independent working mechanism between these modules in the verbal numerical information processing of young poor readers. Similarly, limited studies have investigated those quantifier hyperbole functions that do not authentically describe an event during text comprehension in either literal or inferential information processing. Furthermore, TCM posits that a high arithmetic proficiency positively enhances numerical information processing amongst verbal and Arabic modules. Numerical information during text comprehension can be written in character words or Arabic numbers [e.g. ten (10), eleven (11)]. However, it remains unknown whether students with various arithmetic proficiency levels also demonstrate differences in their understanding of verbal numerical information [e.g. quantifier: 十次(ten times) ], which applies hyperbole function via literal and inferential information comprehension.

**The Current Study**

Overall, there are three major research gaps in past studies on text comprehension that are relevant to the present study. First, previous studies have mostly focused on individual characteristics (e.g. brain function) or text categories (e.g. narrative, persuasion and exposition) (e.g., Armeni et al., 2019; Cohn, 2020). In comparison, little is known about hyperbole comprehension, especially poor readers' performance in literal and inferential information processing. Second, only few studies have tested the association between Arabic numerical information processing and quantifier comprehension in text amongst school-aged students (e.g. Yang & Wang, 2022). Moreover, whether a high level of arithmetic skills can compensate for poor readers' insufficient decoding skills in quantifier comprehension remains unknown. Third, whether verbal quantifier comprehension performance differs amongst learners with varying levels of arithmetic skills also remains unclear. In other words, whether a higher mathematics proficiency is linked to a better processing of numerical information in verbal form requires further examination.

Therefore, the current study extends previous research by examining the relationship between the arithmetic skills and ability to process numerical information in text amongst 168 Chinese poor readers in Grade 1. This study has two research questions:

(1) What is the link between arithmetic skills and quantifier literal comprehension? Related to this, students with higher arithmetic skills are hypothesised to demonstrate better quantifier literal comprehension performance across various experimental conditions with and without quantifier construction forms and hyperbole functions.

(2) What is the link between arithmetic skills and quantifier inferential comprehension? Related to this, students with higher arithmetic skills are hypothesised to demonstrate better quantifier inferential comprehension performance across various experimental conditions with or without quantifier construction forms and hyperbole functions.

## Method

### Participants

After collecting the consent forms and conducting preliminary data analysis, a total of 168 Grade 1 Chinese students in Shenzhen, China were recruited via online posters. All the students were classified as 'poor readers', whose scores in the Chinese reading comprehension proficiency test and character reading test were at least one standard deviation lower than the average. These scores were retrieved from a database containing information about 1261 students. All participants were typical developed children who were not diagnosed with any special education needs. They all came from families with low socioeconomic status (earning less than 4,500 RMB per month). Compared with the overall sample pool ($N$ = 1261), 84 students (42 boys, 42 girls, mean age = 6.19, $SD$ = .57) showed poor arithmetic performance, as reflected in their arithmetic proficiency test scores that were 1 standard deviation lower than the average. The other 84 students (44 boys, 40 girls, mean age = 6.02, $SD$ = .58) showed excellent arithmetic performance, as reflected in their math subject grades that were 1 standard deviation higher than the average. The preliminary analysis results show that these two groups of students demonstrate similar reading comprehension performance ($F$ = .51, $p$ > .10) when the effects of age and gender are controlled.

**Screening Measures**

***Reading Comprehension***

The participants' Chinese reading comprehension ability was assessed using the 20 cloze narrative sentence comprehension items developed by Li (2009). Each sentence item featured a blank, and the participants were required to choose the option that best fit the sentence [example item: 我___做一名好学生 (I am___ to be a good student): A. 质疑 (questioned) B. 决心 (determined) C. 表明 (declared)]. The answer can be a noun, verb, adjective or adverb. All three choices for the same item are in the same word class but differ in terms of their meaning and usage. The participants were required to use literal and inferential comprehension processes to answer each question. They were also asked to complete as many items as possible within five minutes. Prior to conducting the formal test, two practice items were used to familiarise the participants with the testing procedure. Each item contained around seven characters, and one point was awarded for each correct answer. This scale had a maximum score of 20 and a Cronbach's α of .73.

### *Arithmetic Performance*

The participants' early arithmetic abilities were assessed via the arithmetic test designed by Ye (2018). The number range used in the questions and answers was within 20 integers (0–50). The simple arithmetic task involved 100 items that assessed the participants' arithmetic abilities in addition (25 items, example item: 3 + 5 = ___), subtraction (25 items, example item: 19 - 7 =___), multiplication (25 items, example item: 3×6 =___) and division (25 items, example item: 12÷3=___). The participants were required to answer as many problems as possible within three minutes. Each correct answer was awarded one point, and a wrong answer was awarded 0. This simple arithmetic test had a maximum score of 100 and a Cronbach's α of .96.

### *Character Reading*

Fan (2017) compiled a list of 60 single-character words retrieved from primary school Chinese textbooks used throughout Mainland China. The words in this list were arranged from the easiest to the most difficult to assess the participants' Chinese character reading ability. They were required to read each item aloud, and the test was stopped if a participant failed to read 10 consecutive words. Each correct item reading was awarded one point. This test had a maximum score of 60 and a Cronbach's α of .90.

## Control Measures

### *Nonverbal Intelligence*

Sections A to C of Raven's Standard Progressive Matrices (Raven et al., 1995) were used to assess the participants' nonverbal intelligence. Each section contained 12 items, with each item having one blank. Amongst six to eight possible answers, the participants were required to select the option that best filled these blanks. Each correct answer was awarded one point. This measure had a maximum score of 36 and a Cronbach's α of .88.

### *Verbal Working Memory*

The 18-item digit span test was used to test the participants' verbal working memory. The same measure was also used in previous studies (Wu, 2003). The participants were required to repeat the digits orally forwards and backwards. Two to seven digits were presented with increasing difficulty level, each containing three items. The participants were required to repeat the reverse order of the presented digits. Each correct answer was awarded one point. The test had a maximum score of 18 and a Cronbach's α of .87.

### *Chinese Receptive Vocabulary*

In the 60-item Chinese receptive vocabulary test adopted from Li (2018), the participants were asked to select the picture (from four options) that best illustrated the target words orally presented by the experimenter. Each correct answer was awarded one point. The test had a maximum score of 60 and a Cronbach's α of .83.

### *Chinese Grammatical Knowledge*

The word order task designed by Zhang (2017) was used to assess the participants' basic awareness in Chinese sentence structure (e.g. subject–verb–object). The participants were required to arrange three to six sentence elements to construct a correct sentence [example item: Question Presentation: 1. 是 (am/is/are), 2. 学生 (student), 3.我 (I), 4. 好(good) and 5. 一名 (a/one). Correct answer: 我是一名好学生 (I am a good student)]. The word order task included 10 items, and each correct answer was awarded one point. The test had a maximum score of 10 and a Cronbach's α of .89.

***Morphological Awareness***

Compound awareness was used to assess the participants' morphological awareness or their ability to construct new compound words using their current morpheme knowledge. In this 20-item test developed by Chen (2011), each item was orally presented in Mandarin, and the participants were required to construct new words based on the given instructions. For example, '靠蒸汽的车叫蒸汽车 (If we call a car 'steam–car' because the steam drives the car), 那么靠风的车叫什么 (what should we call a car that is driven by wind)? The correct answer is 风车 (wind–car)'. Each correct answer was awarded one point. The test had a maximum score of 20 and a Cronbach's α of .91.

**Outcome Measures**

All formal experimental reading materials came from the standard Chinese narrative sentences list developed by the China National Office in the *HSK* test. To control the structure, content knowledge and text category effects on sentence comprehension, all selected narrative sentences comprised seven characters in the subjective–verb–objective format. Only one quantifier was involved in every sentence. Half of the selected sentences contained a quantifier that only applied the hyperbole function, and the remainder of the sentences were typical ones without any hyperbole function application. The quantifier words in the selected sentences were placed at either the beginning (B) or end (E) and had two structures: single (S) numeric plus a unit [e.g. 十次(ten times) ] and double (D) numeric plus a unit [e.g. 二一年(two one years) ]. Specifically, BS quantifier words occupied the first two characters in a sentence [e.g.**一枝**(one branch)红杏出墙来], BD quantifier words occupied the first three characters [e.g.**五千仞**(five thousand levels)岳上摩天], ES quantifier words occupied the last two characters [e.g.疑是银河落**九天**(nine levels)], and ED quantifier words occupied the last three characters [e.g. 梁子工文**四十年** (four ten years)].

All characters used in the selected sentences were amongst the 800 highest-ranking characters in the Chinese characters list (Li, 2018). The numeric characters included '一~十' (one to ten), 百 (hundred), 千 (thousand) and 万 (ten thousand). A total of 82 subject–verb–object format narrative sentences were also used, of which 80 were included in the formal experiment: 20 sentences in every construction form (BS, BD, ES and ED) of which 10 had hyperbole application and 10 had no rhetoric application. Before the formal experiment, two five-character sentences, of which one had a hyperbole application and one without, were used to help the participants familiarise themselves with the experimental procedure. These two sentences were retrieved from a Chinese subject textbook familiar to the participants. Example sentences can be found in **Appendix I**. The participants' reaction times for each item were recorded.

## Research Design

### *Research Procedure*

Before the formal experiment, all participants were screened for their arithmetic and reading comprehension. Poor readers with good or poor arithmetic abilities were divided into two groups. After the screening, all selected participants took a test that was developed based on six control measures. They were required to complete the test within 90 minutes in a silent school classroom with a 30-minute break in between. After completing the test, they started the formal experiment.

The formal experiment was implemented using E-prime 1.0. The participants' quantifier comprehension performance was assessed by asking one literal question and two inferential questions. The inferential questions required them to make an inference on event representation through a provided sentence; the event representations were not provided directly from the words. The participants were also required to read every randomly presented sentence with just one quantifier item and answer the given questions. The literal question required the participants to identify the objective that is restricted by the quantifier words from three potential options [example item: 三万里河东入海 (sentence presentation), 这个量词是写什么的 ('What object does the quantifier 三万里 (thirty thousand miles) describe: A. 河 (river) B. 海 (sea) C. 岸 (bank)]. The participants were asked to make an inference regarding the key event in the poetry sentence for inferential question 1 [e.g. 请推测'三万里'指的是长度图吗 ('Please make an inference on the quantifier whether 三万里 (three ten-thousand miles) represent a great picture of length? A. 是 (Yes) B. 否 (No)] and whether the quantifier in this poetry sentence describes a fact or event for inferential question 2 [e.g. 这个量词描述的事物是真实的吗 [Does (Do) the quantifier represented the event/story authentically/truthfully? A. 是 (Yes) B. 否 (No)]. The participants spent around 20 minutes to finish the formal experimental procedure. An example question was presented in **Appendix I**, and an example experimental item was presented in **Appendix II**.

**Data Analysis**

A mixed-effect model was used for the data analysis, as the number of participants in the two comparison groups differed. The random effect was set with nonverbal intelligence, verbal working memory, grammatical knowledge, character reading and morphological awareness. The fixed effect was set for the arithmetic proficiency group. All participants were expected to achieve 100% accuracy in quantifier sentence reading. This is because, according to previous empirical findings (Authors, 2020), the participants could easily answer all questions that were designed based on their frequently used vocabularies. Therefore, their reaction times were analysed. However, the reaction times for those questions that were any incorrectly answered were excluded. The average reaction times for the quantifier and non-quantifier hyperbole sentences that included quantifiers (BS, BD, ES and ED) were measured. The reaction time for inferential comprehension was computed as the sum of the reaction time for one literal question and two inferential questions, because inferential comprehension involved the processing of literal and text situational information. We cannot ignore the information process effect of one literal question on the later inferential comprehension items. The average reaction times for a quantifier construction form (BS, BD, ES and ED) in the hyperbole and non-hyperbole application sentences were used in the data analysis. Hedge's *g* was used to measure the effect size, as the number of participants between the good and poor arithmetic performance groups was not the same.

## Results

### Descriptive Analysis

We used skewness and kurtosis value to examine the participants' performance on each reading item, and the results showed that the skewness and kurtosis values were within ±2 across all test items, thereby indicating the absence of outliers in the sample. The participants' mean score, standard deviation, skewness, kurtosis and sample size in age, reading proficiency test, arithmetic proficiency test, nonverbal intelligence, verbal working memory, Chinese receptive vocabulary, Chinese grammatical knowledge, Chinese character reading, morphological awareness and literal sentence and inferential comprehension under the arithmetic proficiency category are presented in **Tables 1 to 3**. The success rate for each formal experimental item ranged from 95.24% to 100% and from 95.72% to 100% for the poor and good arithmetic proficiency students, respectively. Inaccurate answers were randomly distributed amongst all items without showing systematic patterns of errors.

**Research Question 1: Literal Comprehension Performance Comparison between Good and Poor Arithmetic Levels**

The control variables included nonverbal intelligence, verbal working memory, receptive vocabulary, grammatical knowledge, character reading and morphological awareness. Results of the mixed-effect model analysis indicate that both the good and poor arithmetic students demonstrated a similar performance in terms of quantifier literal comprehension ($p > .10$). Specifically, with the hyperbole application of quantifier words in sentence reading, these two groups demonstrated similar levels of literal information comprehension for the BS ($F = .09$, $p > .05$, Hedge's $g = .05$), BD ($F = .30$, $p > .05$, Hedge's $g = .06$), ES ($F = 2.91$, $p > .05$, Hedge's $g = .31$) and ED quantifiers ($F = .68$, $p > .05$, Hedge's $g = .12$). Meanwhile, without the hyperbole application of quantifier words in sentence reading, the two groups also demonstrated similar levels of literal information comprehension for the BS ($F = .04$, $p > .05$, Hedge's $g = .05$), BD ($F = .08$, $p > .05$, Hedge's $g = .07$), ES ($F = .43$, $p > .05$, Hedge's $g = .10$) and ED quantifiers ($F = .49$, $p > .05$, Hedge's $g = .11$). These results indicate that arithmetic performance did not affect the quantifier reading performance of poor readers at the primary school level, regardless of whether quantifier words included a hyperbole function and the quantifier construction form (BS, BD, ES and ED). Detailed information can be found in **Table 2**.

**Research Question 2：Inferential Comprehension Performance Comparison between Good and Poor Arithmetic Levels**

The same control variables used in research question (RQ)1 were included in the analysis of RQ2. Results of the mixed-effect model analysis indicate that primary school students with good arithmetic performance had significantly better ($p < .001$) inferential comprehension performance than those with poor arithmetic performance, regardless of the quantifier construction form (BS, BD, ES and ED) and whether the quantifier included a hyperbole function. Specifically, with the hyperbole application of quantifier words in sentence reading, the students with good arithmetic performance achieved a significantly faster reaction time than those with poor performance in BS ($F = 784.47$, $p < .001$, Hedge's $g = 4.32$), BD ($F = 462.79$, $p < .001$, Hedge's $g = 3.18$), ES ($F = 281.18$, $p < .001$, Hedge's $g = 2.57$) and ED quantifier comprehension ($F = 208.08$, $p < .001$, Hedge's $g = 2.22$). Without the hyperbole application of quantifier words in sentences reading, the students with good arithmetic performance still achieved a significantly faster reaction time than those with poor arithmetic performance in BS ($F = 1060.87$, $p < .001$, Hedge's $g = 5.08$), BD ($F = 690.72$, $p < .001$, Hedge's $g = 4.01$), ES ($F = 188.01$, $p < .001$, Hedge's $g = 2.10$) and ED quantifier comprehension ($F = 560.15$, $p < .001$, Hedge's $g = 3.63$). Detailed information can be found in **Table 3**.

## Discussion

Overall, the results showed that students with good and poor arithmetic skills demonstrated similar literal question comprehension levels. Students with good arithmetic skills significantly outperformed those with poor arithmetic skills in terms of inferential comprehension. These results were consistent across all quantifier construction forms (BS, BD, ES and ED) and between quantifiers with or without hyperbole application in sentences.

**Literal Comprehension Performance with Good or Poor Arithmetic Performance**

The above results are partially consistent with those of previous studies on the literal information comprehension performance of poor readers (e.g. Cain & Oakhill, 1999; Authors, 2020; Kim & Petscher, 2020), thereby suggesting that poor readers face difficulties during the shallow literal or semantic reading information process. Regardless of the combination effect of quantifier construction form and whether the quantifier includes a hyperbole function in sentences, those students with either high or low arithmetic proficiency levels demonstrated similar levels of quantifier literal information comprehension. The key to addressing the descriptive literal question is to identify the representation of the unit/dimension (e.g. times, pieces and tons) that is linked to the specific numeric value in the quantifier. Students may identify the information from the processing of the unit/dimension character. For example, when the unit is ‘times’, they must identify the object of the times (e.g. activities and learning experience). Previous studies have shown that receptive vocabulary and adjacent cues positively predict readers’ performance in text semantic comprehension (Authors, 2020; Snow, 2002), but arithmetic skills do not have a significant impact on their semantic comprehension (Swanson & Beebe–Frankenberger, 2004). Relative to arithmetic skills, a higher level of straightforward quantifier literal information comprehension may have a stronger association with language.

Furthermore, the results indicate that arithmetic function does not have a significant effect on these poor readers' word/character surface representation coding when the word plays a subject or object role in the sentence. This indicates that numerical information may have an independent information processing channel when dealing with quantifier literal information amongst Arabic and verbal magnitude representations amongst these poor readers' population. Moreover, object comprehension is affected only by one's understanding of the quantifier and not by verbal numerical information. Therefore, the quantifier comprehension of objects is not associated with the arithmetic skills of poor readers.

**Inferential Comprehension Performance with Good or Poor Arithmetic Performance**

Poor readers with high arithmetic proficiency showed a significantly better inferential comprehension performance than those with poor arithmetic proficiency. These results remain consistent across different quantifier construction form applications and whether the quantifier applied a hyperbole in sentences. These results are also partially consistent with those of previous studies, which demonstrated that students with good arithmetic skills were more sensitive and had faster response to the numeric information process compared with students having poor arithmetic skills (Cummins et al., 1988; Nortvedt et al., 2016; Palm, 2008). Previous studies have also suggested that students with high arithmetic skills demonstrated better performance in processing verbal and analogue nonsymbolic numerical information (Siemann & Petermann, 2018; Wu, 2003; Ye, 2018). As for the current reading, students with good arithmetic proficiency were more likely to regard quantifier comprehension as a kind of 'numerical problem solving' (Adelson et al., 2015; Cummins et al., 1988; Nortvedt et al., 2016). These students also demonstrated a faster response to numeric character identification and further relevant information (e.g. the relationship between quantifier and object) processing at the inferential comprehension phrase. During their inferential comprehension of the quantifier hyperbole, these students were required to identify whether the description of the quantifier word in the sentence was a valid event or fact by engaging in an analogue nonsymbolic representation process. Given that all rhetoric applications in this study were hyperboles, they linked a descriptive event or fact to real living experiences for comparison and sought answers from the comparison results.

In addition, students with good arithmetic skills demonstrated a better performance in manipulating numerical information and a faster processing speed across verbal, Arabic and analogue nonsymbolic information processes compared with those having poor arithmetic skills. The results indicated that primary school poor readers with good arithmetic proficiency were also sensitive to reading non-Arabic numerical information (e.g. analogue nonsymbolic and verbal). In addition, students with good arithmetic proficiency were more sensitive than poor proficiency students in processing quantifier information in common units/dimensions (e.g. length, weight and space) being used in their quantifier reading materials. Results also informed that the numerical information process could across verbal, Arabic and analogue nonsymbolic forms at the inferential information comprehension level amongst poor readers' population. This means that the numerical information process could generalise across languages at the inferential information comprehension level amongst the poor readers. Moreover, arithmetic proficiency may only affect the processing 'number' in the reading context. High arithmetic proficiency was linked to a better performance in processing Arabic and non-Arabic numerical information.

Fostering the arithmetic skills of poor readers might be a potential approach to improve their quantifier comprehension, regardless of hyperbole function application. The findings of this study indicate that training students' arithmetic skills may also enhance their quantifier inferential information comprehension but not their quantifier literal information comprehension. Therefore, the challenges encountered by young poor readers in literal or inferential information processing should be considered when designing relevant interventions.

**Limitations**

Some limitations of this study should be addressed in future works. First, this study only investigated hyperbole comprehension in text reading and ignored inferential comprehension in other rhetoric categories (e.g. metaphor, synaesthesia and personification). Second, this study only investigated the effects of arithmetic proficiency on quantifier comprehension in morpho-syllabic context reading, whilst previous studies have demonstrated that the pronunciation of numeric habit also affects one's text comprehension (Liu, Lin, & Zhang, 2016). Numeric pronunciation rules also vary between logographical and alphabetic scripts. Take the number 12 for example. The Chinese pronounce this number as 'ten two', which is different from English and German scripts. Moreover, this study only involved quantifier words constructed by one or two numeric characters and one unit/dimension. Therefore, text comprehension in those quantifier words constructed by the same two characters [e.g. 日日 (every day), 人人 (everyone)] warrants further investigation.

Regarding the effect of parts of speech, the hyperbole comprehension performance for words inserted in the middle components of sentences needs to be investigated. The internal reliability of reading comprehension (Cronbach's $\alpha$ = .73) was lower than expected for a cloze procedure even though the test still has adequate reliability. Moreover, a standardised Chinese reading comprehension test with a high reliability index has yet to be designed. Therefore, future research can develop a standardised reading comprehension test for primary school students and replicate the findings of this study. This work also explored the relationship between arithmetic skills and quantifier comprehension amongst poor readers but ignored the underlying mechanisms. Thus, further studies may examine the roots of this link, such as the shared cognitive function involved.

In addition, this study only focused on poor readers, which may render the results inapplicable for typically developing readers. Further research should thus examine whether the findings of this work can be extended to typically developing readers. Finally, due to the available test items limitation, this study did not examine readers' literal and inferential comprehension ability separately. Kim (2020) reported that readers cannot achieve inferential comprehension during text comprehension without literal comprehension, whilst the current study use the total reaction time of literal and inferential comprehension to represent readers' inferential comprehension ability. Therefore, future studies can improve the examination accuracy of readers' inferential comprehension ability, readers' literal and inferential comprehension ability by measuring them independently.

## Conclusion

Arithmetic contributes to the inferential comprehension of verbal quantifier words amongst primary school students. Young poor readers with high arithmetic proficiency are highly sensitive to verbal quantifier reading at the inferential information comprehension process. Regardless of the format presentation of the quantifier construction form and whether the quantifier includes a hyperbole function, young poor readers exhibit a consistent performance throughout the quantifier shallow information process. Relative to those with poor arithmetic proficiency, young poor readers with high arithmetic proficiency demonstrate a faster response to quantifier inferential information comprehension, regardless of the construction form of the quantifier and the application of hyperboles. Furthermore, for young poor readers at the primary level, the numerical information process is independent at the literal information stage but shows a significant interaction amongst verbal, Arabic and analogue nonsymbolic numerical information forms at the inferential information process stage.

## References


Adelson, J. L., Dickinson, E. R., & Cunningham, B. C. (2015). Differences in the reading–mathematics relationship: A multi-grade, multi-year statewide examination. *Learning and Individual Differences*, *43*, 118-123.

Akhondi, M., Malayeri, F. A., & Samad, A. A. (2011). How to teach expository text structure to facilitate reading comprehension. *The Reading Teacher*, *64*(5), 368-372.

Armeni, K., Willems, R. M., Van den Bosch, A., & Schoffelen, J. M. (2019). Frequency-specific brain dynamics related to prediction during language comprehension. *NeuroImage*, *198*, 283-295.

Arsalidou, M., & Taylor, M. J. (2011). Is 2+ 2= 4? Meta-analyses of brain areas needed for numbers and calculations. *Neuroimage*, *54*(3), 2382-2393.

Åsberg, J. (2010). Patterns of language and discourse comprehension skills in school-aged children with autism spectrum disorders. *Scandinavian Journal of Psychology*, *51*(6), 534-539.

Åsberg, J., & Sandberg, A. D. (2010). Discourse comprehension intervention for high-functioning students with autism spectrum disorders: preliminary findings from a school-based study. *Journal of Research in Special Educational Needs*, *10*(2), 91-98.

Bavelier, D., Corina, D., Jezzard, P., Padmanabhan, S., Clark, V. P., Karni, A., ... & Neville, H. (1997). Sentence reading: A functional MRI study at 4 Tesla. *Journal of Cognitive Neuroscience*, *9*(5), 664-686.

Beymer, D., Orton, P. Z., & Russell, D. M. (2007, September). An eye tracking study of how pictures influence online reading. In *IFIP Conference on Human-Computer*

*Interaction* (pp. 456-460). Springer, Berlin, Heidelberg.

Bianco, M., Bressoux, P., Doyen, A. L., Lambert, E., Lima, L., Pellenq, C., & Zorman, M. (2010). Early training in oral comprehension and phonological skills: Results of a three-year longitudinal study. *Scientific Studies of Reading*, *14*(3), 211-246.

Bott, O., & Radó, J. (2009). How to provide exactly one interpretation for every sentence, or what eye movements reveal about quantifier scope. *The Fruits of Empirical Linguistics*, *1*, 25-46.

Brasoveanu, A. (2011). Sentence-internal different as quantifier-internal anaphora. *Linguistics and Philosophy*, *34*(2), 93-168.

Cain, K., & Oakhill, J. V. (1999). Inference making ability and its relation to comprehension failure in young children. *Reading and Writing*, *11*(5), 489-503.

Cain, K., Oakhill, J., & Bryant, P. (2000). Investigating the causes of reading comprehension failure: The comprehension-age match design. *Reading and Writing*, *12*(1), 31-40.

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology*, *96*(1), 31-42.

Cain, K., & Oakhill, J. (2006). Profiles of children with specific reading comprehension difficulties. *British Journal of Educational Psychology*, *76*(4), 683-696.

Chall, J. (1976). The great debate: Ten years later, with a modest proposal for reading stages.

Cohn, N. (2020). Your brain on comics: A cognitive model of visual narrative comprehension. *Topics in Cognitive Science*, *12*(1), 352-386.

Collins, A. A., Compton, D. L., Lindström, E. R., & Gilbert, J. K. (2020). Performance variations across reading comprehension assessments: Examining the unique contributions of text, activity, and reader. *Reading and Writing*, *33*(3), 605-634.

Cummins, D. D., Kintsch, W., Reusser, K., & Weimer, R. (1988). The role of understanding in solving word problems. *Cognitive Psychology*, *20*(4), 405-438.

Davenport, H. (1999). *The higher arithmetic: An introduction to the theory of numbers*. Cambridge University Press.

Dehaene, S. (1992). Varieties of numerical abilities. *Cognition*, *44*(1-2), 1-42.

Desai, S., McLean, J., Lawrence, C., & Filik, R. (2021). The impact of hyperbole on perception of victim testimony. *Journal of Pragmatics*, *174*, 143-156.

Author. (2020). Enhancing Poor Readers' Reading Comprehension Ability through Word Semantic Knowledge Training. *Reading & Writing Quarterly*, 1-17.

Duke, N. K. (2000). 3.6 minutes per day: The scarcity of informational texts in first grade. *Reading Research Quarterly*, *35*(2), 202-224.

Daneman, M., & Merikle, P. M. (1996). Working memory and language comprehension: A meta-analysis. *Psychonomic Bulletin & Review*, *3*(4), 422-433.

Diakidoy, I. A. N., Stylianou, P., Karefillidou, C., & Papageorgiou, P. (2005). The relationship between listening and reading comprehension of different types of text at increasing grade levels. *Reading Psychology*, *26*(1), 55-80.

Glenberg, A., Willford, J., Gibson, B., Goldberg, A., & Zhu, X. (2012). Improving reading to improve math. *Scientific Studies of Reading*, *16*(4), 316-340.

Graesser, A. C., Millis, K. K., & Zwaan, R. A. (1997). Discourse comprehension. *Annual Review of Psychology*, *48*(1), 163-189.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review*, *101*(3), 371-395.

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in composing of elementary school students: A new methodological approach. *Journal of Educational Psychology*, *89*(1), 170-182.

Grimm, K. J. (2008). Longitudinal associations between reading and mathematics achievement. *Developmental Neuropsychology*, *33*(3), 410-426.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. *Psychology of Learning and Motivation*, *22*, 193-225.

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*(2), 127-160.

Kim, Y. S. G. (2016). Direct and mediated effects of language and cognitive skills on comprehension of oral narrative texts (listening comprehension) for children. *Journal of Experimental Child Psychology*, *141*, 101-120.

Kim, Y. S. G. (2020). Hierarchical and dynamic relations of language and cognitive skills to reading comprehension: Testing the direct and indirect effects model of reading (DIER). *Journal of Educational Psychology*, *112*(4), 667-684.

Kim, Y. S. G., Guo, Q., Liu, Y., Peng, Y., & Yang, L. (2020). Multiple pathways by which compounding morphological awareness is related to reading comprehension: Evidence from Chinese second graders. *Reading Research Quarterly*, *55*(2), 193-212.

Kim, Y. S. G., & Petscher, Y. (2020). Influences of individual, text, and assessment factors on text/discourse comprehension in oral language (listening comprehension). *Annals of*

*Dyslexia*, 1-20.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, *95*(2), 163-182.

Kintsch, W. (1993). Information accretion and reduction in text processing: Inferences. *Discourse Processes*, *16*(1-2), 193-202.

Kreuz, R. J., & Roberts, R. M. (1995). Two cues for verbal irony: Hyperbole and the ironic tone of voice. *Metaphor and Symbol*, *10*(1), 21-31.

Kurtzman, H. S., & MacDonald, M. C. (1993). Resolution of quantifier scope ambiguities. *Cognition*, *48*(3), 243-279.

Liberman, A. M. (1992). The relation of speech to reading and writing. In *Advances in Psychology* (Vol. 94, pp. 167-178). North-Holland.

Liu, Y., Lin, D., & Zhang, X. (2016). Morphological awareness longitudinally predicts counting ability in Chinese kindergarteners. *Learning and Individual Differences*, *47*, 215-221.

Lyster, S. A. H., Snowling, M. J., Hulme, C., & Lervåg, A. O. (2021). Preschool phonological, morphological and semantic skills explain it all: Following reading development through a 9-year period. *Journal of Research in Reading*, *44*(1), 175-188.

McGlone, M. S. (2011). Hyperbole, homunculi, and hindsight bias: An alternative evaluation of conceptual metaphor theory. *Discourse Processes*, *48*(8), 563-574.

McKeown, M. G., Beck, I. L., & Blake, R. G. (2009). Rethinking reading comprehension instruction: A comparison of instruction for strategies and content approaches. *Reading Research Quarterly*, *44*(3), 218-253.

McKoon, G., & Ratcliff, R. (1992). Inference during reading. *Psychological Review*, *99*(3), 440-456.

McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, *14*(1), 1-43.

Mecartty, F. H. (2000). Lexical and grammatical knowledge in reading and listening comprehension by foreign language learners of Spanish. *Applied Language Learning*, *11*(2), 323-348.

Morgan, P. L., Farkas, G., & Wu, Q. (2011). Kindergarten children's growth trajectories in reading and mathematics: Who falls increasingly behind?. *Journal of Learning Disabilities*, *44*(5), 472-488.

Morgan, P. L., Li, H., Farkas, G., Cook, M., Pun, W. H., & Hillemeier, M. M. (2017). Executive functioning deficits increase kindergarten children's risk for reading and mathematics difficulties in first grade. *Contemporary Educational Psychology*, *50*, 23-32.

Nation, K., Clarke, P., Marshall, C., & Durand, M. (2004). Hidden language impairments in children: Parallels between poor reading comprehension and specific language impairment? *Journal of Speech, Language, and Hearing Research*, *47*, 199–211.

Niehaus, J., & Young, R. M. (2014). Cognitive models of discourse comprehension for narrative generation. *Literary and Linguistic Computing*, *29*(4), 561-582.

Norris, D., Cutler, A., McQueen, J. M., & Butterfield, S. (2006). Phonological and conceptual activation in speech comprehension. *Cognitive Psychology*, *53*(2), 146-193.

Nortvedt, G. A., Gustafsson, J. E., & Lehre, A. C. W. (2016). The importance of instructional quality for the relation between achievement in reading and mathematics. *Teacher Quality,* *Instructional Quality and Student Outcomes*, 97-113.

Palm, T. (2008). Impact of authenticity on sense making in word problem solving. *Educational Studies in Mathematics*, *67*(1), 37-58.

Potocki, A., Ecalle, J., & Magnan, A. (2013). Narrative comprehension skills in 5-year-old children: Correlational analysis and comprehender profiles. *the Journal of Educational Research*, *106*(1), 14-26.

Primor, L., Pierce, M. E., & Katzir, T. (2011). Predicting reading comprehension of narrative and expository texts among Hebrew-speaking readers with and without a reading disability. *Annals of Dyslexia*, *61*(2), 242-268.

Rader, A. W., & Sloutsky, V. M. (2002). Processing of logically valid and logically invalid conditional inferences in discourse comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*(1), 59-68.

Raven, J. C., Court, J. H., & Raven, J. (1995). *Raven's Coloured Progressive Matrices*. Oxford, United Kingdom: Oxford Psychologists Press

Robertson, D. A., Gernsbacher, M. A., Guidotti, S. J., Robertson, R. R., Irwin, W., Mock, B. J., & Campana, M. E. (2000). Functional neuroanatomy of the cognitive process of mapping during discourse comprehension. *Psychological Science*, *11*(3), 255-260.

Roehling, J. V., Hebert, M., Nelson, J. R., & Bohaty, J. J. (2017). Text structure strategies for improving expository reading comprehension. *The Reading Teacher*, *71*(1), 71-82.

Schuh, J. M., Eigsti, I. M., & Mirman, D. (2016). Discourse comprehension in autism spectrum disorder: Effects of working memory load and common ground. *Autism Research*, *9*(12), 1340-1352.

Siemann, J., & Petermann, F. (2018). Evaluation of the Triple Code Model of numerical processing—Reviewing past neuroimaging and clinical findings. *Research in Developmental Disabilities*, *72*, 106-117.

Silinskas, G., Leppänen, U., Aunola, K., Parrila, R., & Nurmi, J. E. (2010). Predictors of mothers' and fathers' teaching of reading and mathematics during kindergarten and Grade 1. *Learning and Instruction*, *20*(1), 61-71.

Snow, C. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. Rand Corporation.

Swanson, E., Wanzek, J., Vaughn, S., Fall, A. M., Roberts, G., Hall, C., & Miller, V. L. (2017). Middle school reading comprehension and content learning intervention for below-average readers. *Reading & Writing Quarterly*, *33*(1), 37-53.

Swanson, H. L., & Beebe-Frankenberger, M. (2004). The relationship between working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology*, *96*(3), 471-491.

Van Bon, W. H., & Van Der Pijl, J. M. (1997). Effects of word length and wordlikeness on pseudoword repetition by poor and normal readers. *Applied Psycholinguistics*, *18*, 101–114

Van Dijk, T. A. (1979). Relevance assignment in discourse comprehension. *Discourse Processes*, *2*(2), 113-126.

Varga, D. (2000). Hyperbole and humor in children's language play. *Journal of Research in Childhood Education*, *14*(2), 142-151.

Vought, J. R., & Dean, R. S. (2011). Woodcock-Johnson III Tests of Cognitive Abilities. In S.

Goldstein & J. A. Naglieri (Eds.), *Encyclopedia of child behavior and development* (pp. 1577–1578). Springer US.

Wolfe, M. B., & Woodwyk, J. M. (2010). Processing and memory of information presented in narrative or expository texts. *British Journal of Educational Psychology*, *80*(3), 341-362.

Wen, Y., Snell, J., & Grainger, J. (2019). Parallel, cascaded, interactive processing of words during sentence reading. *Cognition*, *189*, 221-226.

Wu, Y., Barquero, L. A., Pickren, S. E., Barber, A. T., & Cutting, L. E. (2020). The relationship between cognitive skills and reading comprehension of narrative and expository texts: A longitudinal study from Grade 1 to Grade 4. *Learning and Individual Differences*, *80*(20),1-14.

Yang, M., & Wang, Y. (2022). The Relations between Cardinal Number Knowledge and Quantifier Comprehension. *Language Learning and Development*, 1-17.

Zhang, X., & Lin, D. (2018). Cognitive precursors of word reading versus arithmetic competencies in young Chinese children. *Early Childhood Research Quarterly*, *42*, 55-65.

**Table 1**

*Descriptive Information of Control Measures and Demographical Information*

| | Poor Arithmetic | | | | | Good Arithmetic | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sample* | *Mean* | *SD* | *Skewness* | *Kurtosis* | *Sample* | *Mean* | *SD* | *Skewness* | *Kurtosis* |
| Age (unit: months) | 84 | 74.28 | 6.84 | <.01 | -.16 | 84 | 72.24 | 6.96 | <.01 | .08 |
| Proficiency test | | | | | | | | | | |
| Reading comprehension | 84 | 5.73 | 1.95 | .18 | -1.25 | 84 | 5.96 | 2.09 | -.06 | -1.40 |
| Arithmetic | 84 | 19.13 | 4.80 | .02 | -1.06 | 84 | 57.61 | 5.46 | -.02 | -1.46 |
| Control measures | | | | | | | | | | |
| Nonverbal intelligence | 84 | 18.87 | 1.79 | .12 | -1.28 | 84 | 18.95 | 1.73 | -.05 | -1.10 |
| Verbal working memory | 84 | 9.79 | 1.29 | .21 | -1.03 | 84 | 9.56 | 1.41 | .27 | -1.42 |
| Chinese receptive vocabulary | 84 | 38.21 | 6.89 | -.17 | -1.08 | 84 | 37.58 | 7.21 | -.07 | -1.20 |
| Chinese grammatical knowledge | 84 | 6.54 | .81 | .36 | -.52 | 84 | 6.75 | .71 | .20 | -.62 |
| Character reading | 84 | 30.58 | 3.33 | -.26 | -1.12 | 84 | 29.86 | 3.43 | .00 | -1.17 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Morphological awareness | 84 | 10.52 | 1.00 | -.10 | -1.03 | 84 | 10.50 | .98 | -.28 | -.96 |

**Table 2**

*Comparison of Quantifier Hyperbole Literal Comprehension Between Two Arithmetic Levels*

| | Poor Arithmetic | | | | | Good Arithmetic | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Sample* | *Mean* | *SD* | *Skewness* | *Kurtosis* | *Sample* | *Mean* | *SD* | *Skewness* | *Kurtosis* | *F* | Hedge's *g* |
| Comprehension measures (unit: s) | | | | | | | | | | | | |
| Literal Comprehension_Y_BS | 81 | 5.77 | .21 | -.19 | -.13 | 83 | 5.78 | .18 | -.37 | -.13 | .09 | .05 |
| Literal Comprehension_Y_BD | 80 | 7.15 | .30 | .27 | .03 | 81 | 7.13 | .36 | .17 | -.76 | .30 | .06 |
| Literal Comprehension_Y_ES | 84 | 8.87 | .53 | .28 | .34 | 82 | 8.69 | .63 | -.11 | .01 | 2.91 | .31 |
| Literal Comprehension_Y_ED | 81 | 10.90 | .53 | -.25 | -.55 | 83 | 10.83 | .64 | -.09 | -.38 | .68 | .12 |
| Literal Comprehension_N_BS | 80 | 5.25 | .16 | -.44 | -.28 | 84 | 5.24 | .20 | -.08 | .27 | .04 | .05 |
| Literal Comprehension_N_BD | 83 | 6.57 | .28 | -.11 | .50 | 82 | 6.59 | .28 | .46 | -.23 | .08 | .07 |
| Literal Comprehension_N_ES | 81 | 8.12 | .57 | .08 | .05 | 80 | 8.18 | .57 | .00 | -.76 | .43 | .10 |
| Literal Comprehension_N_ED | 82 | 10.16 | .65 | -.06 | .44 | 83 | 10.09 | .65 | .01 | .26 | .49 | .11 |

*Note*. $^{***}$ $p < .001$; Y = quantifier applied hyperbole in sentence. N = quantifier did not apply hyperbole in sentence. BS = Single numeric character in the quantifier and the quantifier was located at the beginning of the sentences; BD= Double numeric character in the quantifier and the quantifier was located at the beginning of the sentences; ES= Single numeric character in the quantifier and the quantifier was located at the end part of the sentences; ED= Double numeric character in the quantifier and the quantifier was located at the end part of the sentences

**Table 3**

*Comparison of Quantifier Hyperbole Inferential Comprehension Between Two Arithmetic Levels*

| | Poor Arithmetic | | | | | Good Arithmetic | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Sample* | *Mean* | *SD* | *Skewness* | *Kurtosis* | *Sample* | *Mean* | *SD* | *Skewness* | *Kurtosis* | *F* | Hedge's *g* |
| Comprehension measures (unit: s) | | | | | | | | | | | | |
| Inferential Comprehension_Y_BS | 81 | 14.57 | .31 | .05 | -.35 | 83 | 13.33 | .26 | -.08 | -.54 | 784.47*** | 4.32 |
| Inferential Comprehension_Y_BD | 80 | 16.40 | .36 | .30 | -.03 | 81 | 15.20 | .39 | -.04 | -.68 | 462.79*** | 3.18 |
| Inferential Comprehension_Y_ES | 84 | 18.10 | .60 | .23 | .52 | 82 | 16.50 | .64 | -.15 | -.03 | 281.18*** | 2.57 |
| Inferential Comprehension_Y_ED | 81 | 20.61 | .55 | -.26 | .08 | 83 | 19.23 | .68 | .02 | .40 | 208.08*** | 2.22 |
| Inferential Comprehension_N_BS | 80 | 12.57 | .25 | -.22 | -.01 | 84 | 11.24 | .27 | .21 | -.17 | 1060.87*** | 5.08 |
| Inferential Comprehension_N_BD | 83 | 14.48 | .32 | -.22 | .43 | 82 | 13.17 | .33 | .24 | .03 | 690.72*** | 4.01 |
| Inferential Comprehension_N_ES | 81 | 15.95 | .62 | .08 | -.18 | 80 | 14.67 | .59 | -.03 | -.61 | 188.01*** | 2.10 |
| Inferential Comprehension_N_ED | 82 | 20.00 | .86 | -.02 | 1.06 | 83 | 17.11 | .72 | .06 | .35 | 560.15*** | 3.63 |

*Note*. *** $p < .001$; Y = quantifier applied hyperbole in sentence. N = quantifier did not apply hyperbole in sentence. BS = Single numeric character in the quantifier and the quantifier was located at the beginning of the sentences; BD= Double numeric character in the quantifier and the quantifier was located at the beginning of the sentences; ES= Single numeric character in the quantifier and the quantifier was located at the end part of the sentences; ED= Double numeric character in the quantifier and the quantifier was located at the end part of the sentences.

**Appendix I**

*Example Information of Experimental Materials Presentation*

| Number | Title | Author | Sentences | Quantifier | Construction form | Literal Question | Literal Question Answer | Other Option 1 | Other Option 2 | Quantifier for hyperbole application | Authentic/realistic of the quantifier |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Practical Items | | | | | | | | | | | |
| 1 | 江雪 | 柳宗元 | 千山鸟飞绝 | 千山 | ES | “千山”是写什么的 | 山 | 鸟 | 水 | Y | Y |
| 2 | 何满子 | 唐张祜 | 一声何满子 | 一声 | ES | “一声”是写什么的 | 声音 | 儿子 | 春天 | N | N |

*Note*. Y = quantifier applied hyperbole in sentence. N = quantifier did not apply hyperbole in sentence. ES= Single numeric character in the quantifier and the quantifier was located at the end part of the sentences

**Appendix II**

Example Item Presentation