

## A WEB-BASED ASSESSMENT FOR PHONOLOGICAL AWARENESS, RAPID AUTOMATIZED NAMING (RAN) AND LEARNING TO READ CHINESE

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### ABSTRACT

The present study examined the equivalency of conventional and web-based tests in reading Chinese. Phonological awareness, rapid automatized naming (RAN), reading accuracy, and reading fluency tests were administered to 93 grade 6 children in Taiwan with both test versions (paper-pencil and web-based). The results suggest that conventional and web-based versions were equally predictive of Chinese reading measures. However, the equivalency of the two testing mediums was found with RAN only.

### INTRODUCTION

Despite the establishment of phonological awareness as sine qua non for reading alphabetic languages (see reviews in Adams, 1990; Torgesen & Mathes, 2000; Wagner & Torgesen, 1987), studies have shown that phonological awareness skills are associated and predictive of Chinese reading (Chen, Hao, Geva, Zhu, & Shu, 2009; Ho & Bryant, 1997a, 1997b; Huang & Hanley, 1995; Hu & Catts, 1998; Li, Anderson, Nagy, & Zhang, 2002; Liao, Georgiou, & Parrila, 2008; McBride-Chang & Zhong, 2003; Siok & Fletcher, 2001; Shu, Peng, & McBride-Chang, 2008; Tong & McBride-Chang, 2010). Phonological awareness, the sensitivity to the sound structure of a language and the ability to manipulate segments of words, is often measured by tasks that involve analyzing, synthesizing, and categorizing speech sounds of one's language (Wagner et al., 1997; Wagner, Torgesen, & Rashotte, 1994; Wagner & Torgesen, 1987).

Chinese syllables are conventionally dissected into onsets (initial sound) and rimes (final sound), thus, reading studies in Chinese usually focus on awareness of three sound units: syllables, onsets, and rimes (Li et al., 2002; Lu, 2003). In Taiwan, for example, there are 21 symbols for the initial sounds (onsets) and 16 symbols for the final sounds (rimes) in the phonetic system used in the early years of primary school (Zhu-Yin-Fu-Hao, which literally means "phonetic symbols" in Chinese). For beginning readers, at least, the ability to perceive and manipulate subsyllabic phonological units is required to acquire basic reading skills. Generally, syllable awareness tasks are often used to assess sensitivity of sound with preschoolers (e.g. McBride-Chang and Ho, 2000; McBride-Chang & Zhong, 2003; McBride-Chang, Tong, Shu, Wong, Leung, & Tardif, 2008; Shu et al., 2008; Tong, McBride-Chang, Shu, & Wong, 2009) while onset and rime awareness tasks are more frequently used with children who have received formal reading instruction (e.g. Chen et al., 2009; Chen, 2010; Liao et al., 2008; Siok & Fletcher, 2001; Tsai & Liao, 2010; Tong & McBride-Chang, 2010).

Converging Chinese reading research has demonstrated positive relations between onset and rime awareness and character recognition (Chen, 2010; Ho, 1997; Ho & Bryant, 1997a, 1997b; Ho, Wong, & Chan, 1999; Huang & Hanley, 1997; Hu & Catts, 1998; Liao et al., 2008; Siok & Fletcher, 2001; Tsai & Liao, 2010; So & Siegel, 1997). Chen (2010), for example, found that onset and rime awareness correlated with and predicted character recognition with 102 fourth graders in Taiwan. After age, IQ, and rapid naming were controlled, onset and rime awareness still accounted for an additional 7.3% of the variance in character recognition. Similarly, Siok and Fletcher (2001) measured phonological awareness with an oddity test (onset and rime level) and found that onset and rime awareness correlated with and predicted 22% and 15%, respectively, significant amount of variance in character reading, independent of non-verbal intelligence in grade 2 and grade 5.

In addition to the significant contribution of phonological awareness to reading, a substantial body of evidence has shown that rapid automatized naming (RAN) is related to and account for unique variance in alphabetic reading performance (e.g., Blachman, 1984; Compton, 2003; de Jong & van der Leij, 1999; Kirby, Parrila, & Pfeiffer, 2003; Manis, Doi, & Bhadha, 2000; Parrila, Kirby, & McQuarrie, 2004; Sprugevica & Høien, 2004; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wagner & Torgesen, 1987). Generally, rapid automatized naming (RAN) refers to how fast a person can continuously name a set of familiar stimuli on a page (Wolf & Bowers, 1999). The key components of this definition of RAN are that the stimuli are name

continuously from the first to the last, and that they are extremely familiar to the participants (Kirby, Georgiou, Martinussen, & Parrila, 2010). Studies have shown that correlations are usually lower between discrete trials of naming (the stimuli are presented and named individually) and literacy skills than continuous naming (de Jong, 2009; Torgesen, Wagner, & Rashotte, 1994; Wagner et al., 1997). This phenomenon may as well indicate the closely relationship between the underlying processes of RAN and the behaviour of reading.

Existing literature supports the imperative role of RAN to nonalphabetic Chinese (Chen, 2010; Chow, McBride-Chang, & Burgess, 2005; Hu & Catts, 1998; Kang, 2004; Liao et al., 2008; McBride-Chang, Chow, Zhong, Burgess, & Hayward, 2005; McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Tan, Spinks, Eden, Perfetti, and Siok, 2005; Tsai & Liao, 2010; Wang, 2005). Studies attempting to account for the relationship between RAN, the ability to name highly familiar symbols or stimuli (letters, numbers, colours, or pictured objects) as fast as possible, and Chinese reading shows that (1) RAN correlates significantly with character recognition among beginning readers in Taiwan (Hu & Catts, 1998; Liao et al., 2008; Tsai & Liao, 2010), Hong Kong (Chow et al., 2005; McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002; McBride-Chang et al., 2003; McBride-Chang & Zhong, 2003; McBride-Chang et al., 2008; Tong et al., 2009) and China (McBride-Chang et al. 2005; Wang, 2005); (2) RAN predicts character recognition (Hu & Catts, 1998; McBride-Chang et al., 2003, Tan et al., 2005) and character and word reading fluency (Chen, 2010; Kang, 2004; Liao et al. 2008; Tsai & Liao, 2010 ) concurrently (3) RAN contributes longitudinally to character recognition (McBride-Chang & Zhong, 2003; Tong et al., 2009; Wang, 2005) and paragraph reading fluency (Wang, 2005); (4) RAN deficits is one of the dominant cognitive deficits in Chinese developmental dyslexia (Chan, Ho, Tsang, Lee, & Chung, 2007; Ho, Chan, Tsang, & Lee, 2002; Ho, Chan, Lee, Tsang, & Luan, 2004).

In addition to the important roles of phonological awareness and RAN to reading success, the utility of these constructs to identify potential reading deficits is well-acknowledged. Phonological awareness and RAN are often used for diagnosing children with reading disabilities not only because they distinguish good and poor readers but also these tasks can be administered to children as young as four, which make them ideal screening and diagnosis instruments for early identification and early intervention (Chan et al., 2007; Ho et al., 2002; Ho et al., 2004; Lu, 2003). Reading is a complex activity and there are multiple factors contribute to reading failure, such as weaknesses in phonological awareness, RAN, orthographic processing, and morphological awareness (e.g. Ho et al., 2004; Lu, 2003; Shu, McBride-Chang, Wu, & Liu, 2006). However, among these factors, phonological awareness and RAN are particularly important theoretically because of the proposed double-deficit hypothesis by Wolf and Bowers (1999). According to the hypothesis, individuals with deficits in both phonological awareness and RAN will experience more severe reading difficulties than individuals with only one of the deficits.

Conventionally, phonological awareness is assessed individually by presenting the items orally by the experimenter. For example, in a rime awareness task, after hearing the four syllables “cat, rat, dear, mat “, children are asked to choose the syllable that has the different rime. RAN, on the other hand, is conventionally assessed individually with stimuli equally distributed in rows on a paper or on a computer screen. Four types of stimuli, colours, pictures, digits and letters, are used most often in RAN tasks. Participants are asked to name the items as fast and accurately as possible. The response time (RT) is measured by the onset of the first item to the last stimuli named by a stopwatch and errors are recorded manually. For example, a child may be shown a page of 50 Arabic numerals (e.g., 2, 4, 5, 7, 9) equally distributed in five rows in semi-random order with 10 items in each row and asked to name them as fast and accurate as possible. The score of the task is the total time spent in reading the 50 digits.

Even though conventional test versions of phonological awareness and RAN are widely used in reading research, there are disadvantages and limitations in the existing formats, including limited sample size, inaccurate response time and error scoring, inconsistent presentation, and higher chance of human error. Limited sample size, for example, eliminates the efficiency and sufficiency of the tests to screen a large number of children at young age and identify those manifest potential symptoms of reading difficulties as early as possible. Conventional test versions require individual testing. Both time and labour constraints make school-wide testing unachievable, which in turn reduce the efficacy of early identification and early intervention. Inaccurate RT and error scoring might occur due to inadequate test administration, and false judgment of the onset/end of naming, and error identification during testing. Consistent presentation is particularly important for phonological awareness since all the test items are presented orally by the experimenter to the participants. Thus, consistency between trials and participants needs to be met to ensure reliable results obtained. Finally, conventional tests involve large amount of human supervision which increases the probability of unexpected errors during the process of testing.

To summarize, the purposes of the present study are: first, to eliminate the limitations of conventional test versions by developing web-based phonological awareness and RAN tests; second, to examine the equivalency of conventional and web-based phonological awareness and RAN tasks to Chinese reading performance; and finally, to investigate and to compare the contributions of the two test versions to character recognition and word reading fluency. Given what the existing studies in reading research, we expected that the web-based test system will become valuable tools to the Assessment and Research community by providing:

1. uniform oral and visual presentation,
2. precise response time and error scoring
3. fast and simultaneous results and analyses
4. easy access of tests in remote areas
5. large group sampling
6. early identification and early intervention for children with reading difficulties

To our knowledge, the present study is the first study to examine web-based assessment in phonological awareness, RAN and reading skills. The advantages of web-based tests would improve the existing screening and diagnosis system of reading disabilities, and moreover, provide researchers more accessible and convenient tools for conducting empirical studies.

## **METHOD**

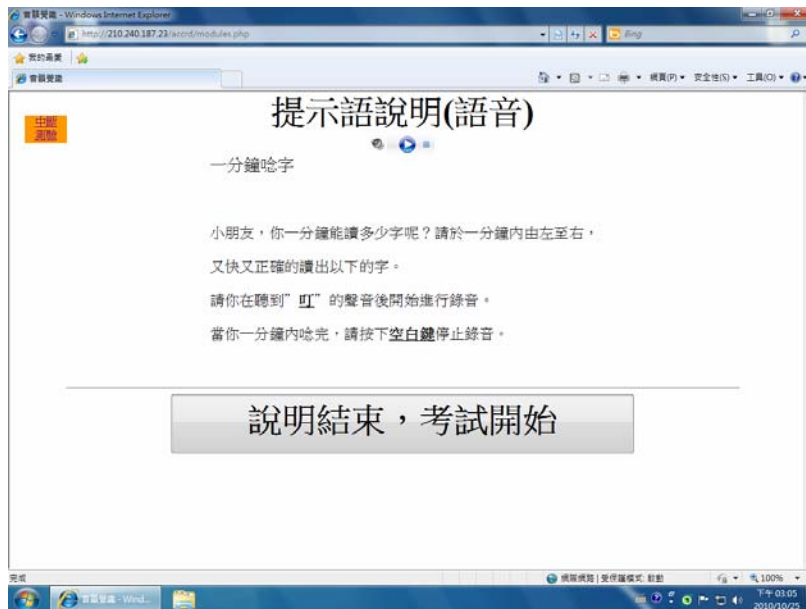
### *Materials and procedures*

All participants were assessed on a nonverbal intelligence test, two reading tasks (character recognition, one-minute word reading), two phonological awareness tasks (onset detection, rhyme detection), and two RAN tasks (RAN colours, RAN digits). For the two reading tasks, character recognition was administered with the paper-pencil version and one-minute word reading was administered with the web-based version. For phonological awareness and RAN tasks, with the same test items, both web-based and paper-pencil versions were used.

*Nonverbal Intelligence.* A measure of nonverbal intelligence was included in the present study because some previous studies have found that Chinese reading is significantly correlated with IQ (e.g., Huang & Hanley, 1995; 1997). Raven's standard progressive Matrices (Raven, Court, & Raven, 1998) was used to assess nonverbal intelligence in this study. The test required participants to select one of six to eight options that best completed a matrix with a part missing. There are five sets of 12 items each in the test. Scoring procedures were based on the local norm established in 2006.

*Graded Chinese Character Recognition Test* (Character Recognition; Huang, 2001). This is a standardized group administered reading measure with 200 single-syllable characters graded in difficulty. The test is frequently used in Taiwan for measuring reading abilities in grades 1 to 9. Participants were asked to write down the name of the character next to it using Zhu-Yin-Fu-Hao, which is the phonetic system used in Taiwan. Children started to learn the phonetic system in the beginning of grade 1 and used it till grade 6. Thus, first graders have already acquired the skills in converting Chinese syllables in writing by using Zhu-Yin-Fu Hao. The score of the test was the number of characters answered correctly.

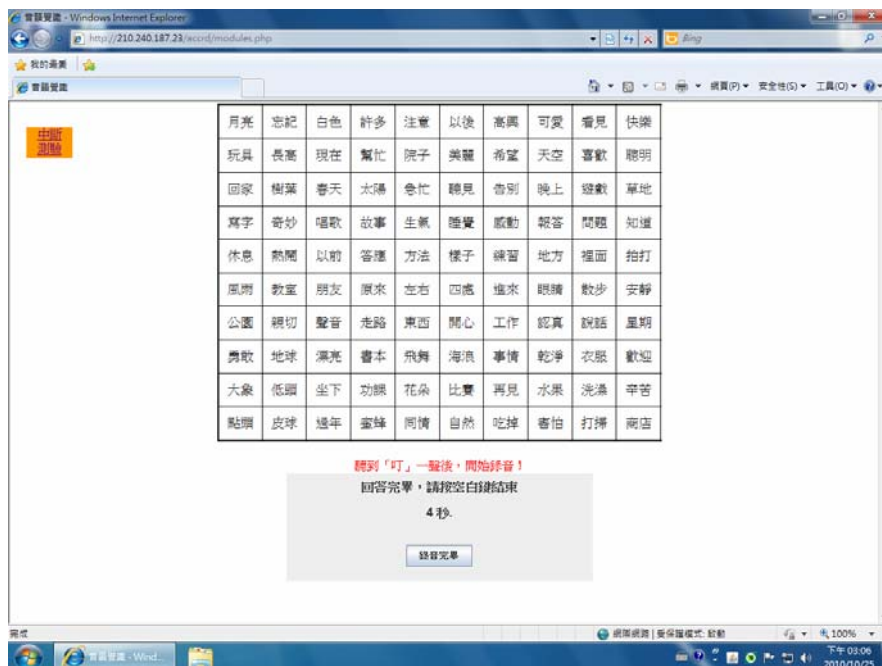
*One-Minute Word Reading.* The web-based test consisted of 100 familiar Chinese two-character words (see Figure 2). Children were instructed to read the words as fast and accurately as possible in one minute after the beeping sound occurred (see Figure 1). After the beep, the system started recording. Children who finished reading within one minute would press the space bar to terminate recording. The test stopped mandatorily while one minute is reached and the sound file was sent to and saved by the server for scoring and further analysis. The score was the number of words read correctly within one minute.



One Minute Word Reading: How many words can you read in a minute? Please read from left to right as fast and accurately as possible in a minute. When you hear the beep, the system will start recording. Press the space bar when you are done to stop recording.

Press this button to start the test.

Figure 1. Interface of One-Minute Word Reading Instruction



This picture shows 100 familiar Chinese two-character words. The participant are required to read these words from left to right as fast and accurately as possible in one minute.

Press the button to stop recording.

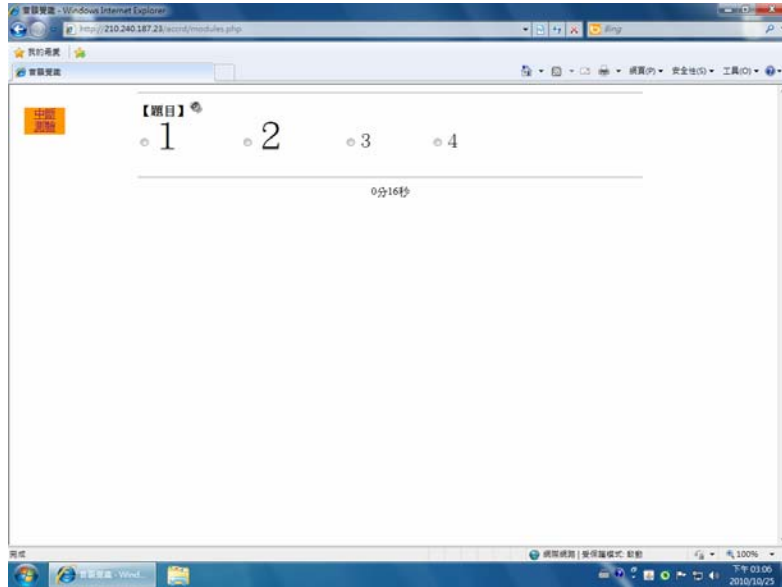
Figure 2. Interface of One-Minute Word Reading

*Onset Detection.* The task was developed to assess children’s sensitivity to the onsets of Chinese syllables. Detection of the initial sound of Chinese syllables was employed because of the presumed onset and rime characteristic of Chinese syllables. Chinese single-syllable words were used in the task. There were 2 practice trials and 12 test trials. Tones of syllables were controlled such that all four syllables in each trial were in the same tone. Children were instructed to wear earphones before the test. After listening to the four syllables, children were asked to press the number keys (1, 2, 3, 4) which syllable had the different onset (see Figure3). For example, after listening to [fu]1膚, [ma]1 媽, [mi]1咪, [mau]1貓, children were supposed to press “1” which had the different onset than the other three. Each test item was presented twice. The font size of the number options became larger when a syllable was presented. The function was specially designed as a reminder to the participants, and at the same time, to decrease the memory load.

*Rhyme Detection.* The task was developed to assess children’s sensitivity to the rimes of Chinese syllables.

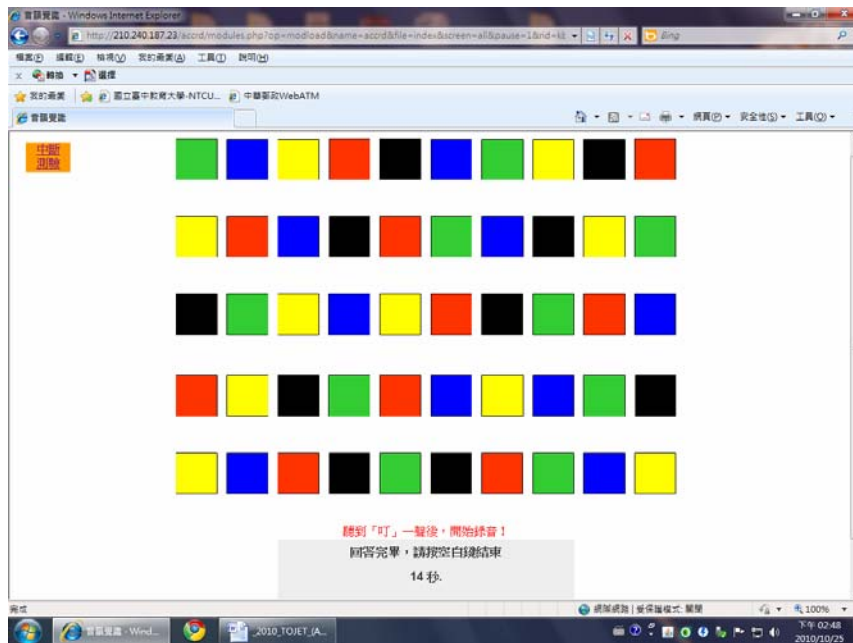
Chinese single-syllable words were used in the task. There were 2 practice trials and 12 test trials. Tones of syllables were controlled such that all four syllables in each trial were in the same tone. The testing procedure was the same as Onset Detection.

*Rapid Automatized Naming (RAN).* Two rapid naming tasks were used in the present study: colour naming (RAN Colours) and digit naming (RAN Digits). Each naming task contained 50 stimuli presented on a computer screen (see Figure 4). RAN Colours involved five colours, namely black, red, yellow, blue, and green. RAN Digits involved five numbers, 2, 4, 5, 7, and 9 (see Figure 5). In all tasks, the items were equally distributed in five rows with 10 items in each row. A practice trial preceded each test trial to ensure familiarity with the stimuli. Children were asked to wear the earphone with a microphone, to name the items as fast and accurately as possible after the beeping sound occurs, and to press the space bar when the last stimulus was read to stop recording. The sound file was then sent to and saved by the server for scoring and further analysis.



In the Onset and Rhyme Detection task, the font size of the number options becomes larger when a syllable is presented.

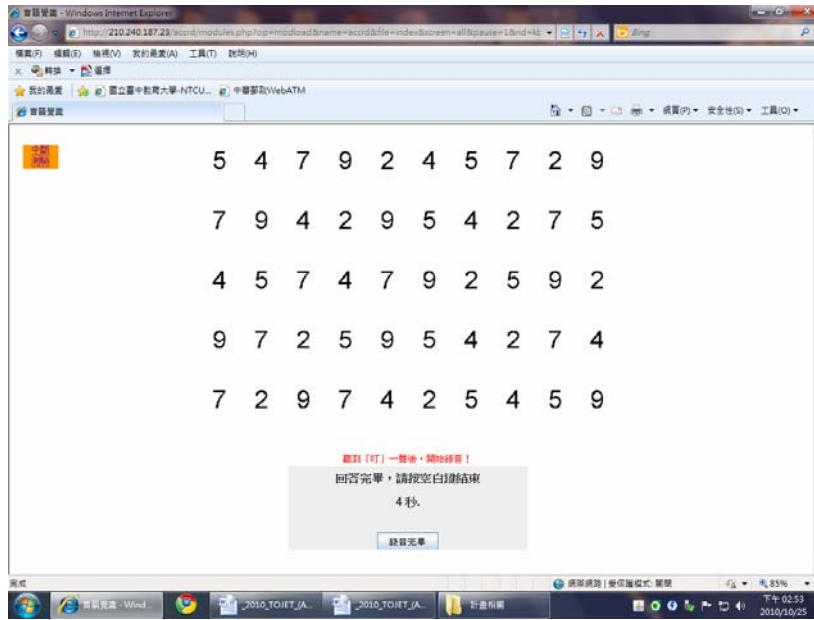
Figure 3. Interface of Onset and Rhyme Detection



This picture shows 50 stimuli consisted of five colours and the participant read it from left to right and from top to bottom as fast and accurately as possible.

When colour naming is finished, press the space bar to stop recording.

Figure 4. Interface of RAN Colours



This picture shows 50 stimuli consisted of five digits and the participant read it from left to right and from top to bottom as fast and accurately as possible.

When digit naming is finished, press the space bar to stop recording.

Figure 5. Interface of RAN Digits

*Implementation of web-based phonological awareness and RAN assessment system*

The proposed web-based phonological awareness and RAN assessment system has been implemented based on PHP and MySQL with APACHE web servers. Figure 6 shows the system architecture which consists of 9 modules: Account Management Module, Item Bank Management Module, Test Management Module, Scoring Module, Test Module, Test Report Module, User-profile Database, Item Bank Database, and Test Result Database.

The Account Management Module provides creation and management of user accounts. The functions of Item Bank Management Module include the creation, modification, and deletion of items. The function of Test Management Module is to arrange test battery and test administration process. After finishing the test, the Scoring Module evaluates responses and computes the domain scores automatically. The Test Report Module is used to generate the report of diagnosing results for each examinee.

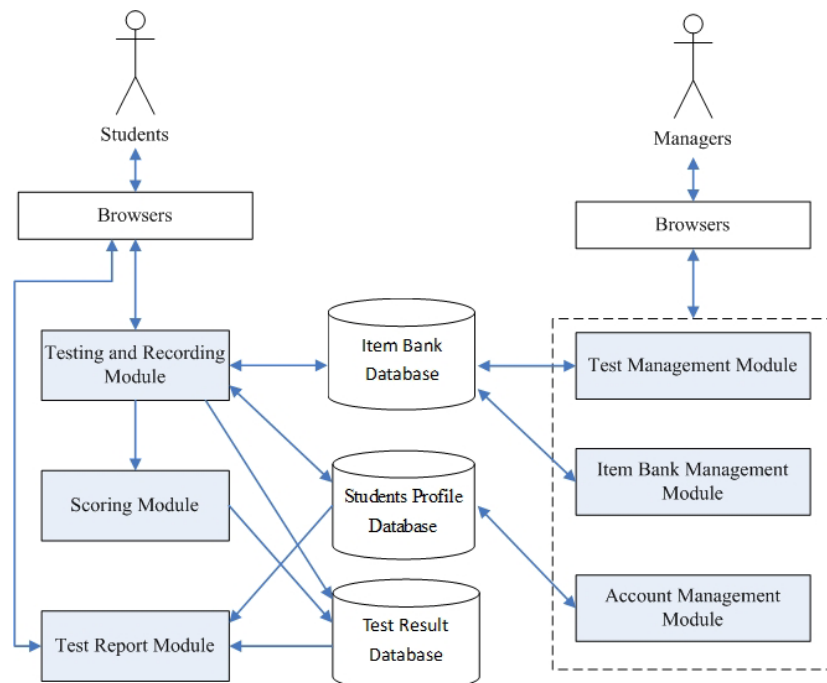


Figure 6. Architecture of web-based phonological awareness and RAN assessment system

### Participants

Participants were 93 (52 boys, 41 girls) grade six students from 3 classes of an elementary school in Taichung, Taiwan. The mean age of the participants was 12.3 years (range 11.75 to 12.8, SD =3.54). None of the children was previously diagnosed with any emotional, behavioural or sensory difficulties.

### RESULTS

Descriptive statistics for all the variables used in this study are presented in Table 1. The correlations ( $r_s$ ) amongst variables on conventional testing session showed that, overall, the two reading measures, Character Recognition and One-Minute reading correlated significantly with nonverbal IQ, Onset Detection (not in the case of One-Minute Reading), Rhyme Detection ( $r_s = .25$  to  $.34$ ), RAN Digits ( $r_s = -.22$  to  $-.58$ ), and RAN Colours ( $r_s = -.23$  to  $-.48$ ). An examination of the correlations between phonological awareness and RAN revealed that only Rhyme Detection and RAN Colour was mildly associated ( $r = -.22$ ; see Table 2).

In the web-based testing session, significant associations were found between Character Recognition and nonverbal IQ, One-Minute Reading, Onset Detection ( $r = .27$ ) Rhyme Detection ( $r = .34$ ), and RAN Colour ( $r = -.24$ ); whereas One-Minute Reading correlated significantly with both RAN tasks ( $r_s = -.34$  to  $-.62$ ) but not with phonological awareness measures. Moreover, no associations were found between phonological awareness and RAN in the web-based session (see Table 3).

An important goal for the present study was to investigate the equivalency between conventional and web-based tests. Correlations between scores on conventional and web-based phonological awareness and RAN tasks were presented in Table 4. The results showed that the two test mediums are highly correlated ( $r_s = .77$  to  $.84$ ) for RAN, suggesting that children's performance were comparable in these two sessions. However, the same was not found with phonological awareness measures. Only Rhyme Detection was moderately associated, whereas no equivalency was found for Onset Detection. The low associations on the two phonological awareness tests in the conventional and web-based sessions indicated the possibility of inconsistent item presentation between the two testing mediums.

To examine the contribution of phonological awareness and RAN to reading, two separate fixed-order hierarchical multiple regression analyses were conducted (see Table 5 and Table 6). In all regression analyses, age and nonverbal IQ were entered first, followed by phonological awareness tasks (both Onsets and Rhyme Detection entered simultaneously), and RAN tasks (both RAN Digits and RAN Colours entered simultaneously). For the equations predicting Character Recognition, phonological awareness tasks explained an additional 8.3 % and 6.4% of the variance, respectively, on conventional and web-based tests, after age and nonverbal IQ were controlled. However, no significant amount of variance was found with RAN in step 3 on both sessions.

To predict One-Minute Reading, RAN explained 31% and 34.5% of the unique variance after age, nonverbal IQ, and phonological awareness scores were controlled. In contrast to what was found for Character Recognition, phonological awareness was not a significant predictor in step 2. The total variance accounted for by all predictors was 40.7% and 41.2 %, respectively, on conventional and web-based sessions.

### DISCUSSION

Investigating the relationship between phonological awareness, RAN, reading accuracy, and reading fluency, the results, in general, are in line with previous studies showing that phonological awareness tasks are associated with Chinese reading measures (e.g., Huang & Hanley, 1997; Hu & Catts, 1998; Siok & Fletcher, 2001; So & Siegel, 1997; Tong & McBride-Chang, 2010; Tsai & Liao, 2010; Wang, 2005). Thus, for six graders, being sensitive to the sound structure is important for word decoding and fluent reading. However, few inconsistencies were observed in the conventional and web-based tests, particularly with the correlations between Onset Detection and reading scores. A low and non-significant correlation of .048 was found between Onset Detection and Character Recognition on conventional session (compare to web-based session,  $r = .27$ ,  $p < 0.01$ ) and a low correlation of .061 was found between Onset Detection and One-Minute reading on web-based session (compare to conventional session,  $r = .22$ ,  $p < 0.05$ ). Moreover, the correlation coefficients show that Rhyme Detection is a stronger and more stable correlate to Chinese reading accuracy and fluency than Onset Detection suggesting that Rhyme Detection might be more representative than Onset Detection to assess phonological awareness skills. This finding is in line with previous studies with third graders in Hong Kong (Kang, 2004) and fourth graders in Taiwan (Tsai & Liao, 2010).

The results of RAN tasks in the present study are in agreement with previous work (Chow et al., 2005; Hu & Catts, 1998; McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002; McBride-Chang et al., 2003;

McBride-Chang & Zhong, 2003; Wang, 2005) which shows positive and consistent associations between RAN and reading measures. With the two RAN tasks, RAN Colour and RAN Digits demonstrated similar relations with character reading, whereas RAN Digits appears to be stronger associated with word reading fluency. Previous studies also report that RAN digits is a superior correlate and predictor than RAN Colour to reading fluency (Georgiou, Parrila, Papadopoulos, 2008; Liao, et al, 2008; Liao, 2006), therefore, this study suggests that assessing the speed of naming digits may be more appropriate measure of the construct of rapid naming.

In the two test mediums, no association was found between phonological awareness tasks and RAN tasks, with the exception of Rhyme Detection and RAN Colour in the conventional session ( $r = -.22$ ). One of the most dominant theoretical accounts for rapid naming asserts that RAN involves mainly phonological processing, specifically speaking, RAN tasks measure the ability to access and to retrieve stored phonological information from long-term memory, therefore RAN should be considered as part of the phonological processing construct, along with phonological awareness, and phonological memory (Torgesen et al., 1994; Wagner & Torgesen, 1987). Another alternative conceptualization of RAN proposed by Wolf and her colleagues (Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000), arguing that rapid naming involves attentional, perceptual, conceptual, memory, lexical, and articulatory processes those are independent of phonological processing. Whether RAN is more closely related to phonological processing or other cognitive processes is beyond the scope of the present study. Further investigations are warranted.

To examine the relative contributions of phonological awareness, RAN, and reading measures, hierarchical regression analyses were conducted. The results show that phonological awareness explained unique variance in reading accuracy, while RAN predicted reading fluency beyond what was accounted for by the controlled variables in both testing sessions. These findings are in line with previous studies showing that phonological awareness predicts character recognition (e.g., Huang & Hanley, 1997; Ho & Bryant, 1997b; Siok & Fletcher, 2001; Shu et al., 2008) and RAN predicts word reading fluency (e.g., Kang, 2004, Liao et al., 2008; Liao, 2006; Tsai & Liao, 2010). One possible explanation for the different roles play by phonological awareness and rapid naming in Chinese reading is that there are different underlying processes involved in the two reading measures for grade six children. Character Recognition, which assesses the number of characters children have acquired, requires the derivation of the pronunciation of each character that inclined largely on the phonological information of mental lexicon. Therefore, it is not surprising to see that phonological awareness tasks explained the variability of reading accuracy. In contrast, One-Minute Word Reading (reading fluency), which consisted of 100 two-character words, was developed to assess the rate of processing familiar Chinese words requires operations that are also involved in RAN, which is the ability to name highly familiar symbols or stimuli. To sum up, in the present study, the two test versions of phonological awareness and RAN are equivalent in accounting the variance in reading accuracy and fluency in Chinese.

To examine the equivalency of conventional and web-based tests, the low correlations between conventional and web-based phonological awareness tasks ( $r_s = .094$  to  $.401$ ) suggest that the two phonological awareness testing modes are inequivalent, which in turn contribute to the inconsistent correlations reported above. The conventional phonological awareness tasks were presented orally by the experimenters who were the homeroom teachers of the participants. Even though the teachers were trained prior testing to follow the instruction, disparities regarding individual accent, tone, speed, volume, and expression, compared to uniform presentation on web session, would produce different outcomes. Adding to that, children may well select an answer by observing teacher's lip movement for articulation. To our knowledge, no existing studies have reported equivalency between conventional and web-based phonological awareness tests, further work should attempt to examine both types of test mediums.

In contrast to phonological awareness tests, the present study shows high equivalency between conventional and web-based RAN scores ( $r_s = .771$  to  $.844$ ), suggesting the interchangeability of the two RAN versions. In a comparable study investigating the equivalency between conventional and computerized RAN tests, Howe and her colleagues (Howe, Arnell, Klein, Joanisse, and Tannock, 2006) reported a very high correlation with sixty-two university students. However, it should be noted that in Howe's study, the main difference between the conventional and computerized (English) RAN tests was the apparatus used to display the stimuli (computer versus paper) since both test sessions were administered individually. In our web-based session, Chinese RAN tasks were designed to assess a large group of sample at the same time which in turn makes the most of the widespread utility of RAN by reducing the need of labour, increasing the number of participants, guaranteeing accurate and consistent presentation and instruction, and finally allowing simultaneous data analyses and item bank updating.

To summarize, the equivalency between conventional and web-based test versions of phonological awareness



tasks and RAN tasks is partially established in the present study. The two test modes of phonological awareness and RAN are equivalent in explaining the variability in reading accuracy and fluency in Chinese, and the high correlations between conventional and web-based RAN scores suggesting the interchangeability of the two RAN test mediums, but the same was not found for phonological awareness tasks. Future studies should be more cautious of human presentation of test items to ensure the uniformity of testing procedure.

Table 1. Descriptive Statistics for All Variables

	Conventional Versions				Web-based Versions			
	Min	Max	M	SD	Min	Max	M	SD
Age(months )	141	154	147.65	3.541	141	154	147.65	3.541
IQ	27	59	44.27	6.752	27	59	44.27	6.752
Character Recognition	75	180	133.69	27.504	75	180	133.69	27.504
One-Minute Reading	60	160	108.68	20.524	60	160	108.68	20.524
Onset Detection	5	12	10.40	2.044	3	12	9.12	2.399
Rhyme Detection	4	12	9.74	2.363	5	12	9.57	1.925
RAN Digits (seconds )	9.45	23.38	16.3617	3.33495	9.15	22.70	15.9063	3.32409
RAN Colours (seconds)	20.37	51.03	34.8033	7.59725	21.06	54.45	36.3327	7.63173

Table 2. Intercorrelations Between the Variables on Conventional Testing Session

Variables	1	2	3	4	5	6	7
IQ	1						
Character Recognition	.336**	1					
One-Minute Reading	.207*	.329**	1				
Onset Detection	.330**	.048	.223*	1			
Rhyme Detection	.250*	.343**	.249*	.359**	1		
RAN Digits (RT)	-.180	-.218*	-.582**	-.089	-.193	1	
RAN Colours (RT)	-.178	-.226*	-.484**	-.139	-.224*	.542**	1

\*\*\* p-value<0.001    \*\* p-value<0.01    \* p-value<0.05

Table 3. Intercorrelations Between the Variables on Web-based Testing Session

Variables	1	2	3	4	5	6	7
IQ	1						
Character Recognition	.336**	1					
One-Minute Reading	.207*	.329**	1				
Onset Detection	.220*	.273**	.061	1			
Rhyme Detection	.292**	.340**	.198	.418**	1		
RAN Digits (RT)	-.114	-.193	-.616**	.029	-.142	1	
RAN Colours (RT)	-.188	-.241*	-.336**	.025	-.120	.407**	1

\*\*\* p-value<0.001    \*\* p-value<0.01    \* p-value<0.05

Table 4. Intercorrelations Between Scores on Conventional and Web-based Phonological Awareness and RAN

Variables	
Onset Detection	.094
Rhyme Detection	.401***
RAN Digits	.844***
RAN Colours	.771***

\*\*\* p-value<0.001    \*\* p-value<0.01    \* p-value<0.05

Table 5. Hierarchical Regression for Predicting Character Recognition on Conventional and Web-based Sessions

Step	Variables	Conventional			Web-based		
		Adjusted R <sup>2</sup>	R <sup>2</sup>	R <sup>2</sup> change	Adjusted R <sup>2</sup>	R <sup>2</sup>	R <sup>2</sup> change
1	Age, IQ	.115	.134	.134**	.115	.135	.135**
2	Phonological Awareness	.182	.217	.083*	.162	.199	.064*
3	RAN	.183	.236	.019	.181	.234	.035

\*\*\* p-value<0.001    \*\* p-value<0.01    \* p-value<0.05

Table 6. Hierarchical Regression for Predicting One-Minute Reading on Conventional and Web-based Sessions

Step	Variables	Conventional			Web-based		
		Adjusted R <sup>2</sup>	R <sup>2</sup>	R <sup>2</sup> change	Adjusted R <sup>2</sup>	R <sup>2</sup>	R <sup>2</sup>
1	Age, IQ	.023	.044	.044	.022	.043	.043
2	Phonological Awareness	.057	.098	.054	.024	.067	.024
3	RAN	.366	.407	.310***	.371	.412	.345**

\*\*\* p-value <0.001    \*\* p-value <0.01    \* p-value <0.05

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