Jurnal Sains Kesihatan Malaysia Isu Khas 2018: 145-154
DOI : http://dx.doi.org./10.17576/JSKM-2018-20

A Review on Phonological Awareness and Visual-Spatial Ability among Children with Dyslexia

(Satu Tinjauan Mengenai Kesedaran Fonologi dan Kebolehan Visual-Spasial dalam Kalangan Kanak-kanak Disleksia)

AGNES CHONG SHU SZE, NORMAH CHE DIN, NORHAYATI IBRAHIM, MAHADIR AHMAD, PHEH KAI SHUEN & ROGAYAH ABDUL RAZAK

ABSTRACT

This review aims to present an overview of current research findings on the possible relationship between phonological awareness and visual-spatial skills among individuals with dyslexia. Narrative review of the relevant articles were obtained through computerized searches of databases such as PubMed, PubMed Central (PMC) and Google Scholar which included articles from SAGE, Taylor & Francis and Massachusetts Institute of Technology (MIT) Press from the year 2000 to 2014. The key words were explored, both exclusively and in combination with each other, so as to provide a better understanding of the relationship between them among individuals with dyslexia. Although it is evident that there is a phonological deficit in individuals with dyslexia, however, it is inconclusive with regards to the visual-spatial deficit and strength. There is a consensus on the nature of phonological awareness skill deficits but not on the visual spatial abilities in dyslexia. In fact, the relationship between phonological awareness and visual spatial abilities in dyslexia is dependent on the area of visual ability measured.

Keywords: Dyslexia; visual-spatial abilities; phonological awareness skills

ABSTRAK

Tinjauan ini bertujuan untuk membentangkan satu pandangan menyeluruh dapatan kajian terkini mengenai hubungan yang mungkin antara kesedaran fonologi dan kemahiran visual-spasial dalam kalangan individu disleksia. Tinjauan naratif artikel yang relevan diperolehi melalui pencarian berkomputer pangkalan data seperti PubMed, PubMed Central (PMC), dan Google Scholar yang meliputi artikel dari SAGE, Taylor & Francis dan Massachusetts Institute of Technology (MIT) Press dari tahun 2000 hingga 2014. Kata kunci diteroka kedua-duanya secara eksklusif dan secara bergabung antara satu sama lain untuk memberikan lebih kefahaman antara mereka dalam kalangan individu disleksia. Walaupun terdapat bukti adanya defisit fonologi dalam individu disleksia, namun tiada kesimpulan mengenai defisit dan kekuatan visual-spasial. Terdapat konsensus mengenai sifat semulajadi defisit kemahiran kesedaran fonologi tetapi tidak ke atas kebolehan visual-spasial dalam disleksia. Malah, hubungan antara kesedaran fonologi dan kebolehan visual-spasial dalam disleksia bergantung kepada bidang kebolehan visual yang diukur.

Kata kunci: Disleksia; kebolehan visual-spasial; kemahiran kesedaran fonologi

INTRODUCTION

Dyslexia, which is included in the diagnosis of Specific Learning Disorder (SLD) in the DSM-5, is a type of neurodevelopmental disorder in which an individual faces difficulties in reading, spelling and writing due to some deficits in their underlying phonological components. It is however, very important to note that the difficulties are not due to low education attainment and/or intelligence. Dyslexia has been found to be the most common learning disability in today's society (Wajuihian & Naidoo 2011). In a local context, recent studies using Malaysian samples have suggested that phonological deficits are among the main contributors of SLD (Lee 2008; Pheh et al. 2012). To date, SLD with impairment in reading is prevalent among 314 000 students in the country and in the same study done by Oga and Fatimah (2012), experiences of being a person with SLD revolved around facing challenges in academic areas and having below average orientation skills and perform well in creative activities like art which may reflect visual abilities. Therefore, it is important to not only take note of its aetiology and related-theories of deficit, but also it would be beneficial to determine the positive side of this learning disability. Despite these deficits, there has been increasing interest in the efforts to determine the talents of people with dyslexia.

In a series of studies conducted, Von Károlyi (2001) found a superiority in global visual-spatial abilities in the dyslexia group, indicating that this group of individuals performs better on tasks requiring holistic visual processing, as compared to typical readers. Several other studies such as the study by Geiger (2008) and Lipowska, Czaplewska, and Wysocka (2011) also supported the findings of phonological awareness deficit alongside

visual-spatial talents in individuals with dyslexia, using a wide range of assessment methods and measurement tools. Due to the atypical development of brain hemispheres, individuals with dyslexia may have superior abilities that are controlled by the right hemisphere in contrast to the phonological awareness skill which is controlled by the left hemisphere resulting in what is widely known to be a phonological deficit (Von Károlyi 2001).

On the contrary, studies such as those by Pinto and Peixoto (2011), Stothers and Klein (2010), Rüsseler et al. 2005), Sperling, Lu and Manis (2004), Von Károlyi and Winner (2004) conclude contrasting findings where a visual spatial deficit was found to accompany deficit in the phonological awareness skills. These findings indicate that individuals with dyslexia do not have superior talents in visual spatial abilities and may in fact, perform worse on visual spatial and visual perceptual tasks, when compared to typical readers, a pattern that is likened to the pattern of deficit on phonological awareness skills.

A narrative review is therefore conducted with the purpose of providing an overview of the previous research findings from the Year 2000 to 2014, on the phonological awareness skill and visual-spatial area in dyslexia, and the possible relationship between both variables. Narrative review does not describe the methodological approach that would permit reproduction of data nor answer to specific quantitative approach questions as required in a systematic review. As this is a narrative review paper, we do not appoint some experts to evaluate the articles or to evaluate the intervention designs. Papers are selected as long as they met the inclusion criteria, in full text and focus on phonological awareness and visual-spatial ability.

Results from the narrative review consisting of an overview of a range of research using validated tools and measurement to assess how these variables manifest in children with dyslexia in different countries will also provide insight into the direction for future intervention or research, as highlights or patterns of the areas requiring further attention can be derived from these studies. Last but not least, it provides a fair judgement on not only weaknesses but also potential strengths that may be present in individuals with dyslexia.

METHOD

The search for this study was conducted through PubMed, PubMed Central (PMC) and Google Scholar (directed to SAGE journals, Taylor & Francis, Inc. and MIT Press). The string of terms for the various searches include: for PubMed were dyslexia AND "phonological awareness" AND "visual spatial ability" with full text in 2 hits (selected 1), phonological awareness AND visual spatial OR perceptual organization AND dyslexia with free full text but limited to articles dated from 2000/01/01 to 2014/12/31 with 6 hits (selected 2) and phonological awareness in dyslexia with full text, involving, human subjects but limited to 2000/01/01 to 2014/12/31 with 58 hits (selected 2). For Google Scholar, search terms included dyslexia AND "phonological awareness" AND "global visual spatial" with 30 hits (selected 6) and dyslexia AND "phonological awareness" AND "visual spatial ability" with 88 hits (selected 1). For PubMed Central (PMC), the string of terms were dyslexia AND "phonological awareness" AND "global visual spatial" with 98 hits (selected 1) and "specific learning disability" AND "visual spatial" AND "phonological awareness" with 8 hits (selected 1). Standard search terms in MeSH include dyslexia. The reason behind setting the limit of years searched is so that only recent research are included in the review beginning from the 21st century, Year 2000 up until the end of this year, Year 2014. The inclusion criteria were relatively broad where any research in English (translations included) that touched on phonological awareness skill testing, IQ tests, visual spatial assessments or measurement on dyslexia and reading abilities were included whereas the exclusion criteria was the presence of other disorders aside from specific learning disabilities and comorbid ADHD, such as Autism Spectrum disorders. A total of 14 articles were selected and reviewed out of 290 across all databases by excluding irrelevant articles based on the title, abstract, and paid full-text accessibility (Table 1). Therefore, the 14 articles selected were of relevance in terms of their free full text accessibility, their title and content where the term or related concepts to phonological awareness and dyslexia such as reading was present, any form of IQ and/or visual spatial assessments were used in the study. The relevance of each article was evaluated by reviewing its abstract, to look for the variables measured, sample population and measurement tools. When these information were not present in the abstract, a further review of its text emphasizing on its Methodology and Discussion was done.

Nevertheless, there were several limitations while conducting the review. Due to the wide range of assessment tools used to measure the outcomes of the studies, it was a challenge to perform a direct comparison between two articles. Additionally, the age range of the sample population, severity of dyslexia or reading disorder, and language used in each country where the studies were carried out, differs. This situation proved to be a challenge when comparing the outcome of each study, as these variables may play a role in mediating the results obtained.

RESULTS

As shown in Table 1, results from the review does not provide a conclusive evidence as to how strengths and weaknesses are manifested across individuals with dyslexia or reading disorder in different countries in terms of phonological awareness skills and visual spatial ability.

TABLE 1. Studies included in the literature review

No.	Reference	Participant	Method	Results	Outcome
1	Berninger et al. (2008) 'Writing problems in developmental dyslexia: Under-recognized and under-treated'	- 80 Male, 42 Females with dyslexia (Mean age: 138.3 months). - recruited parents of children: 244 participants but only 115 Male, 85 Female had obtained the same criteria on a minimum of one area of measurement (Mean age: 543.2 months). - Ethnicity: American-heritage (European-American, African-American, Native-American, Asian American, others)	- Comprehensive Test of Phonological Processing (CTOPP). - Phoneme Reversal subtest. - Nonword Memory Task from CTOPP (pre-published version).	- Adults (parents of children) performed poorly in the repetition of the Nonword Memory Task from CTOPP. - Elision and phoneme reversal is slightly nearer to the mean of the population.	- Children found to have deficits in writing, spelling and written composition. - phonological awareness in children was less distinct but was tested prior inclusion through to Verbal IQ.
2	Geiger et al. (2008) 'Wide and diffuse perceptual modes characterize dyslexics in vision and audition'	- Dyslexia group: 11 Males, 2 Females (Mean age: 10.39) - Control group: 4 Males, 5 Females (Mean age: 10.99) - Italian speakers	- Wechsler Intelligence Scale Revised (WISC-R) - Test 'g' culture fair - Form-resolving-field (FRF) measurement of visual perception - Phoneme elision and synthesis	- IQ above 85 - Dyslexia group has wider average FRF (higher diffusion in visual perception) - Phonological awareness deficit	
3	Kovelman et al. (2012) 'Brain basis of phonological awareness for spoken language in children and its disruption in dyslexia'	- Dyslexia group: 8 Males, 4 Females (Mean age: 9) - Control group 1: 6 Males, 6 Females (Mean age: 10.99) - Control group 2: 7 Males, 3 Females (Mean age: 5.9) - English speakers	- fMRI - auditory word rhyming task	- All used Left dorsolateral prefrontal cortex (DLPFC) to judge phonological aspects. - Left DLPFC: a critical area in phonological awareness development. - Underutilization of left DLPFC is not the sole predictor of phonological awareness but may cause reading difficulties in individuals with dyslexia.	- Used medical technology.
4	Lachmann et al. (2012) 'Learning to read aligns visual analytical skills with grapheme-phoneme mapping evidence from illiterates'	- Illiterate group: 14 Males, 18 Females (Mean age: 28) - Control group: 19 Males, 7 Females (Mean age: 26) - Indians (non-English speaking)	- 24 unique stimuli (capital letters, geometric shapes) presented either in isolated, congruent or non-congruent background.	- Both groups had equal speed in all tasks. - Holistic perception in children. - Analytic perception in adults.	- Participants were not diagnosed as dyslexia or specific learning disabilities although illiterate
5	Lipowska et al. (2011) Visuospatial deficits of dyslexic children	- Dyslexia group: 32 Males, 30 Females (Mean age: 11.2) - Control group: 30 Males, 37 Females (Mean age: 11.6) - Polish speakers (Poland)	- Clock Drawing Test - Rey-Osterrieth Complex Figure Test - Spatial Span subtest from WMS-III	- Dyslexia group performed poorly on the tests but equal ability on forward bricks arrangement (working memory in visuospatial skills).	- Participants were assessed on phonological awareness skills. - Emphasis is placed on visual-spatial skills.
6	Murphy & Schochat (2009) 'Correlations between reading,	- Dyslexia group: 19 Males, 14 Females (Mean age: 10.5)	- Phonological Awareness Test - Test of Single Word	- Dyslexia group had poor phonological awareness and poor reading.	- Participants not assessed on visuospatial skills. - Emphasis is placed on

Continued

TABLE 1. *Continue*

No.	Reference	Participant	Method	Results	Outcome
	phonological awareness and auditory temporal processing'	- Control group: 12 Males, 15 Females (Mean age: 10.8) - Brazilian Portuguese native speakers	Reading		phonological awareness skills.
7	Pinto & Peixoto (2011) Neurocognitive profile of children with developmental dyslexia	- Dyslexia group: 10 Males, 5 Females (Mean Age: 10.27) - Control group: 11 Males, 4 Females (Mean Age: 10.27)	Neuropsychological Assessment: - Visual Object and Space Perception - Symbol Search & Digits subtests of the WISC - Verbal Learning Task of Spanish Verbal Learning Test (SVLT-CC) - Five Digit Test Trail Making Test - Exploration of Specific Dyslexia Test (ESDT) administered to dyslexia group only.	- Dyslexia group had poorer visual-spatial and visual perceptual abilities. - Dyslexia group performed poorer in verbal learning task measuring retention.	- Did not directly assess phonological awareness. - Emphasis is placed on visual-spatial ability.
8	Rüsseler et al. (2005) 'Mental rotation of letters, pictures, and three-dimensional objects in German dyslexic children'	- Dyslexia group: 18 Males, 16 Females (Mean Age: 8.46). - Control group: 18 Males, 18 Females (Mean Age: 8.43). - German speakers	- Intelligence Tests (KFT 1-3-Kognitiver Fähigkeitstest, German Cognitive Test- administered to half of the dyslexic group, CFT 1- Grundintelligenztest CFT 1, German intelligence test- administered to another half of the dyslexia group). - Reading & Spatial Ability: DRT-2 (Diagnostischer Rechtschreibtest für 2 -German spelling test), ZLT (Zürcher Lesetest-German reading test). - Mental Rotation & Spatial Ability: Figure Rotation Test, Letter Rotation Test, Bilder Rotation Test, Embedded Figures Test. - Left/Right Orientation: Line Bisection Test - Visual Attention: Test d2.	- Dyslexia group performed poorly in all the tasks compared to the control group. - Individuals with dyslexia have visual spatial deficits.	- Used various German tests.
9	Simmers & Bex (2001) Deficit of visual contour integration in dyslexia	- Dyslexia group: 10 (Mean age: 22.3). - Control group (matched age and gender)	- Gabor elements (8×8/ 10×10/14×14) of equal size. - Randomly/path-based. - QUEST staircase: to detect and present participants with the next suitable stimulus	- Individuals with dyslexia take longer to move from one stimulus to (i.e. less sensitive to path stimuli) when compared to the group who had no reading disability. - Individuals with dyslexia have poor perceptual organization and integration skills.	- Global processing controlled by right hemisphere in this study.
10	Sperling et al. (2004) 'Slower implicit categorical	- 54 Psychology students from University of Southern California.	- Reading Test: Woodcock Johnson Test of Achievement-III (Letter	- Spatial Relations score was lower in the poor reading group as compared to typical readers.	- Not all poor readers have dyslexia.

Continued

TABLE 1. *Continue*

No.	Reference	Participant	Method	Results	Outcome
	learning in adult poor readers'	(2 recruited from advertisements). - Good readers group: 11 Males, 19 Females (Mean age: 21.5). - Poor readers group: 5 Males, 19 Females (Mean age: 20.7).	Word Identification, Word Attack). - Orthographic Skills (Exception Word Reading, Orthographic choice). - Cognitive Ability Test: Woodcock Johnson Tests of Cognitive Abilities-III (Spatial Relation, Verbal Comprehension) - Categorical Learning Task (Explicit, Implicit)		- Some may have reading difficulties only.
11	Stothers & Klein (2010) 'Perceptual organization, phonological awareness, and reading comprehension in adults with and without learning disabilities'	49 adults who were diagnosed with learning disability.	- Phonological Awareness: Non-word Span Task, Spoonerisms. - Perceptual Organization: Block Design of WAIS-III, Gestalt Closure. - Reading Achievement Test: Reading Speed Subtest of Form H of Nelson-Denny Reading Test, Word Attack subtest of Woodcock Johnson Tests of Achievement-III, Figurative Test, Reading Comprehension subtest of adult version SAT	- Perceptual organization component especially Gestalt closure was a significant predictor of the variance of Reading Comprehension. - deficit in phonology	
12	Von Károlyi (2001) 'Visual-spatial strength in dyslexia: Rapid discrimination of impossible figures'	Pilot Study Dyslexia group: 4 Males, 6 Females Control Group: 8 Males, 11 Females Main study Dyslexia group: 28 Males, 12 Females (High school dyslexia/language-based disabled students) Control Group: 12 Males, 10 Females	- Celtic Matching Task (CMT) - Impossible Figures Task - Celtic Matching Task - Impossible Figures Task	- Dyslexia group performed poorer than control group in the CMT but faster in IFT - Dyslexia males performed poorer than normal control group males in CMT, no difference for females in both groups. - Dyslexia group faster than control group in IFT but not in terms of accuracy.	- Various dyslexia subtypes (Heterogenous group) - Phonological awareness skills was not assessed. - Emphasis is placed on visual-spatial ability.
13	Von Károlyi & Winner (2004) 'Investigations of visual-spatial abilities in dyslexia'	Study 1: Dyslexia group: 10 Males, 11 Females - Control Group: 16 Males, 23 Females - Students from a private university in New England	- Diagnostic Assessments of Reading (DAR) - Nelson-Denny Reading Test - Self-report - Visual spatial task: Vandenberg Test of Mental Rotation (Version B), Rey-Osterrieth Complex Figure, Hidden Figures Test	- Dyslexia group performed worst in DAR and Nelson-Denny Reading Test. - Dyslexia group reported more reading and language related problems. - Females in both groups performed poorly in Vandenberg Test of Mental Rotation (Version B). - No difference in both groups on Rey-Osterrieth Complex Figure although female with dyslexia performed slightly poorer.	- Different level of dyslexic severity. - Heterogenous group.

Continued

TABLE 1. *Continue*

No.	Reference	Participant	Method	Results	Outcome
				- No gender differences on Hidden Figures Test.	
		Study 2: Dyslexia group: 9 Males, 6 Females (students from private school for language based learning disorders) - Control Group: 8 Males, 14 Females	- Assessed reading, spelling, phonological skills, retrieval speed. - Retain visual spatial tasks from Study 1 and added matrices from K-BIT, drawing task, Pyramid puzzle, Archimedes screw, word problems - Phonological awareness measure through: WRMT-R (Form G), Nelson Denny Reading Test, Spelling subtest of DAR. - Rapid Automatized Naming and Rapid Alternating Stimulus tests.	- Phonological awareness deficit in dyslexics. - Dyslexics performed poorly in all the tests except for the Hidden Figures, Archimedes' Screw, Drawing Task (equal performance).	- Pyramid puzzle was excluded due to the high level of difficulty.
		Study 3: Dyslexia group: 28 Males, 12 Females (students from private school for language based learning disorders). Control Group: 13 Males, 10 Females (public high school, middle-upper class area)	- Spatial Orientation: - Card Rotation test - Vandenberg Test of Mental Rotation - Boat Test - Spatial Visualization: - Form Board Task - Figure Flexibility: - Storage task - Closure speed: - Gestalt Completion Test - Reference Memory Task from Morris Maze Test	- Individuals with dyslexia performed poorer in spatial orientation, timed version of figure flexibility, untimed version of visual spatialization, spatial reference memory. - Dyslexics performed equally well in timed version of visual spatialization, untimed version of figure flexibility, closure speed. - Dyslexics performed slightly better in impossible figure version of Archimedes' Screw.	- Interaction between gender and group and attention. - ADHD does not affect visual spatial task.
		Studies 4 & 5: Dyslexia group: 17 Males, 12 Females Control Group: 18 Males, 17 Females - High school students	- Identify figures using a computer.	- Individuals with dyslexia performed better (Von Károlyi, 2001). - Dyslexics can inspect rapidly and holistically (visual spatial talent) (Von Károlyi et al. 2003).	- Based on phonological awareness deficit findings from previous studies
14	Watson et al. (2003) 'Sensory, cognitive, and linguistic factors in the early academic performance of elementary school children: The Benton-IU project	470 children (elementary school)	Phonological Processing: - Comprehensive Test of Reading-Related Phonological Processes (measures phoneme analysis, blending phonemes and serial naming). - Reading achievement: Letter-Word Identification and Word Attack of Woodcock Reading Mastery Test-Revised	- Phonological awareness skills predict achievements in reading. - Poor reading may reflect poor phonological awareness skills.	- Emphasis is placed on phonological awareness.

DYSLEXIA AND PHONOLOGICAL AWARENESS

Findings from Watson et al. (2003) who conducted a study on elementary school students over a duration of three years showed that phonological awareness predicted achievement in reading through the Comprehensive Test of Reading-Related Phonological Processes which measured phoneme analysis, blending phonemes and serial naming. Reading achievement is later assessed with Letter-Word Identification and Word Attack of Woodcock Reading Mastery Test-Revised (WRMT-R; Woodcock 1987). Findings indicate that difficulties in reading among people with dyslexia may reflect a deficit in phonological awareness skills. Similarly, Berninger and colleagues (2008) found a phonological deficit among parents of children with dyslexia. The adult group displayed a weakness in terms of verbal language especially as they faced increased difficulties in repeating the nonwords from the Nonword Memory Task. Elision and phoneme reversal factors by adults, however, were found to be slightly nearer to the mean score. Phonological awareness in children were not so distinct in this study but was already tested at the outset of the study through the Verbal IQ. Therefore, a general conclusion could be drawn in that the adult population with dyslexia may appear to have phonological awareness deficits. However, it should be noted that these studies were not carried out on children with dyslexia. Therefore, generalization to individuals with dyslexia requires caution.

Among studies conducted with children with dyslexia, Murphy and Schochat (2009) who recruited 27 children with mean age of 10.8 in the control group and 33 children with mean age of 10.5 in the experimental group, of native Brazilian Portuguese speakers, found that the dyslexia group had acquired poor phonological awareness and poor reading. The administration of the Phonological Awareness Test in the study that included phonemic blending, exclusion, rhyme identification and phonemic segmentation and Test of Single Word Reading were presented using the computer, where participants were required to name the stimulus which was read aloud. Subsequently, Kovelman et al. (2011) who recruited three groups of subjects: 17 right-handed typical readers, 12 children with dyslexia, with ages ranging from 7 to 13 and kindergarteners with ages ranging from 5 to 6, found that the left dorsolateral prefrontal cortex is used when they are making judgements related to phonological awareness skills. The word-rhyming task was administered using functional magnetic resonance imaging (fMRI) to detect areas that are activated in the brain, and concluded that the left dorsolateral prefrontal cortex was not only important in developing phonological awareness skills, but it was also found to be important in determining the cause of dyslexia. The under activation of the left dorsolateral prefrontal cortex, thus, made it difficult for dyslexics to read although it did not by itself reflect a deficit in phonological awareness skills. Given the unanimity of findings, it is evident that there is a phonological awareness skill deficit among individuals with dyslexia.

DYSLEXIA AND VISUAL-SPATIAL ABILITY

Results on visual spatial ability are inconclusive. In a study done by Lachmann et al. (2012) with 26 Indian students who were typical readers and 32 Indians who were illiterate using 24 unique stimuli such as geometric shapes that were either solely presented on the screen or presented with a congruent and incongruent background, it was found that the non-readers performed on par, in terms of speed, in processing the stimuli and that letter superiority effect was present in the same group in which letters, as compared to non-letters were processed faster. Perhaps a holistic perception is common in children whereas an analytic perception is more common among adults. Being able to perceive things holistically would reflect the global visual-spatial ability present in dyslexics as proposed by Von Károlyi (2001) through the diverging ability hypothesis. However, participants in this group were not diagnosed as having a specific learning disability or dyslexia. Thus, the applicability of the findings to the dyslexic population requires careful interpretation.

Simmers and Bex (2001), on the contrary, found that people with dyslexia required a longer time to move from one stimulus to the other as they are less sensitive to path stimuli when compared to the group who had no reading disability, indicating that there is no superiority in visual processing in the group with dyslexia. Instead, people with dyslexia tended to have poor perceptual organization and integration skills. Using computerized testing is a different and new approach in analysing visual perception and contrary to the assumption that visual-spatial ability is controlled by the left hemisphere, this study found that global processing is caused by a deficit in the right hemisphere (Simmers & Bex 2001). Pinto and Peixoto (2011) further supported this finding as they found that the group with dyslexia had decreased ability in performing visual-spatial and visual perceptual tasks. The study was conducted with an equal number of 15 participants aged between 8 to 14 years old in each group (developmental dyslexia and typical readers) and was assessed using neurological assessments. In conclusion, results on visual spatial ability among individuals with dyslexia differs across the type of measures taken focusing on different components of visual ability.

DYSLEXIA, PHONOLOGICAL AWARENESS, AND VISUAL-SPATIAL ABILITY

The association between phonological awareness and visual-spatial ability deemed inconclusive, where certain studies found a visual spatial talent (Von Károlyi 2001; Von Károlyi et al. 2003) whereas others did not. Von Károlyi (2001) are among the researchers who found that people with dyslexia might have increased ability in

terms of the global visual-spatial processing. Many studies were conducted beginning with a pilot study of 10 adults (4 male, 6 female) with dyslexia and 19 adults (8 male, 11 female) who were free from reading disabilities that showed adults with dyslexia performed poorly on the Celtic Matching Task, measuring local information processing, but was faster in completing the Impossible Figures Task, measuring global information processing, in comparison to the normal reading adults. Similar results were obtained from the main study of 40 high school students (28 male, 12 female) with dyslexia and 22 (12 male, 10 female) typical readers.

Geiger et al. (2008), however, used a different approach by administering intelligence tests on 13 children with dyslexia (11 male, 2 female) and 9 normal reading ability children (4 male, 5 female) with a mean age of 10.39 in the experimental group and a mean age of 10.99 in the control group of Italian speakers. They were tested on phonological awareness skills, among others, through the phoneme elision and synthesis and it was found that children with dyslexia have a wider Form-resolving field (FRF) in comparison to normal reading children (Geiger et al. 2008). Lipowska et al. (2011) reinforced this finding when his study found that children with dyslexia have visual deficits. Individuals with developmental dyslexia not only have a deficit in their left hemisphere which is related to phonology, but they would also have a deficit in their right hemisphere which explains their poor performance on the Clock Drawing Test (CDT). Participants included 62 individuals (30 female, 32 male), fourth to sixth grade students who were diagnosed with developmental dyslexia and 67 (37 female, 30 male) control group participants of normal reading ability. Results showed that children with dyslexia obtained incorrect time in the Clock Drawing Test (CDT) more often than children in the control group. In the Rey-Osterrieth Complex Figure Test, the children with dyslexia scored lower than children in the control group as well. Besides that, the study also found that although children with dyslexia performed poorer in the reverse order bricks arrangement that emphasizes attention, both groups perform equally well in forward bricks arrangement of the Spatial Span subtest from the Wechsler Memory Scale-Third Edition (WMS-III) that emphasized on the working memory in visual and visuospatial functions.

Contrary to the findings of visual spatial strength, several other studies found otherwise. This was apparent in the study done by Sperling and colleagues (2004) where poor reading participants with language impairment tended to perceive what other non-learning difficulties people would not notice leading to difficulty eliminating non-relevant stimuli. Specifically, the score on Spatial Relations was lower in the poor readers group compared to typical readers. Von Károlyi and Winner (2004) also had similar findings in a few studies they conducted in relation to phonological skills and visual-spatial abilities among individuals with dyslexia. Initial studies conducted among public and private high school, college and university students of varying ages did not show a strength in visual spatial ability although various tests were administered.

The result whereby children with dyslexia performed poorer than children in the control group on all the mental rotation tasks, indicating that there is a deficit in spatial abilities among children with dyslexia was also found in the study done by Rüsseler et al. (2005) with 36 typical readers and 34 individuals with dyslexia who were all in grade 2. Having ruled out the types of materials as causal factors of this deficit, this finding is further reinforced by age factor in that younger children who performed poorly in the mental rotation tasks may show improvement as they progress through the developmental stages and if there is spatial ability, it is most probably acquired after the age where reading has already been acquired. Therefore, contrary to the findings by Von Károlyi (2001), deficiency in spatial abilities may accompany phonological awareness skill deficit present in people with developmental dyslexia, even though spatial ability is thought to be age-specific.

By implementing more specific exclusion criteria of brain injury, depression, anxiety, seizure and any other illness that interferes with auditory working memory as well as English being a second language, Stothers and Klein (2010) found that the perceptual organization component especially Gestalt closure was a significant predictor of the variance of Reading Comprehension with a deficit in phonology as shown in previous research by Rüsseler et al. (2005). However, it should be noted that the language studied in the different studies varies as Rüsseler et al. (2005) conducted the study on German speakers whereas Stothers and Klein (2010)'s study was conducted on English speakers. In conclusion, findings showed that phonological awareness skill deficit in dyslexia is apparent but it may or may not be accompanied by a superiority in visual-spatial abilities, and this may be due to the wide range and non-specificity of visual spatial components assessed using various measures.

DISCUSSION

In general, dyslexia is a common learning disability which involves about 80 percent of the learning disabled population although the prevalence rate may differ from country to country (Wajuihian & Naidoo 2011). As a growing disability, there has been discussions as to whether a left hemisphere deficit is accompanied by right hemispheric superiority. Therefore, in this review, we aim to determine if this assumption is true. More specifically, the objective is to determine the relationship between phonological awareness and visual-spatial ability among individuals with dyslexia.

It has been widely believed that a deficit in phonological awareness skills is present among people with dyslexia. This is particularly evident as reflected through poor reading ability as phonological awareness skills predicted reading (Watson et al. 2003; Berninger

et al. 2008; Murphy & Schochat 2009; Kovelman et al. 2011). Notwithstanding the employment of the different methods such a neuropsychological assessment tools and medical technology, similar findings were obtained. Hence, phonological awareness skill deficit among individuals with dyslexia is quite established, indicating that this area should be of concern when dealing with children with dyslexia.

Findings on the visual-spatial ability aspect, however, is still inconclusive. Few studies found that individuals with dyslexia tend to perceive things holistically or have a widespread visual perception (Geiger et al. 2008; Lipowska et al. 2011). This ability reflects the global visual-spatial ability present in children with dyslexia as proposed by Von Károlyi (2001) through the diverging ability hypothesis. However, it is important to note that the participants in the study done by Lachmann et al. (2012) who suggested that children tend to employ a holistic or global perception, were not diagnosed as having a specific learning disability or dyslexia, although they were illiterate.

On the other hand, few studies found no superiority in visual processing in the group with dyslexia. Instead, people with dyslexia tended to have poor perceptual organization, integration skills and had decreased ability in visual-spatial and visual perceptual tasks (Simmers & Bex 2001; Sperling et al. 2004; Von Károlyi & Winner 2004; Pinto & Peixoto 2011). This type of deficiency may be age-specific (Rüsseler et al. 2005). However, there is a possibility for improvement in children's performance on the mental rotation tasks as they grow older (Rüsseler at al. 2005). Therefore, considerations in future intervention programs for children with dyslexia may consider this factor. It is also important to consider the wide multisensory perceptual modes and its consequences that may impact one's reading as there was a wider and highly diffused visual perceptual modes found in children with dyslexia when compared to normal reading children (Geiger et al. 2008).

Perceptual organization especially Gestalt closure was a significant predictor of the variance of Reading Comprehension with a deficit in phonology (Rüsseler et al. 2005; Stothers & Klein 2010). This indicates that visual ability may predict reading comprehension. However, it should be noted that the language studied in the different studies varies as Rüsseler et al. (2005) conducted the study on German speakers whereas Stothers and Klein (2010)'s study was conducted on English speakers. Generally, the findings showed that visual-spatial superiority may or may not exist together with phonological awareness skill deficit in dyslexia, depending on factors such as the specific type/area measured, form of measures in terms of psychometric property of tools, target population and the language involved. Hence, all these factors should be taken into consideration when conducting future research or planning an intervention plan, especially in areas of visual spatial ability to better accommodate the learning needs of individuals with dyslexia.

LIMITATIONS

We take into account that research outcomes from the 21st century may not be comprehensive enough to cover this issue at hand. This review was also restricted to certain databases as costs was a factor and most databases required special access either by paying or registering as a member. In addition, dyslexia manifests variations across different languages. Therefore, the linguistic differences of languages concerned should be a factor to be considered when examining reading in the respective languages. Different writing scripts and shallow/deep orthography of languages will influence the outcome of reading performance.

CONCLUSION

Although various studies agree on the assumption of phonological awareness skill deficits, the findings on visual-spatial abilities are inconclusive in that some studies found a superiority whereas others found a deficit or equal performance, with four studies supporting the hypothesis of the current review. This may also be due to that fact that visual spatial abilities encompass a wide area and it is challenging to pinpoint one specific area although in this review, focus has been placed on global visual-spatial abilities. Thus far, there is no clear conclusion on the relationship of phonological awareness and global visual-spatial abilities as there is limited supporting evidence and some mixed research findings. Hence, future studies can further explore this relationship especially in the Malaysian context in terms of the local languages in order to contribute to a more holistic overview of the issues discussed. By doing so, the profile of how these variables manifest in Malaysian children can be derived which will benefit future intervention studies and programs, where strengths of these children are incorporated into intervention programs to not only compensate their weaknesses but also to offer a more tailored and conducive learning environment.

REFERENCES

Berninger, V. W., Nielsen, K. H., Abbott, R. D., Wijsman, E., Raskind, W. 2008. Writing problems in developmental dyslexia: Under-recognized and under-treated. *Journal of School Psychology* 46(1): 1-21.

Geiger, G., Cattaneo, C., Galli, R., Pozzoli, U., Lorusso, M. L., Facoetti, A. & Molteni, M. 2008. Wide and diffuse perceptual modes characterize dyslexics in vision and audition. *Perception* 38: 1745-1764.

Kovelman, I., Norton, E. S., Christodoulou, J. A., Gaab, N., Lieberman, D. A., Triantafyllou, C. & Gabrieli, J. D. E. 2012. Brain basis of phonological awareness for spoken language in children and its disruption in dyslexia. *Cerebral Cortex* 22: 754-764.

Lachmann, T., Khera, G., Srinivasan, N. & Van Leeuwen, C. 2012. Learning to read aligns visual analytical skills with grapheme-phoneme mapping evidence from illiterates. *Frontiers in Evolutionary Neuroscience* 4(8): 1-8.

Lee, L.W. 2008. Development and validation of a reading-related assessment battery in Malay for the purpose of dyslexia assessment. *Annals of Dyslexia* 58(1): 37-57.

Lipowska, M., Czaplewska, E. & Wysocka, A. 2011. Visuospatial deficits of dyslexic children. *Medical Science Monitor* 17(4): CR216221.

Murphy, C. F. B. & Schochat, E. 2009. Correlations between reading, phonological awareness and auditory temporal processing. *Pró-Fono Revista de Atualização Científica* 2(1): 13-18.

Oga, C. & Fatimah, H. 2012. Life experiences of individuals living with dyslexia in Malaysia: A phenomenological study. *Procedia-Social and Behavioural Sciences* 46: 1129-1133.

Pheh, K.S., Normah, C.D. & Kaur, S. 2013. Reliability and validity of Dyslexia Screening Test Bahasa Malaysia Version. *Seminar Internasional Pasca Siswazah Pendidikan Khas UKM-UPI*, 2: 1344-1352.

Pinto, A. & Peixoto, B. 2011. Neurocognitive profile of children with developmental dyslexia. *Journal of Health Sciences* 1(3): 115-125.

Rüsseler, J., Scholz, J., Jordan, K. & Quaiser-Pohl, C. 2005. Mental rotation of letters, pictures, and three-dimensional objects in German dyslexic children. *Child Neurospsychology 11*: 497-512.

Simmers, A. J. & Bex, P. J. 2001. Deficit of visual contour integration in dyslexia. *Investigative Ophthalmology & Visual Science* 42(11): 2737-2742.

Sperling, A. J., Lu, Z. L. & Manis, F. R. 2004. Slower implicit categorical learning in adult poor readers. *Annals of Dyslexia* 54(2): 281-303.

Stothers, M. & Klein, P. D. 2010. Perceptual organization, phonological awareness, and reading comprehension in adults with and without learning disabilities. *Annals of Dyslexia* 60: 209-237.

Von Károlyi, C. 2001. Visual-spatial strength in dyslexia: Rapid discrimination of impossible figures. *Journal of Learning Disabilities* 34(4): 380-391.

Von Károlyi, C. & Winner, E. 2004. Investigations of visual-spatial abilities in dyslexia. In H. D. Tobias (Ed.). *Focus on dyslexia research* (pp.1-25). Hauppauge, NY: Nova Science.

Wajuihian, S. O. & Naidoo, K. S. 2011. Dyslexia: An overview. *The South African Optometrist* 70(2): 89-98.

Watson, C. S., Kidd, G. R., Horner, D. G, Connell, P. J., Lowther, A., Eddins, D. A. & Watson, B. U. 2003. Sensory, cognitive, and linguistic factors in the early academic performance of elementary school children: The Benton-IU project. *Journal of Learning Disabilities* 36: 165-197.

Agnes Chong Shu Sze
Normah Che Din
Norhayati Ibrahim
Mahadir Ahmad
Health Psychology Program
School of Healthcare Science
Faculty of Health Science
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abdul Aziz
50300 Kuala Lumpur, Malaysia

Rogayah Abdul Razak
Speech Sciences Program
School of Rehabilitation Sciences
Faculty of Health Science
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abdul Aziz
50300 Kuala Lumpur, Malaysia

Pheh Kai Shuen
Department of Psychology and Counselling
Faculty of Arts and Social Sciences
Universiti Tuanku Abdul Rahman

Corresponding author: Normah Che Din
Email: normahcd@ukm.edu.my
Tel: +603-2687 8182
Fax: +603-2687 8192

Received: August 2017
Accepted for publication: January 2018