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BRINGING READING RESEARCH IN MULTILINGUAL NUSANTARA INTO A NEW DIRECTION THROUGH EYE-TRACKING

Warid Mihat, *Hazita Azman & Or Kan Soh

Eye-Tracking Analysis Lab (ETAL), Centre for Literacy and Sociocultural Transformation, Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia
*Corresponding author: hazita@ukm.edu.my

ABSTRACT

Current understanding of the psychological mechanisms underlying reading comprehension among multilinguals are typically limited to external observations of their ability to read and comprehend text. Additionally, descriptions of the nature of comprehension processes relied perilously on the use of memory taken after the reading process. In this article we introduce the potential of using eye tracking as a tool in collecting internal attention data for a deeper understanding of EFL text processing among multilinguals. The eye tracking procedures will enable researchers to combine perspectives collected from internal and external observations, to explicate and elucidate the complex cognitive processes of the multilingual when involved in reading. Since the use of the eye-tracking in reading research methodology is fairly new, particularly in multilingual contexts such as Malaysia and Nusantara in general, we will emphasize how progress has been achieved elsewhere in understanding text processing through the use of eye-tracking. The article will introduce relevant research projects that can be conducted using eye-tracking, after sketching the historical progression of eye-tracking research in the field. It concludes by suggesting that eye-tracking can provide a framework for studying the full range of the multilingual readers' competencies in reading while expanding related theories about EFL reading.

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1.0 INTRODUCTION

A plethora of change and interventions have been introduced in Malaysia towards the continual improvement of English language education at all levels of the education system. In fact in the last 5 years the Ministry of Education has introduced several noteworthy innovative programmes such as the Dual Language Programme (DLP), the Highly Immersive Programme (HIP), and the adoption of an international benchmarked curriculum standards for the English language curriculum, the Common European Framework of Reference (CEFR), at the primary and secondary school levels. It is anticipated that these significant developments in English language teaching and learning in Malaysia will bring about transformations and improvements in the ways of learning, teaching and assessing language competencies among the multilingual learners situated in their own local contexts (Azman, 2016).

While the aforementioned initiatives are meant to bring the quality of teaching and learning English language forward into the 21st century and on par with international standards, fundamental issues of illiteracy, as well as low language proficiency skills in speaking, writing, reading and listening remain as the persistent problem among language learners, particularly in the rural areas (Azman, 2016; Mihat, 2015). However, this paper selects to highlight the recurring issues pertaining to poor reading performance among multilingual learners of English in Malaysia.

2.0 READING COMPETENCY ISSUES IN MALAYSIA

The shocking realization that majority of Malaysian pupils at the primary schools are poor readers came to light with the PISA results of 2015 which placed the country's performance at one third from the bottom and below the OECD average score internationally (MOE 2016b). Similarly, at the local level, national primary school examinations or the UPSR (Primary School Assessment Test) taken at primary six by pupils aged between 11-12, reported equally poor results for reading comprehension. In this test, pupils sit for two English test papers: Comprehension and Writing papers. The 2015 results for English comprehension paper for National schools (SK) revealed that only 12.1% of the overall 38,344 population scored A, while 19.9% scored B, 22.3% scored C, whereas 28.3% pupils scored D, and 17.4% pupils scored E (failed) in the test (MOE 2016a). Hence it can be surmised that majority of the 2015 primary six pupils are poor readers as nearly 45.7% of them scored D's and E's. Similar dismal results for reading in the 2016 UPSR was also reported where 23% test takers failed to achieve the minimum D in the Writing paper while approximately 16% did not achieve the minimum D for the Reading Comprehension paper (MOE 2016a).

Meanwhile achievement for the English Language examination papers in the 2015 and 2016 SPM (Malaysian Certificate of Examination), the national examination taken by all form five students (aged between 16-17) in secondary schools, revealed an average of 23% failure rates. However, the 2017 SPM English results was more promising as 54.9% of the candidates successfully obtained a pass in the subject. Nevertheless, more than 45% of the overall population failed to achieve the minimum pass.

At the tertiary level, all students must sit for a proficiency test known as MUET (Malaysian University English Language Test). It is compulsory to be taken for university entrance and is a requirement for graduation. The Reading component in MUET is 40% of the overall score, while the Writing component makes up 30%; whereas the Listening and Speaking components

are allocated 15% each in the overall scoring. The total scores achieved in MUET is described in terms of MUET bands, which is from the lowest proficiency at Band 1 to highest proficiency at Band 6 (MPM, 2015). The minimum targeted level of proficiency that as stipulated in the English language Education Roadmap by the Ministry of Education for graduating university students is Band 4 or the equivalent of B2 on the CEFR scale, an internationally benchmarked standard for English language proficiency (MOE, 2015).

A comparison of MUET results between 2015 and 2016 signaled a slight improvement in the levels of English language proficiency achieved by prospective university applicants. It was found that for the reading component (800/3), although majority of the candidates or nearly 41% obtained Bands 1 and 2 (or CEFR A1-A2) in 2015, 10% less candidates or only 31% were categorized in this same band in 2016. However, the number of candidates who achieved Band 3 (CEFR B1) were about the same in 2015, at 34%, and in 2016 at 32%. Interestingly, a significant percentage of candidates (27%) obtained Band 4 (CEFR B2) in 2016 compared to only 19% in 2015. Likewise, the percentage of candidates (10%) who achieved Bands 5 and 6 (CEFR C1-C2) in 2016 has increased from 7% in 2015. Table 1.1 and Table 1.2 below depict results for all four components in the MUET test results for 2015 and 2016 respectively as ranked by Bands. At the time of writing MUET results data for 2017 was not made available.

Table 1.1: 2015 MUET Results

Band	800/1		800/2		800/3		800/4		800	
	%	Cumulative Percentage	%	Cumulative Percentage	%	Cumulative Percentage	%	Cumulative Percentage	%	Cumulative Percentage
6	1.56	1.56	0.30	0.30	0.48	0.48	0.01	0.01	0.02	0.02
5	12.71	14.27	4.70	5.00	6.38	6.86	1.17	1.18	2.96	2.99
4	31.94	46.21	26.70	31.70	19.29	26.15	15.91	17.09	22.31	25.30
3	24.07	70.28	46.00	77.70	33.78	59.94	66.42	83.51	48.28	73.58
2	21.90	92.17	19.43	97.14	31.45	91.39	14.38	97.88	24.24	97.82
1	7.83	100.00	2.86	100.00	8.61	100.00	2.12	100.00	2.18	100.00

(Source: Majlis Peperiksaan Malaysia [MPM], 2015)

Table 1.2: 2016 MUET Results

BAND	800/1		800/2		800/3		800/4		800	
	BIL	%	BIL	%	BIL	%	BIL	%	BIL	%
6	5,940	13.68	77	0.18	178	0.41	8	0.02	12	0.03
5	11,619	26.76	1,893	4.33	4,159	9.58	550	1.27	2,287	5.28
4	9,956	22.93	10,912	24.99	11,492	26.48	8,111	18.68	14,245	32.91
3	5,198	11.97	19,720	45.16	14,051	32.37	25,048	57.68	16,359	37.79
2	5,994	13.80	9,267	21.22	10,934	25.19	8,733	20.11	9,255	21.38
1	4,720	10.87	1,800	4.12	2,592	5.97	978	2.25	1,130	2.61

(Source: Majlis Peperiksaan Malaysia [MPM], 2018)

In sum, a cursory evaluation of the reading comprehension results obtained by English language learners from primary through to tertiary as discussed above reveals the need to rethink ways, as highlighted by Swan and Walter (2017), on how the teaching and learning of reading as practiced in Malaysia can produce more proficient readers over average readers. Swerling (2015) for example, advocates that recognizing the underlying patterns of poor reading is especially helpful in understanding the needs of the readers and in providing effective interventions and differentiation of classroom instruction.

To do so however, reading researchers have to balance their understanding of text processing and its relationship with reading comprehension by looking at the processes from perspectives of internal and external attentions (Rayner, Pollatsek, Ashby, & Clifton, 2012). These two notions were first introduced by LaBerge and Samuel in 1974, (as cited in Samuel 2013) as they attempt to describe the 'automaticity' in reading from internal and external attentions.

The internal attention, which is observable behaviours or outcomes, can be represented by the use of comprehension marks, written reflections of what one has read and other means that may record the after-reading outcomes. Internal attention on the other hand mirrors the moment-to-moment process of reading, yet it is not directly observable and would require an apparatus in order to capture the target process. Apart from the term used in this paper, different terms have been used to label this area such as 'while-reading', 'during reading', 'indirect' and more (Rayner & Reichle, 2011).

Regardless of what terms is used to describe the attention, readers' internal attention has become an important research area for cognitivists, neuroscientists and psycholinguistics (Clifton et al., 2016; Angele & Rayner, 2012; Reichle, Rayner, & Pollatsek, 2012). In all these areas of studies, the eye-tracking tool and procedures is employed to capture the internal moment-to-moment processes. Through this method these studies managed to observe the internal attention of readers and have yield myriad of interesting findings about how skilled readers process texts, that is otherwise limited when only external attention data is available. Even so, employment of eye-tracking in examining text processing among multilingual EFL readers are still limited.

While eye tracking methodology has flourished in other fields such as business, medical and neurocognitive fields, a limited number of studies have examined multilingual readers' reading processes through closely utilizing the eye-tracking methodology, particularly in the local context. The following sections further highlight aspects about eye-tracking procedures and how internal attention data is derived and analysed from applying eye-tracking in research studies on reading. It will also highlight the limited number of related local studies in this field that is available in the current literature. At the end of this paper, we highlight several research areas in EFL reading and multilingual readers that can be undertaken by those who may be keen to employ eye-tracking in their investigations in Malaysia.

3.0 EYE TRACKING AND READING RESEARCH

3.1 What is Eye Tracking?

Figure 1: An Eye-Tracking Apparatus
(Source: www.tobipro.com)

Miller (2015) refers to eye-tracking as a tool (see Figure 1) that detects the size and the movements of the pupil and the location of the eye of a reader. The movements of the eyes are detected by shining an infrared light into the eye and capturing the light that passes through the pupil before it is reflected back by the cornea to a video camera; depending on the models of eye tracking, the camera can be located on or near the screen. Some eye tracking models also require the participants to wear a goggle or a headset. Once mounted, the participant sits at a known distance from a screen, with his or her chin on the chin-rest, and a computer coordinates the position of the eyes and what appears on the screen. Despite being technically stringent, eye-tracking is a precise data collection tool. For eye tracking tool that is labelled as 250Hz, it is capable of capturing circa 250 data frames for every x second. This means for every 1 minute of eye tracking observation, the tool is capable of producing around 15000 data frames of eye movements. Duchowski (2007) explains that these accuracies are possible because the density of the most sensitive type of photoreceptor cell, the cone, varies dramatically across the retina. Despite being accurate, eye tracking data need to be interpreted carefully and set at the right level. This is why, Miller (2015) suggests that eye tracking research requires carefully controlled research designs and triangulation of multiple methods in order to ensure the limitations are being addressed appropriately.

3.2 Saccade, Fixation and Regression

The plurality of the word 'movement' suggests that our eyes make several kinds of actions with each of these actions sending signals to cognitive psychologists to further interpret. Studies related to eye-movements, like other cognitive psychologist methods, come with a set of technical terminologies. The basic terms in eye tracking research are: 1. saccade, 2. fixation 3. regression and 4. regions of interest (ROI) (Raney et al., 2014). All these terms are important to be understood as they carry significant meaning in eye tracking research.

Saccade can be referred as eye movement from right to left or vice versa, depending on the orthographical features of a text (Rayner, 2009). For instance, in the sentence *'The boy bought herself a book'* the representation of saccade would be the movement of the eyes along the sentence, from left to right (since English is read from left to right). Fixation on the other hand

refers to a behaviour that occurs when the eye fixates or stops on a particular word in a sentence. For example, *'The boy bought herself a book'* where the eyes fixate on the word 'herself'. This could happen because of conflict of schemata (readers' background knowledge) or increase of interest shown by the readers towards the word. Due to such conditions, regression can then be detected when the eyes move back to the words before the fixated one, such as in ***The boy bought herself a book'*** where the eyes regress to the word 'the boy' to double check the relation between the word 'herself' and the 'boy'. Figure 2 helps to visualize the concepts of saccade, fixation and regression.

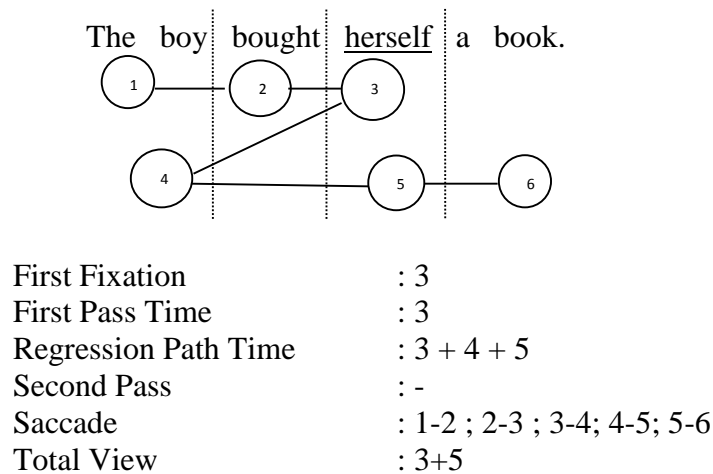|				
First Fixation	: 3
First Pass Time	: 3
Regression Path Time	: 3 + 4 + 5
Second Pass	: -
Saccade	: 1-2 ; 2-3 ; 3-4; 4-5; 5-6
Total View	: 3+5

Figure 2: Saccade, Fixation and Regression

Through these three concepts, eye tracking apparatus can track down and produce statistical data related to the readers' oculomotor behaviours. The measurements can be divided into two parts: 1. first pass reading (fixations) and 2. look-backs (regressions). First-pass reading can be further divided into progressive eye movements that move forward in the sentence and re-inspective fixations made within the sentence before the reader moves on to the next sentence. Forward fixation time reflects the initial processing of the sentence, while first-pass re-inspections sift into the integrative processing of the sentence content. Look-backs, on the other hand, are strategic in nature (Hyönä & Nurminen, 2006), where they reflect the conscious effort of refreshing text information in working memory in order to incorporate it to the text representation (Kaakinen & Hyönä, 2007). Look-backs also occur when readers try to resolve a coherence break introduced by the sentence and it may occur within the word itself or between words; also known as inter-regression or intra-regression (Kaakinen, Lehtola, & Paattilammi, 2015). However, look-back or regressions may also occur due to problems in comprehending the material, hypermetric eye movements, or inference making (Olitsky & Nelson, 2003).

3.3 Global, Local Statistics, Gaze-plots and Heat-maps

In the studies about reading that have used eye-tracking apparatus, two forms of data are generated. First, in the form of statistics and second in the form of two-dimensional graphics represented by gaze-plots and heat-maps. The statistics data produced by eye-tracking can be categorized into the fixation, saccade, and regression which are analysed at Global and Local levels. Global analyses are used to find the association between overall oculomotor movements and the texts, while Local analyses are conducted to measure the initial and late processing durations, examining how participants read a specified target word (Soh, 2017; Li, Liu & Rayner, 2011). According to Soh (2017) the eye movement in local analyses indices are

encompassing of first fixation duration, gaze duration, rereading duration and total fixation time. He further explains that the first fixation duration is the duration where readers first fixate their eyes on the word; gaze duration was the duration used to decode the word meanings (Bruninghan & Folk, 2012); rereading duration was the duration used on all fixations; and total fixation time was the duration used to process a word. Figure 3 shows an example of how data from eye tracking are reported.

Table 1. Global Eye Movement Analyses for Participants' Reading on Science and Corresponding Texts

Eye-movement Variables	Science Texts M (SD)	Corresponding Texts M (SD)
Average Total Reading Time (s)	78.20 (30.08)	49.89 (29.07)
Average Saccade Length (ms)	4.66 (0.90)	4.97 (1.05)
Average Number of Regressive Saccades (ms)	89.17 (37.87)	57.76 (25.70)
Average Fixation Duration (ms)	227.80 (20.09)	230.50 (19.80)

Table 2. Comparisons of Participants' Eye Movements while Reading Science Terminology and Replaced Words

Eye-Movement Variables (ms)	Science Terminology M (SD)	Replaced Words M (SD)
First Fixation Durations	244.78 (35.47)	242.67 (35.01)
Gaze Durations	304.78 (67.05)	298.78 (56.89)
Rereading Time	625.45 (284.76)	344.78 (254.15)
Total Fixation Durations	978.65 (313.24)	617.68 (235.56)

Figure 3: Example of Eye Tracking Data Analysis.

(Source: Soh, 2017)

The gaze-plots on the other hand is a record of eye movements that shows the sequences of eye movements which then are grouped into either saccade, fixation or regression. It allows researchers to study where the first landing is and subsequently the following ones (Bojko, 2009). The gaze-plots are often represented in circles with numbers written in them where each circle represents the sequence of eye movements on the reading text. Gaze-plots are particularly important especially in detecting regressions in reading and exit interview. Whilst the gaze-plot explains the sequencing and direction of the eye movements, the heat-maps, or *Attention Heat-maps,* show the data directly on the stimuli used. Figure 4 shows examples of gaze-plots (left) and attention heat-map (right).

Figure 4: Gaze-plot (Left) and Attention Heat-map (Right)

(Source: Personal collection)

Attention heat-maps help to provide quick information on any patterns or trends that may exist on the data. Based on Figure 3, data on the heat-map are normally represented in three colours: 1. green, 2. yellow and 3. red. The Red colour on the heat-map reflects a good amount of fixation on the stimulus (Bojko, 2009). This means, the more a reader fixates on a certain part of a stimulus, the colour will gradually change from green to yellow, and from yellow to red. According Bojko (2009) there are different types of heat-maps: 1. Fixation count heat-map (FCH), 2. Absolute gaze duration heat-map (AGDH), 3. Relative gaze duration heat-map (RGDH) and 4. Participant percentage heat-map (PPH). Despite their different purposes, researchers have to be aware that each attention heat-map can be a representation of a reader (individual) or as a group (collective). For example, if the researcher decides to use a heat-map to guide the lab interview process (also called exit-interview), the researcher might want to use the individual heat-map because it represents the cognitive processes of the interviewee. The collective attention heat-map, on the other hand, represents the summary heat-map of the research samples.

As mentioned earlier, eye tracking apparatus generates both quantitative and qualitative data, which allow for mixed-methods research design and convergence analysis procedure. With internal attention data generated through gaze-plots and heat-maps as well as external data generated from a post tracking interview for example, a convergent analysis that consolidates these external and internal attention data can generate a deeper understanding of the processes that the reader undergoes in getting meaning from what he or she is reading. On the other hand, a research design that relies on external attention data only, most often reveals perceived notions of these processes from the readers when they are interviewed or asked to respond to a questionnaire. This limited research design is exemplified by the following study.

Li (2015) investigated the effects of metacognitive scaffolding on reading strategy use and reading performance of Chinese EFL tertiary students. A pre and post semi-experimental design was employed. The procedure of the research required the participants to answer a

questionnaire before and after the intervention, followed by an interview. Evidently, this design of the study was not able to generate the internal data that depicts the moment-to-moment process of strategy use by the reader.

On the other hand, a mixed methods design that elicits both internal and external data would offer a closer examination of how metacognitive scaffolding directly influenced strategy use in the readers. Employing the use of the eye-tracking procedures could generate scientific knowledge that can be supported further by perceived information derived from the questionnaire and interviews. Through convergence analysis of both these internal and external data, a more comprehensive and complete understanding of the effects of metacognitive scaffolding on reading strategy use and reading performance of these readers could have been obtained. Hence this illustrates the extent to which the conventional research on reading processes which usually relied on perceptions, observations and test results can be strengthened and supported further with scientific data that depicts cognitive processes in action through eye-tracking methodology.

3.4 Identifying Regions of Interest

Regions of Interests (hereafter ROI) is another technical term that needs to be understood in this field as it is a critical aspect that influences the results in every eye-tracking research. The ROIs represent areas that receive more fixation than certain areas. Technically, regions of interests can be set on the eye-tracking system (e.g Tobi Studio) either before or after the data collection; but researchers identify their ROIs before research is carried out in order to avoid the chances of data errors.

1a) The boy bought <u>himself</u> a book.
1b) The boy bought <u>herself</u> a book.

2a) Ali grilled the <u>chicken</u> in the oven
2b) Ali grilled the <u>bird</u> in the oven

Figure 5: Example of Latin Square Design

In a typical setting, stimuli for eye tracking research are often organized in randomized Latin-Square design (See Figure 5). The stimuli tested comes in a set of paired sentences where comparison are made between (A) and (B); also called as 'Filler'. However once presented to participants, they will only see each sentence once. For example, Participant 1 will only see sentences 1A and 2A and Participant 2 will only see 1B and 2B. In the examples given, the regions of interest would be to investigate the pronoun effects (1a and 1b) and lexical effects (2a and 2b)

Identifying ROIs, hence, is based on the objectives of the research. Soh (2016) for example, set 'scientific terms' on the stimuli as the ROI in his study. Perez, Joseph, Bajo, and Nation (2015) studied how adults process and revise their schemata when they encountered illogical phrases embedded in the texts. The researchers locked the ROIs on the illogical phrases and studied the fixation rates produced by the participants. Another example of identifying the ROIs at paragraph level are through text components. Passages in reading texts are often categorized based on the text components as well as their purposes. Narrative texts, or stories, often involves characters, plots, timelines and other narrative elements (Medina & Piloneata,

2006). Although Latin-Square design specifically look at comprehension at sentence level, comparison can also be done by comparing simple, compound and complex sentences at passage level. With different characteristics, researchers have found several intriguing research areas for reading such as looking at morphological processing (see Juhasz, Starr, Inhoff, & Placke, 2003), lexical ambiguity resolution (see Duffy, Morris, & Rayner, 1998), incidental word learning (see Joseph & Nation 2018), syntactic ambiguity (see Sturt, 2007), pronoun resolution (Cunnings & Sturt, 2018) as well as, dependencies and word order (see Staub, Dillon, & Clifton, 2017).

As a result of understanding these technical terms and parameters in identifying regions of interest, previous researchers who employed eye-tracking ROIs in their research design have managed to identify similarity and discrepancy patterns related to the issues raised in their studies. For example, Kaakinen et al. (2015) investigated the influence of a reading task on adults and children's eye movements during reading. In their study, they looked at how participants adjusted their reading behaviours to meet the task demands by giving a 'why' question before participants began to read expository texts. They found that although adults modified their reading behaviours better than the children, children in this study also modified their reading behaviours in order to comprehend the text. Kaakinen et al. (2015) shed some light by discussing further the findings by Van den Broek, Tzeng, Risden, Trabasso, and Basche (2001) who highlighted that pre-questioning might pose an extra processing load for young readers which subsequently would cause a general slow-down in reading. Kaakinen's and her colleagues' findings highlighted the importance to relook at the way how pre-questioning strategy can be done with children.

Perez et al. (2015) also used ROIs through eye-tracking to investigate inferential comprehension in narrative texts and critical sentences. They looked at how 40 adult readers (undergraduate and postgraduate students) processed and revised information that contradicts their schemata (e.g. grilling a turkey instead of roasted a turkey on Christmas day). Their study found that prior interpretation competed with new information indicating difficulties in inhibiting no longer relevant information among slow readers. Another study that looks at inferential comprehension is by Soh (2016). Unlike Perez et al. (2015), Soh's (2016) research investigated how adults process scientific terms in two situations: English and Mandarin. In his study, 80 undergraduate students had to read texts in both languages. Where past studies have highlighted that participants with least background knowledge withdrew from setting up contextualized information that can help them to infer the unfamiliar terms, Soh's (2016) findings contradicted the foregoing conclusion and highlighted the need for teaching of scientific texts and terms in isolation.

The purpose of citing the studies above is to highlight how discrepancies between internal (eye-tracking) and external (observation) findings may occur, requiring the need to carefully and critically relook at the way how we understand reading for teaching and learning purposes. While the previous studies have proven to be valid and reliable, the suggestion for further research that includes the employment of eye-tracking methodology is put forward here as a way for sound conclusions to be made (Rayner et al., 2012) from internal attention perspectives. In particular, there is a need to further encourage this practice in second language acquisition and language learning research in Malaysia.

4.0 CRITICISMS OF EYE TRACKING RESEARCH

One of the frequent disparagements that eye tracking research often receives is the query on whether the 'eyes' have enough features to represent the processes in the brain. In response to this criticism, Rayner et al. (2012) and Lin and Tsai (2015) explains that in the brain, the optic nerve transmits vision signals to the lateral geniculate nucleus (LGN), where visual information is relayed to the visual cortex of the brain that converts the image impulses into objects that we see. Hence, the ability of a human to see is due to his or her capacity for visual perception in defining the surrounding environment.

Figure 6: Human's Eyes and Brain

(Source: Lin & Tsai [2015])

Lin and Tsai (2015) suggest that as long as a human has functioning eyes, where they are connected to the visual cortex, which is situated at the hind part of human brain, the brain will process the information received; and such a situation supports the claim that eye-movements, as projected on the attention heat-maps, is a representation of brain activities. Perhaps, this is why some scientist label the eyes as the 'outer' part of the brain. Given this scientific explanation, data produced from eye-movements investigation, such as the statistics, gaze-plot and attention heat-maps, are conceived as representations of cognitive processes.

The second arguable issue that surrounds eye-tracking is its 'lab-based' nature. Many eye-tracking studies are conducted in a lab or outside from the 'real environment' such as the classroom. Such a situation has posted challenges to researchers as they try to ensure the validity and reliability of the findings. Whilst this issue can be solved with careful planning, the biggest concern is directed to the stimuli used in investigating the research. According to Rayner et al. (2012) stimuli used in eye tracking research rarely adhere to the 'real' reading materials because it has to be edited before it can be uploaded into the eye tracking system. In relation to this, many also highlighted that there is a list of discrepancies between reading on paper and reading on the screen.

In justifying the methodology, Rayner et al. (2012) assert that whilst eye-tracking research is not conducted in real settings, the 'mechanisms' that are being studied remain as real as the mechanisms in real settings. They further explained that in a study that investigated walking for example, the researchers need not ask the research subject to walk 1KM before any conclusions regarding walk patterns can be derived, because having the participant to walk for

50M would also allow researchers to observe similar patterns. Similarly the eye-tracking researcher can conclude that the mechanisms as portrayed by the oculomotor behaviours of participants in lab settings remains similar to the mechanisms in real settings.

Nevertheless, in response to the aforementioned criticisms and in pursuit for more accurate and reliable internal scientific data, eye tracking technology have continuously improved the eye tracking apparatus and its computer modellings. With the advance of technology, eye tracking research has seen shifts in the design of the stimuli; from word level to sentence level and from sentence level to paragraph level, making the apparatus more user friendly than previous models. With such improvements, investigating mechanisms in real setting will no longer be an issue, while potentially expanding the scope of eye tracking research.

5.0 FURTHER APPLICATIONS FOR EYE-TRACKING RESEARCH IN MALAYSIA

Because eye tracking in second language research is relatively new in Malaysia, there is a need to highlight what it can do to provide new insights into research fields pertaining to the local contexts. In this section, we highlight several possible research areas where researchers can combine eye-tracking analysis and external attention observations.

5.1 Investigating Patterns of Reading Difficulties Among Multilinguals

Studies on patterns of difficulties in reading have yield interesting findings and have been helpful in assisting teachers in the classroom to plan literacy intervention and support programmes for their students. Swerling (2013, 2015) for example, have come up with a matrix, based on a review done on previous studies and classroom observations. Through the matrix, readers can be categorized into three groups: 1. Readers who require specific word reading difficulties (SWRD); 2. Readers who have problems with specific reading comprehension difficulties (SRCD) and 3. Readers who have mixed reading difficulties (MRD). By identifying the characteristics of readers in each category, teachers can identify suitable intervention for their pupils.

Having acknowledged the importance of this research area, the need to balance the findings from moment-to-moment perspectives becomes more apparent. Applying eye tracking in reading research, therefore, can offer another set of findings to further provide intriguing outcomes in this research area. There are bodies of international researches that have investigated this same matter (see Kaakinen et al., 2015; Kendeou, Papadopoulos, & Spanoudis, 2012). However, as reading in second language is also influenced by setting and culture of the learners, there is a need to contextualize eye tracking research in multilingual contexts such as Malaysia so that the findings can attend to the challenges faced by the local population.

5.2 Investigating the Effectiveness of Reading Interventions and Instructional Flow

Generally, studies that introduce reading interventions examine the specific effects of these interventions. Data collection typically involves samples being grouped into experimental and non-experimental, with the experimental group being introduced to the intervention. The significant differences between the groups are then measured by comparing the pre and post data, which are collected either from questionnaire, comprehension score or classroom observation (see Li, 2015; Lin, 2009); relying heavily on the external observation data.

By contrast, eye tracking apparatus can be used as a tool to gather moment-to-moment processes of how reading intervention affects readers' reading processes. For example, a study done by Wotschack (2009) looks at how comprehension questions given before, while and after reading modulate the oculomotor movements of readers and subsequently affect the saccadic rates and attention heat-maps of the readers, providing observable cognitive insights into how the comprehension questions given at different stages of the reading process can affect text processing. Similar investigations into these processes among multilingual Malaysian readers will further inform the ESL/EFL field with rich evidence on second language cognitive processing of the multilingual mind.

5.3 Improving the Design of Reading Materials

Eye tracking has been widely used to investigate how readers look at commercial posters or advertisements. Through their oculomotor movements, the researcher can further enhance the purpose of the poster; whether the poster serves its purposes in promoting the event or product. For example, Higgins, Leinenger, and Rayner (2014) investigated how people read billboards on the road. Their findings are concurrent with Rayner (2009) who found that the average fixation duration when viewing the picture in an ad, which is about 266ms, was significantly longer than when viewing the text, which is about 226ms. Viewers also made longer saccades on average (about 4.5° of visual angle) when examining a picture than when reading the text (about 3.1°). These findings confirm the effective use of pictures over texts in posters.

Likewise, similar principles can be applied to investigate the effective design of reading materials. For example, Takacs (2016) used evidence from eye-tracking data to show how motions in animated storybooks benefit children with visual attention and reading comprehension. He found that animated illustrations that are well matched to the text of the story, are important for understanding the story. Furthermore, eye-tracking procedures can inform us on how characters, headings, pictures and other text components can be manipulated, in terms of their presentation and organization, to support readers in their reading. In the local context, this can be expanded to include the effects of culture-biased content and images in international textbooks that has been controversially perceived to distract Malaysian English language learners from understanding the texts they read.

5.4 Investigating Oral Comprehension

Apart from reading, eye-tracking also opens opportunities for researchers to investigate oral comprehension processes; which is also another research area with a longstanding research practice. Eye-tracking in oral comprehension research looks at how the participants interact with the visual environment around them. For example, a researcher can investigate how test takers process information in a listening test by observing the oculomotor behaviours of the participants on visuals presented to them.

Felser and Cunnings (2012), for example, looks into how participants interpret words with gender attachment. Their research involves 28 L1 participants and 25 L2 English learners. Participants are introduced to sentences that contain reflexives and stereotypical gender mismatching (see figure 7). Their findings indicate that while L2 learners behaved differently than L1 speakers during early stages of processing, they can behave like L1 speakers in an offline task that requires explicit judgement.

1a) The boy injured himself yesterday.
1b) The boy injured herself yesterday.

2a) The soldier injured himself yesterday.
2b) The soldier injured herself yesterday.

Figure 7: Reflexives and Stereotypical Gender Mismatching Fillers

Further applications of eye tracking research in oral comprehension include spoken word recognition (see Allopenna, Magnuson, & Tanenhaus, 1998), bilingual word recognition (see Spivey & Marian, 1999), sentence comprehension (see Tanenhaus, Knowlton, Eberhard, & Sedivy, 1995) and anticipatory processing (see Altman & Kamide, 1999). These areas of research in oral comprehension can be expanded to situate within the Malaysian context.

6.0 CONCLUSION

In this article we have discussed what eye tracking research is about and how it can bring research about ESL/EFL reading in Malaysia into new directions by combining internal observation, gained from eye tracking analysis, with the common external observations, such as classroom observation, questionnaires, interviews and pre-post tests. We have illustrated through examples how reading researches can be more concrete and comprehensive through a convergent mixed methods design which includes eye-tracking methodology. We have emphasized the importance of employing such a design in Malaysian case studies especially, as a deeper and insightful understanding of the reading proficiency problems among the multilingual readers is needed in order to find more focused and directed solutions to this recurring problem at all levels of the education system. Finally, we have highlighted several possible reading research areas that can be situated in Malaysia to inform the field about ESL/EFL reading processes among multilinguals. Recognizing the issues related to eye-tracking are wider than what has been shared in this article, we hope that it has provided basic and useful introduction to eye-tracking and its potential in intensifying research in multilingual reading processes.

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