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Contents

Evaluating mathematical divisibility rules using eye-tracking

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The Department of Basic Education has identified factorisation as a problem area in Mathematics for Grade 9 learners. The building blocks for factorisation start already at earlier grades. By knowing the divisibility rules, it can help learners to determine the factors of a number. The divisibility rules are done in Grade 5. Learners from Grade 4 to Grade 7 were tested on the divisibility rules of five digit numbers with an eye tracker. Learners did an unprepared pre-test about their knowledge on the divisibility rules. They also did a post-test after the divisibility rules were revised. Revision had a huge influence on the results of the learners. Eye-tracking revealed that learners who did not knew the divisibility rules, only inspect the last two digits of the number before indicating their answer. Eye tracking also revealed whether a learner applied the divisibility rules correctly or incorrectly.

Students' Learning Experiences of a Serious Food Service Management Game: Eyetracking and EEG

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The use of serious games in higher education provides complementary ways of delivering content to learner-centred technology-enhanced environments. This study evaluates the learning experiences of foodservice management students of The ExMan game which teaches management skills to foodservice management students. Understanding how students search for and interact with information on-screen, has practical implications for the further development of serious games. The research questions were: (i) How did the foodservice management students interact with the information task passages (based on fixation count and fixation duration)? (ii) What emotions did the foodservice management students experience during gameplay? and (iii) How did the foodservice management students perceive the speech bubbles as information passages in the ExMan serious game? Three usability evaluation methods were employed: (i) Eyetracking, with special focus on sixteen areas of interest; (ii) Electroencephalography (EEG) measurements; and (iii) Verbal protocols as post-gameplay individual interviews with the participants. Individual interviews indicated that participants were excited to play the game and that the learning outcomes of the game were attained. EEG was useful during the evaluation of learning experiences of students of serious games. The various eyetracking measures and related calculations revealed that some speech bubbles, for different reasons, were not viewed at all and others were viewed extensively. During the EEG measurements, no variance could be measured for any of the participants for the engagement and mediation channels, and these were excluded from the results. Short-term excitement displayed the highest average standard deviation, followed by long-term excitement and then frustration, indicating that the students' excitement about the gameplay overshadowed the frustration of the learning that they engaged in.

Translating metaphor in two directions—A process-oriented study

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With many methods in neuro-psychology applied in translation studies, directionality in many language pairs have been studied from cognitive approaches (Maier, 2011; Chang, 2011; Wimmer 2011; Ferreira Alves, 2012; Rodríguez and Schnell, 2012l; Apfelthaler, 2013) etc. As the "ultimate test of any theory of translation" (Toury, 1995: 81), metaphorical expression often "presents insurmountable problems for translation" (Tabakowska, 1993: 67), yet the studies on metaphor translation models are mostly theoretical, and the relationship between metaphor type and directionality (Chinese/English), e.g. the impact of metaphor type in different directionalities on translator's attention distribution model, has scarcely been investigated.

With combined process-oriented methods: eye tracking, key-logging and cue-based retrospective Think Aloud Protocols (TAPs), process of 22 novice translators (L1: Chinese, L2: English) translating three kinds of texts: plain text, cognate metaphor and non-cognate metaphor are chunked into three kinds of micro attention units to form the total attention distribution pattern, namely: Source Text Attention Units (STAU), Target Text Attention Unit (TTAU) and Parallel Attention Unit (PAU). Based on the amount, total duration and pupil dilation of each group of attention units, following findings are made:

1. Metaphor type has a strong impact on task L2-L1, and its impact on task L1-L2 is not as obvious and consistent.
2. In both directions, total amount of attention is highly affected by metaphor type. But the impact of metaphor type on attention distribution pattern and pupil dilation is not as obvious and consistent.
3. Comparing to plain text and metaphor, cognate and non-cognate metaphor has a considerably stronger impact on participants' attention distribution.
4. Based on these findings, two clear sets of cognitive models on metaphor translation are formed, providing researchers a direct and objective view of the impact of metaphor type.

Using Eye tracking to reveal and guide reading strategies to the first year CSI students at University of the Free State

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Eye tracking research can be classified into gaze-contingent and diagnostic studies (Duchowski, 2003), the latter of which is of interest to this paper. The objective of this study is to bring into consciousness, and establish guidelines on how to apply, the five reading strategies that students should follow to attain effectiveness and efficiency in reading. The two reading competencies are denoted by different levels of reading comprehension and reading speed, respectively. The five reading strategies, which are classified as high-speed and low-speed reading strategies, comprise, scanning, skimming, light-reading, word-for-word reading, and reading-to-understand. Each of these strategies is characterised by a specific level of reading speed and yield the necessarily varied comprehension (Ma, 2014). The study therefore reveals how each reading strategy should be applied appropriately in specific reading tasks for optimum efficiency and effectiveness in reading.

The study uses the eye tracking technique to record the movements of eyes as students undertake reading tasks and, through the analysis of eye movement patterns from the three eye-tracking metrics, reveals the levels of reading effectiveness and reading efficiency that groups of students attain during their different reading tasks. The study thereafter outlines the recommendable patterns of eye movements (as deduced from the scan-paths) that readers' eyes should follow for a specific type of reading strategy. This which is guided by the three basic eye tracking parameters: fixations, saccades and regressions (Tobii Technology, 2014).

While the five reading strategies are largely applied in print media, although the application of each strategy is often confused, the study uses electronic reading content as visual stimulus across the selected groups of Computer Science and Informatics students. The groups are given different reading tasks with prescribed reading objectives, which prompt different levels of reading comprehension and reading speed. Each reader is indirectly observed using a Tobii Eye Tracking system, whose analysis of gaze plots, heat maps, fixation durations, saccade lengths, and scan-paths reveal the patterns of eye movement that a subject yields in a given reading activity.

The results are analysed based on the objective of a reading task, such as *'reading' an electronic-newspaper article to get an idea about its content* before deciding on whether to share the article with a class. Such a task should result an above-average reading speed with minimal reading comprehension. On the other hand, a reading task to *'read' a given story in order to answer questions thereafter* is a typical reading for comprehension reading task, which should yield a below-average reading speed with optimal reading comprehension (Ma, 2014).

The guidelines on how to apply each of the five reading strategies with subsequently be drawn based on the eye gaze analysis results from the given reading tasks. Typical types of tasks, which apply to each of the five reading strategies, will also be outlined to help students save mush of their study time while attaining optimal reading comprehension.

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South African students and subtitle reading: What have we learnt from eye tracking?

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In multilingual classrooms, the language of teaching and learning (LOTL) is usually an additional language for most students. In addition to providing access to materials in languages other than the LOTL, the benefits of using subtitles to aid reading and learning are well-documented (Koolstra *et al*.,1997; Markham, 1999; Mayer *et al*., 2001; De Bruycker & d'Ydewalle, 2003; Diao *et al*., 2007; Chai & Erlam, 2008; Ayonghe; 2010; Mahlasela, 2013). However, for subtitles to enhance learning, the viewer should possess basic reading proficiency – if he/she cannot read the text displayed on-screen, the subtitles will present more challenges than benefits (Markham, 1999; Linebarger *et al.*, 2010).

Eye-tracking research on subtitle reading shows that people read subtitles almost automatically, even when presented in a foreign or unfamiliar language (d'Ydewalle *et al*., 1991; Pavakanun, 1992; De Bruycker & d'Ydewalle, 2003; Van Lommel *et al*., 2006; d'Ydewalle & De Bruycker, 2007). In stark contrast, a study on the impact of subtitles on attention distribution and cognitive load in English Second Language (ESL) academic lectures found that Sesotho first language (L1) speakers consciously avoided reading subtitles presented in their L1 (Kruger, Hefer & Matthew, 2014). Almost 60% of the Sesotho L1 subtitles were not read at all. However, the South African context is vastly different from those where most eye-tracking research on subtitle reading has been conducted, with very low literacy levels in the general population, a lack of reading materials in the majority of African languages spoken in the country and very little exposure to subtitled television programming.

In an effort to investigate whether subtitle avoidance was a once-off finding or a recurring pattern amongst Sesotho-speaking students, this paper discusses a proposed longitudinal research project that will examine whether continual long-term exposure to subtitle reading will have an effect on students' subtitle reading behaviour and ability.

Using Eye-Tracking to Assess the Effect of Cartographer Expertise and Map Design on the Speed, Approach and Correctness of Map Interpretation

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In order to make sense of the universe at various scales, it is essential that the human mind makes use of maps. Human senses are limited according to the environment around us. For example, it can take days to fully explore and gather knowledge about the layout of a small town. Maps were created to overcome these limitations. One of the most important properties of cartographic images is that it can be taken in quickly by the eye, which contributes to the effectiveness of maps (Harley, 1987).

The traditional ways of creating maps have been complemented by the development of computer software and multimedia technology. GIS allows geographic data to be captured, modelled, manipulated, retrieved, analysed and presented to a client (Pucher, 2010). When GIS was first developed, it was a tool used only by expert cartographers, as it required high-performance computers and a particular set of skills to use it. However, after the desktop GIS was developed in the early nineties, along with the Internet and online mapping, the development of geo-information started to become popular among expert as well as novice cartographers (Nagi, 2004). Therefore today, it has become possible for almost anyone to create a map, even if they are not aware of standard map design principles.

Krassanakis (2013) state that findings from psychological and human vision research can be of great significance for cartographical research. The speed and correctness of identifying symbols or features can be assessed or eye movement recordings (eye-tracking) can be assessed (Krassanakis, 2013). This study made use of a combination of these methodologies.

Therefore, this study investigated the effects that cartographer expertise, and map design can have on map interpretation, by assessing the speed, approach and accuracy (correctness) of several map interpretation tasks. The study methods involved the use of a head-mounted eye-tracker and two maps with distinct designs and characteristics. Fifteen novice, intermediate and expert cartographers were asked to complete several map interpretation tasks while their eye-movements were recorded.

The eye-tracking data was analysed by creating areas of interest to identify different symbols and features on each of the maps. Statistical tests were used to compare eye-tracking metrics of novice, intermediate and expert cartographers with regard to speed, approach or correctness of map interpretation. Statistical tests were also used to compare the different map characteristics across the two maps.

The final results of these statistical tests have not yet been completed, but the preliminary results indicate that differences in map design can have a significant effect on the speed, approach and correctness of map interpretation. When looking at the different levels of cartographic expertise, there appears to be no significant difference in the speed, approach and correctness with most of the map interpretation tasks that had to be completed.

The study will aim to fill the knowledge gap about factors that can have an influence on the effectiveness and efficiency of map interpretation. This can help to improve the development of maps (digital and otherwise) in modern cartography, so that these maps can give more accurate information, and so that there is a better understanding of where and how these maps can be applied.

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Using Eye Tracking to Enhance Clinical Observations and Interpretation in Occupational Therapy

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INTRODUCTION

Occupational therapy can enable people to participate in the activities of everyday life. Occupational therapists achieve this by working with people and communities to enhance their ability to engage in the occupations they want to, need to, or are expected to do, or by modifying the occupation or the environment to better support their occupational engagement [2].

Clinical observations in Occupational Therapy consist of administration, observations and scoring as well as interpretations. Unfortunately, not all the interpretations given to various clinical signs have been scientifically proven - some are merely clinical impressions gained through experience.

Occupational therapists always want as much data from their patients as possible. If there was a way to improve the method to gather data, it would help them tremendously. Eye tracking can assist occupational therapists towards this goal since they would be able to observe patients' eye movements while they execute specific tasks. The eye movements can also be recorded for post-hoc analysis and replay.

This study will involve the development of a software system that will utilise eye tracking that will allow an occupational therapist to gather data efficiently and assist them with the interpretation thereof.

PREVIOUS WORK

Mayer [3] did a study to examine the empirical, methodological, theoretical, and practical contributions of students using eye tracking as a tool to study and enhance multimedia learning. The results showed that using eye tracking offered a unique path to testing aspects of theories of multimedia learning, particularly concerning perceptual processing during learning.

Bayram et al. [1] analysed the reading disorder of dyslexic students with eye tracking. They examined and compared dyslexic and normal readers, reading habits and eye movements during reading passages and pseudo words, while the eye movements of the participants were recorded. For both text and pseudo word reading, the dyslexic readers showed much longer fixations, but relatively few regressions. An increased length of pseudo words led to greater increase in the number of fixations for dyslexics rather than normal readers.

PROPOSED TOOL

By creating a program that is user friendly, efficient to use and can contribute to further studies, eye tracking can provide occupational therapists and/or cognitive psychologists an opportunity to give easier and efficient means to capture data and gain insight from patients and their problems(s).

The application will consist of two windows on two different monitors, namely a stimulus window where the patient will be expected to execute specific tasks, and a facilitator window which will be used to monitor the patient's eye movements. Eye tracking data will be gathered by an EyeX eye tracking controller from Tobii Technologies.

The occupational therapist would gain new ways of methods of examining patients, acquiring data from the eye tracker, and use this data to acquire new knowledge about the patient and make conclusions.

RESEARCH

The proposed tool will be used in a study where a patient will be expected to follow an object with his/her eyes across the screen. The object will stop moving if the patient experiences trouble to follow it – thus indicating potential limitations with regard to visual mid-line crossing. These results will be correlated with results from traditional occupational therapy instruments to determine if eye tracking can be successfully used to identify limitations with regard to visual mid-line crossing.

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Eye-tracking in on-line reading skills development

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LectorSA

Lifelong learning is the only way to sustain proficient and relevant learning in a rapidly changing world. Knowledge and information are exploding across the globe. We need accurate ways to facilitate the process of drawing external factual information into an internal perceptive advantage from which to interpret and argue new information. It is a well described fact in research that the low levels of learners and students' reading skills play a pivotal role in academic results [1]. It is a fact that university students – even those enrolled for the languages and the arts – are not proficient in reading. Rose and Hart (in Nel and Nel 2010:1) maintain that "Reading is not simply an additional tool that students need at university; it constitutes the very process whereby learning occurs" [2].

Accurate and Effective Reading enables us to act creatively and critically in a world which is ever-changing. It provides rapid, ready access to new information and knowledge that will promote lifelong learning. LAB-on-line, a South African initiative, has proven that Reading Skills Development is possible for 99% of users through visual skills development that improves reading speed and comprehension outcomes. LAB has assisted more than 34 000 users, from Grade 1 to adults in management positions, to read faster, read better and remember more [3].

Our research indicates specific development of optic-motor skills that is needed in the development of a relevant reading outcome. We will look at the 2014/15 LAB-on-line results using an eye-tracking report of pre-and postevaluation of skills to assess the impact on reading skills development in a case study from various institutions across South Africa of students in the Limpopo Province.

Introduction

LAB-on-line is a South African Initiative that began as a quest to understand and enhance the measurable aspects of interaction between the eyes and the brain. By exercising the eyes and training the brain we can increase the activity in the brain, which plays a central role in mental health and ability. LAB-on-line claims to bridge the gap between the student and the curriculum by developing:

- Visual Skills
- Perceptual Skills
- Vocabulary
- Language
- Comprehension Skills
- Reading Strategies
- Study Strategies and Skills

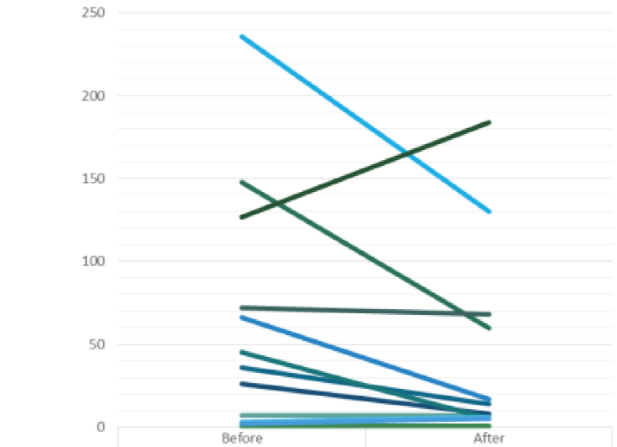
There are currently wide discussions concerning the fact that governments across the world are spending billions on improving curricula and creating cutting edge environments in an effort to improve academic achievement.

Nevertheless students are still struggling to keep up with their studies. There is a gap that is increasing each year, between students and the information they have to study. The question is: can an on-line interface develop skills that is crucial to assist students in developing skills needed to access information intelligently? [4]

The LAB-on-line Solution is CLOUD-based and as a result can be applied in most on-line environments. Lab is developed:

- as an interactive automated process – requiring low to no supervision
- to include Pre- and Post- Evaluations
- to include real time online reporting
- to consist of 20 automated lessons compiled into a reading course
- for lessons to be completed any time anywhere – as long as you have an internet connection on pc, laptop, tablet or smartphone.

Results to be discussed



	Before	After
Fixation	236	130
Regression	66	17
ASR	0,59	6,7
ADF	0,96	0,29
CC	0,66	0,8
ES	7	7
OEF	36	14
OER	26	8
BEO	45	5
DBE	148	60
WPM	127	184
%	72	68
GLE	3	6
Grade	2	5

Various results will be looked at, including the above results.

Academic Impact

Improved Reading skills are proven to have a direct impact on Academic Achievement. At a Rustenburg School 133 learners participated in the Lector program. Their Academic average improved from 74% - 81%.

- Reading speed: 80 wpm improvement
- Comprehension: 30% improvement
- Relative Reading Efficiency: 5 years improvement

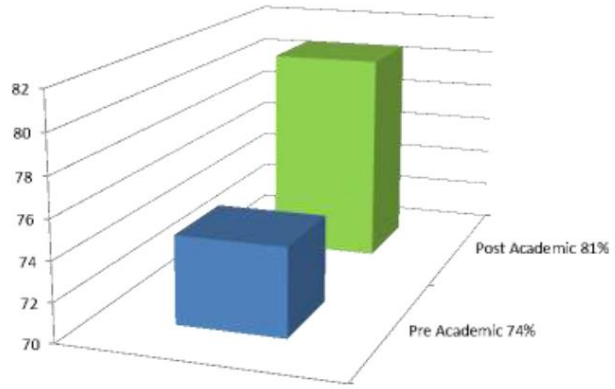


Figure: Academic Improvement measured in average % of results [5]

Conclusion

We can without doubt confirm that the significance of good reading skills for academic success can no longer be ignored. Koenig et al advise that development programmes such as the reading programme should be compulsory for all first-year students in all faculties on their campus [6].

LAB-on-line intervention can be utilized successfully to develop crucial academic skills in students participating in learning through on-line study systems. Further study on the degrees of personal interaction with students should be done in order to assess levels of implementation and success rates.

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How can eye-tracking devices assist with identifying reading problems in first year students at a rural campus.

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After twenty sessions on a reading development program some students are still not reading at the required level for tertiary education. This impacts negatively on academic progress and needs to be addressed. Cognitive control as well as the physiological underpinning of eye-movements are necessary to cope with reading text.

The reading development program focusses on perceptual accuracy, visual efficiency, visual accuracy and memory. The area of interest for this study is visual accuracy which optimizes the eye span, accelerates duration of fixations, ensures accurate perception, minimizes regressions, strengthens word recognition and stimulates visual memory.

With eye-tracking devices the number of regressions and duration of fixations can be measured which might implicate specific areas of the reading process or physiological functioning which need additional and scaffolded support or even medical intervention.

Visualisation tool for gauging reactions to advertisements by using eye trackers and the Emotiv Epoc

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INTRODUCTION

Studies using neural focus groups have shown dissension between what the test subject perceives after viewing the advertisement and what their brain activity reveals.

Falk, Berkman and Lieberman [1] found that participants gave feedback which conflicts with their brain activity. The participants were subjected to a functional Magnetic Resonance Imaging (fMRI) scan while viewing three separate advertisements, afterwards the participants were asked to rate the advertisements. It was noted post-test that the lowest rated advertisement proved to have incurred the most interest in the participants according to the fMRI scan. When tested in the field the least popular advertisement actually performed the best of the three. Therefore, bypassing the need for user input and receiving data directly from the brain seems to be the preferable solution.

Consumer neuroscience, which is a sub-genre of neuroeconomics and is a combination of the fields of neuroscience and economics [2], aims to understand marketing problems using techniques gleaned from brain research. Traditionally both fields attempted to understand human behaviour in different ways, economics looking at behavioural patterns and creating theoretical models from these findings while neuroscience was more concerned with the physiological and chemical processes affecting the brain [2]. Hubert and Kenning define neuroscience as the scientific proceeding while neuromarketing is the application thereof. Neuromarketing attempts to understand how the brain is physiologically affected by advertising stimulus by making

use of functional magnetic resonance imaging (fMRI) and EEG (known collectively as neural imaging) to examine the brain's reaction to the advertisement during viewing. In general neuromarketing is used to detect product preference and brand recognition [3].

The true fear remains that neuromarketing may become so successful that it would impede the consumer's free will, but at this time the technology is far too under developed to achieve that.

PROPOSED TOOL

By using the Emotiv Epoc BCI in conjunction with the Tobii the identified problem could be mitigated. The Epoc is a much more affordable and publically available device than a functional MRI (Emotiv charges between $400 and $500 for the Epoc depending on the model). An application will be needed that can synchronise data obtained from both the Emotiv Affective suite and the Tobii Software Development Kit (SDK).

The application will create a visualisation of the Engagement/Disinterest and Excitement/Calm data observed by the Epoc as well as the fixation point data captured by the eye tracker. From this data a fixation diagram will be drawn similar to that found on Tobii Studio, but colour coded according to dominant emotion instead of participant. For visualisation purposes the user will be allowed to pick between visualising Engagement/Disinterest or Excitement/Calm. If the pointer is hovered over a specific fixation point, more details will appear via pop-up, such as fixation time and the magnitude of each 'emotion'. The data can be loaded after the test is completed or it can be loaded and visualised in real time while the test is being done.

When more than one viewer's data need to be analysed the user will have the option of having multiple fixation diagrams overlaid over one-another or by marking different areas of interest on the viewed image. The user may be able to mark these areas of interest after the test. The areas of interest will allow the user to analyse data from multiple users more efficiently and it will be easier to visualise than multiple fixation diagrams. All recorded data will be stored in a database for future use.

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Parallising eye-tracking: A GPU-assisted approach

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Eye tracking is a well-established tool utilised in many research areas. There are currently many different types of eye trackers available. However, many of the currently available remote eye trackers are either expensive, or provide a relatively low sampling frequency. Increases in computational power coupled with a corresponding decrease in cost has allowed low-cost eye trackers to sample at higher sampling frequencies. However, the increase in computational power is fast reaching its physical limits. The focus in recent years has therefore been on developing parallelised solutions. With this in mind, the question can then be asked what aspects of the eye tracking proccess can be parallised, and what technologies can be utilised to implement the parallelism. The eye tracking solution featured in this presentation presents a low-cost high-speed eye tracker that utilises parallism by exploiting the SIMD architecture of the Graphical Processing Unit in order to facilitate the feature point localization process at higher frequencies. The developed solution is capable of sampling at frequencies in excess of 200 Hz, while allowing for head movements within an area of 10×6×10 cm and an average accuracy of one degree of visual angle. The entire system can be built for less than 700 euros, and will run on a mid-range desktop PC or laptop.