# Intelligent Tutoring Systems, Learning and Cognitive Styles of Dyslexic Students

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## Abstract

Supporting students who have special educational needs is possible when there is availability of teachers who match the students' course/needs and feel comfortable with individuals. This paper discusses that teachers may not always be available for supporting students especially if students live in areas which are relatively inaccessible or too time consuming for teachers to reach. An alternative is intelligent tutoring systems (ITS) offering learners course support. However, it is evident that learners with special educational needs (SEN) may not have the cognitive facility to progress at levels equivalent to their peers and so may require support in strategies in which they could grasp concepts. One way of helping students to learn would be to harness strategies of teaching (Rasheed-Karim, 2019) in ITS. It is suggested that bringing students together with ITS may be a way of helping students learn by using mnemonic strategies successfully. Specifically, it is suggested that ITS will diagnose students' cognitive styles using the model of the Cognitive styles Analysis (Riding, 1991). Additionally, information of brain hemispheric preferences and working memory of dyslexic learners will help ITS to produce a suitable plan for tutoring individuals. ITS will therefore have a profile of each student including their self-concept as this may be important when providing feedback to students. The paper discusses the benefits of using mnemonic strategies by dyslexics learners and ways in which mnemonics could be harnessed in ITS.

**Key words**: dyslexic students; cognitive styles; mnemonic strategies; intelligent tutoring systems

## Introduction

Some of my work experience is supporting higher education students studying for undergraduate and master degrees who have special educational needs such as dyslexia. As I live in a major city this is easy, but when students live in inaccessible areas it may be impossible to meet a supportive teacher. This paper discusses the role of intelligent tutoring systems.The main areas of weakness for university students are spelling and grammar and planning of essays as well as organising research projects. Those students who have English as a second language may have particular difficulties associated with dyslexia. This may affect their self-esteem. This is defined as the extent to which people see themselves as worthy (Gross and MacIIveen, 1998, p.402). This is linked with self-concept and the kinds of images individuals build for themselves due to experiences in learning environments etc. Learners' self-concept may influence the way they absorb information (Mortimore, 2008).

## Brain Physiology and Styles

Students may be left-handed and particularly creative musically and artistically with first degrees in these areas. They will arrive at a course which is primarily scientific and which requires specialist skills in writing, reading and applying course related knowledge. My task is to bridge the gap between their skills they have acquired in the past and help them acquire new ones. To enable this process, an understanding of cognitive styles and learning styles is pertinent as well as the connection between these and left and right brain processing. This is because brain physiology and styles provides an insight into the cognitive processing of dyslexic students and an argument is that, this may help teachers to better understand the behaviours of dyslexic students.

Kozhevnikov (2007) explained that cognitive and neuroscience provided useful information of the neural processes underlying cognitive styles. One form of evidence for the existence of cognitive styles lies in measurable brain activity by recording the electrical activity at the scalp in different positions of the head through electroencephalogram (EEG) and neuroimaging techniques. Kozhevnikov elucidated that studies reveal linkages between cognitive style and other cognitive processes such as memory, attention and metacognition. Researchers investigated differences between the right and left sides of the brain. Riding, Glass and Douglas (1993) argued that EEG alpha suppression indicates mental activity during information processing and is located at the left hemisphere for verbalisers, but, for imagers, most mental activity is located at the right side. Langhinrichsen and Tucker (1990) specified that hemispheric specialisation is associated with the left hemisphere being the location of verbal functioning, while the right hemisphere carries out imagery processing.

Gevins and Smith (2000) reported that when individuals are faced with tasks, different sides of the brain become active and this is dependent on level of ability, verbal as well as non-verbal intelligence. Upon examination of EEG (electroencephalograph) of subjects, those who preferred a verbal style showed greater reduction of alpha signals in the left hemisphere. Those who favour a non-verbal style demonstrate greater alpha reduction in the right hemisphere. Kozhevnikov (2007) explained that the importance of this study is that it shows cognitive styles to be related to neural activity which follows distinct patterns. Individual differences between verbal and non-verbal cognitive styles are due to patterns found in the brain and may not be related to ability in the performance of any task

On the other hand, Riding *et al.* (1993), cannot state clearly where mental activities take place for the Wholist-Analytic dimension other that it is over the left and right side of the brain. Riding and Rayner (2005) also discussed that EEG studies showed interactions between the Wholist-Analytic dimension and electrode locations on the scalp.

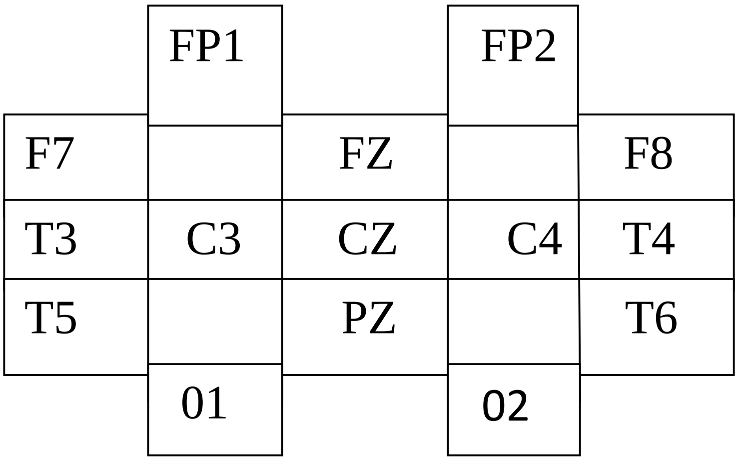


Fig 1**:** Electrode locations on surface of scalp viewed from above (Riding, Glass, Butler and Pleydell-Pearce, 1997; Glass and Riding, 1999). They identified:

**T 4 -** deals with the specific categorisation of concepts and this is where verbalisers show most activity
**T5 -** This part is known as Wernickes Area and it is here where language is processed and used more by verbalisers
**T6 -** deals with the inclusive categorisation of concepts and is the area used more by imagers.

Riding, Glass and Douglas. (1993) and Ungerleider and Mishkin (1982) reasoned that an association between analytic processing and higher level visual system may be because analytics process more information at the occipital visual cortext compared with wholists. Sharrat (2003) concluded that wholists will consider how demanding a task is and will increase levels of alpha suppression accordingly but analytics tend to be cortically active regardless of the demands of the task (Riding, *et al.*, 1997). Sharrat (2003) explained that wholists and to a lesser extent verbalisers and imagers seem to process information more efficiently, in contrast with analytics who may be less accurate with task demands. She specified that imagers tend to show the same level of cortical activity throughout task completion while verbalisers apply effort appropriate for the task. In another study conducted by Motes, Malach and Kozhevnikov (2008) spatial and object visualisers showed different kinds of activation in the dorsal and ventral areas of the brain and they argued that these areas are related to spatial and pictorial processing.

Sternberg and Zhang (2001) concluded that more studies are required which use a range of tasks to clarify the relationship between styles and brain activity. Additionally, Riding *et al.*, (1997) concluded that their investigations of EEG and style should be taken lightly because of the small numbers of males and females who took part. A larger sample would be required to ensure reliability and validity of findings related to gender. Coffield, Moseley, Hall and Ecclestone, (2004) also stated that there is insufficient neuroscientific evidence and explanations to support the claim of individual differences in right and left brain activities and stability of such lateralisation. This is particularly evident with the interpretations of split-brain research conducted by Springer and Deutsch (1989). They reported there are no longitudinal studies of cognitive or learning styles with biological or neuropsychological explanations. Neither is there a study which explains that cognitive styles associated with hemispheres are principally due to genetic inheritance. Coffield *et al.*, (2004) concluded that any one theory based on neurobiology and offering explanations of the origins of cognitive styles should be regarded with caution.

Another area associated with styles of information processing and problem-solving is "working memory". The components of the working memory model are: the central executive, the phonological loop consisting of an articulatory process and a phonological store and finally the visuo-spatial sketch pad. While the central executive does not process visual or auditory information, the phonological loop deals with verbal material and the phonological store allows individuals to rehearse information acoustically. On the other hand, the visuo-spatial sketchpad is used to hold visual memories (Gross and McIlveen, 1998).

## Working Memory and Styles

Baddeley and Hitch (1974) described "working memory" as active when individuals process information. The model is relevant to wide ranging activities including verbal reasoning and comprehension. Furthermore, Baddeley (2000) discussed that working memory capacity may reflect differences in efficiency of processing strategies or skills rather than differences in working memory capacity. Daneman and Carpenter (1980; 1983) theorised that working memory is used to represent strategies and skills in complex mental tasks. Others such as Conway and Engle (1994) argued that differences in working memory capacity affects a range of cognitive tasks, such as problem-solving, reasoning, acquiring new vocabulary words and reading comprehension.

Riding (2002), explained when meaning is given to new information working memory analyses this is with respect to what is already known and the Central Executive System (CES) organises input and output of information from the phonological loop and the visuo-spatial sketchpad. However, the articulatory control process keeps decaying representations in the phonological store intact. The phonological loop is a particular length and if a message is too long, some of it is lost and stored in the central executive. Baddeley, Gathercole and Papagno (1998) also discussed that the pholonogical loop explains many factors affecting memory span and these include word length, phonological similarity and irrelevant speech.

Riding and Rayner (2005), identified that analytics and verbalisers tend to use an elaborated method of processing information during learning and understanding. Analytics examine all features; nonetheless, the methods used by analytics and verbalisers would be inadequate if there is insufficient processing capacity. In such cases, information is lost. In contrast, wholists and imagers will not analyse all information, although they make decisions. This results in inferior performance when compared with analytics and verbalisers. The wholist approach requires less processing capacity and performance is average although memory capacity is enough. However, adequate processing capacity is necessary to prevent poor learning performance (Riding and Rayner, 2005). Even more memory capacity results in elaborated processing and superior learning performances. Nevertheless, performance can be improved for analytics as well as verbalisers whose memory capacity is not great. This is done by reducing the amount of material and decreasing stress levels.

When stress increases anxiety, working memory capacity becomes less effective and the result is confusion as information is processed. This causes further stress and so anxiety increases (Riding and Rayner, 2001) and motivation to learn. Students prefer particular learning styles and these are governed by brain physiology and cognitive styles. Dyslexic students may feel stressed in situations outside their experience. Improving memory can be achieved when information is linked to existing knowledge, broken in smaller parts, mnemonics, creating and finding unusual aspects of things learners would like to remember.

Analytics and verbalisers need more memory than wholist and imagery styles, nevertheless wholists as well as imagers tend to attain above average academic performance. Aspects of working memory will tend to influence the extent to which individuals use verbal and visual codes to problem- solve and the manner with which this is done is a function of individual styles (Riding and Rayner, 2001). Software on smart phones can help students with spelling and reading as word processing facility enables the highlighting of words that are spelt incorrectly. Voice recognition which help users dictate their ideas is also helpful (Drigas and Dourou, 2013). Adults will additionally have behaviours which help them to read and write. These include re-reading sentences, relying on grammar and spell checks and strategies to remember to spell similar sounding words such as ‘hair and hare’.

## Dyslexia, Cognitive Style and Mnemonics

Research in this area is limited, but studies show an association between dyslexia and visual-spatial memory. Tafi, Hameedy and Baghal (2009) showed that dyslexic students have greater strengths in visual and auditory memory of concrete words compared with abstract concepts. Furthermore, their visual-spatial memory was better than their visual-semantic memory. Their pictorial memory was better than their verbal memory and they were found to be more creative and original. Others such as Károlyi, Winner, Gray and Sherman (2003) point out that students were more able to reason globally rather than part by part and this corroborates the finding that they are more able to process visual-spatial information. Motimore (2008) discusses that wholists see the wider picture and use strategies which predict and organise information. In this case, a teacher will produce a frame for students to add information to.

Agbowuro, Taiwo, Mamfa and Usman (2016) in their discussion of the application of mnemonics in science education point out that mnemonic strategies such as imagery, helps the learner of new concepts to link this with older learnt material. This is achieved by visual or acoustic cues. In a study by Wilding, Rashid, Gilmore and Valentine (1986), first letter mnemonics of factors predisposing to carcinoma of the stomach helped recall when there was association of images with first letters. It is envisaged that memory training devices such as mnemonics may be beneficial to dyslexics who have short-term memory issues.

> *'Mnemonic devices can be defined as learning strategies which can often enhance the learning process and later the recall of information. On the other hand, mnemonic systems are special techniques or strategies consciously used to improve memory; they help employ information already stored in long-term memory in order to make memorisation an easier task. There is no doubt that mnemonic techniques are one of the most important methods and methodologies used in education'.*

Jurowski, Jurowska and Krzeczkowska (2015, p 11)

Jurowski, Jurowska and Krzeczkowska (2015) discussed the application of mnemonic devices in learning science concepts. Specifically, teachers who implement mnemonics with learners tend to achieve more knowledge acquisition from students such as dyslexics than if students develop devices of their own. However, those who develop their own mnemonics may be self-empowering and they could share these with other learners and make group learning a routine. It may also be that teachers who incorporate different learning styles including mnemonics may encourage groups of learners to achieve goals. Mastropieri and Scruggs (1998) pointed out that the use of mnemonic strategies organises and integrates difficult information to remember into something more meaningful which can be recalled. This is achieved by making associations between the new item(s) and those stored in long term memory. Rosenheck, Levin and Levin (1989) reported that mnemonic strategies enabled college students to acquire higher order organisation of information in classification of trees and were able to make inferences and transfer knowledge in problem-solving tasks which necessitated manipulation of concepts learned in a novel manner. Mortimore (2008) explains that learners should create scenarios for a subject and convert concept maps into pictures. They should generate key words and link these with images. One way in which mnemonics could aid learning is through the use of intelligent tutoring systems (ITS).

## Intelligent Tutoring Systems

These systems can provide information and examples as well as ask learners to reason at a deeper level (Craig, Sullins,, Witherspoon, & Gholson, 2006). ITS may also be able to answer questions, explain answers, provide problems and allow learners to practice these with demonstrations. Others point out that ITS can scaffold learning, by providing support early on in the learning process and then removing support as the learner achieves goals and build their skills and develop knowledge (Bouyias and Demetriadis, 2012). Others point out that research is currently focusing on the detection of learner emotions by ITS systems (Graesser, 2011). The details of ITS was explored by Nkambou, Bourdeau and Mlzouchi (2010).

The domain model (also called expert knowledge) contains the concepts, rules, and problem-solving strategies of the domain to be learned. It can evaluate the student's performance or detect errors, etc. The crucial problems concern the capability to reason with the model and gradually adapt the explanation of the reasoning to the learner.

The student model is the core component of an ITS. Ideally, it should contain as much knowledge as possible about the student's cognitive and affective states and their evolution as the learning process advances. Wenger (1987) assigned three main functions to the student model: 1) it must gather explicit and implicit (inferred) data from and about the learner; 2) it must use these data to create a representation of the student's knowledge and learning process; and 3) it must account for the data by performing some type of diagnosis, both of the state of the student's knowledge and in terms of selecting optimal pedagogical strategies for presenting subsequent domain information to the student. In the same vein, Self (1999) discusses that the tutoring model receives input from the domain and student models and makes decisions about tutoring strategies and actions. Based on principled knowledge, it must make decisions on whether or not to intervene, and if so, when and how. Content and delivery planning are also part of the tutoring model's functions. More generally, student/tutor interactions usually occur through the learning interface, also known as the communication or interface component. This component gives access to the domain knowledge elements through multiple forms of learning environment, including simulations, hypermedia, micro-worlds, etc.

## A New ITS Model Incorporating Cognitive and Learning Styles of Dyslexic Learners

This paper examines the extent to which cognitive styles could be incorporated into ITS systems for teaching dyslexic students. Riding and Sadler-Smith (1997) point out that the presentation of information to trainees or learners of any system could be in a form that matches the style of the learner such as those who lie along the Wholist-Analytic dimension. They suggest a map of contents will serve to compensate for learners' style deficiencies. This adaptive system will identify the learners' cognitive style quickly using a computer based Cognitive Styles Analysis (CSA) which shows whether an individual is a verbal or visual thinker or will process information either wholistically or analytically (Riding, 1991). To complete the CSA, participants respond to statements or questions by pressing one of two computer key-pad letters masked with either a blue sticker or a red sticker. It is suggested the elements of this CSA is accommodated within the adaptive system.

THE VERBAL - IMAGERY DIMENSION OF THE CSA: This dimension presents two types of statements; half deals with the appearances of items and the other half with categorical items. Twenty-four items dealing with appearance take the form "are A and B the same colour?". For example:

LETTUCE and LAWN are the same COLOUR; BLOOD and TOMATO are the same COLOUR; GRASS and OIL are the same COLOUR

The other twenty-four containing information related to conceptual categories take the form "are A and B the same type?". For example:

CAR and VAN are the same TYPE; COOK and TEACHER are the same TYPE; GOLF and TEA POT are the same TYPE

Statements are presented in a singular fashion and half of the statements of each type are true while the other half are false. Zhang (2008) explains that those who are imagers will respond more quickly to statements which are of the appearance types. This is mainly because the objects in statements are easily represented in the form of mental pictures and imagers can process the information rapidly to make appropriate comparisons. Evidence is derived from neurosychological distinct pathways and Kosslyn, Ganis and Thompson (2001) report that object imagery refers to the appearances of objects in terms of their shape, size, texture, colour and brightness but spatial imagery refers to mainly abstract representations of the spatial relations among objects, parts of objects, locations of objects in space, movement of objects and object parts (Kozhevnikov, Louchakova, Josipovic and Motes, 2009).

THE WHOLIST-ANALYTIC DIMENSION OF THE CSA: A first test consists of pairs of twenty geometrical figures. The figures are similar to those of the Embedded Figures Test (Witkin, Moore, Goodenough, and Cox, 1977) and it has yet to be determined if individuals who are spatial imagers of the type Kosslyn, Ganis and Thompson (2001) describe would be better at distinguishing these kinds of shapes or figures (Zhang, 2008). The CSA asks participants to decide whether pairs of figures are the same or different. Half of the pairs are the same and the other half are different. It is supposed that a fairly fast response to such shapes is possible by wholists. A second test of also twenty geometrical shapes presents a simple square or a triangle and another more complex geometrical figure to participants. This kind of question asks participants to assess the simple shapes contained within the complex and discern whether the complex shape bears similarities to the simple figure (the stimulus) or whether the simple shape is contained within the complex figure. Whilst half of the stimulus items required participants to respond "yes", the other half required "no" answers. Analytics should be relatively quicker with these kinds of questions. The aim according to Riding and Sadler-Smith (1997) is to provide training suitable for all trainees by using a training design of text, pictures and diagrams which will allow learners to explore information using their individual style(s).

It is suggested that on examination of the CSA's results for each individual, the ITS will deduce the extent of hemispheric differences and strengths, if any, and then explore modes of presentation of information such as combination of text and imagery. ITS will establish modes of preferences in learning styles and will examine the self-concept of students which will help ITS to balance levels of encouragement and point out how frequently errors can be disclosed to learners. This will help learners to be encouraged rather than feel defeated with tasks.

For subjects, ITS will have a set of knowledge for students. For example, the reactivity series, the periodic table, organs of the body, plant/animal classification (science students); months of the year, seasons, form filling vocabulary (English for Second Language Learners); the concept of multiple intelligences etc. Students will be provided with an example of a mnemonic for learning a concept and they will choose either to create their own or use the suggestion from ITS. When learners feel they are competent in using a mnemonic, ITS will suggest a task to complete within the topic area with feedback on completion. Students will complete a number of tasks and percentage corrections will be calculated and correct answers to errors provided. ITS will encourage students to do better by presenting simpler tasks and then build to more complex ones so that students transfer knowledge successfully.

Those who did well on a first task may then choose more challenging tasks from an array of options available on ITS. Once mnemonic concepts are grasped, ITS will present students with examination questions.

## Conclusion

Dyslexic students may have hemispheric strengths and this has to be established for designers of ITS. The paper suggests that the CSA may be an appropriate instrument in this respect. However, research is required. Discussed is the contention that there are possible ways in which ITS could interact with students and this is based on knowledge gathered about an individual's level of knowledge, and self-concept. ITS will present learning material according to preferences, for example a combination of text and images, only images/pictures etc. Once mnemonics are grasped with associated knowledge, it is envisaged that students will be able to transfer this to higher levels of problems such as examination questions.

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