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A MEASURING METHOD FOR IDENTIFYING THE PERCEIVED MULTIPLE INTELLIGENCE OF PEOPLE WITH EPILEPSY

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Abstract

Among the challenging problems faced by People with Epilepsy (PWE), the main problems are under-employment and unemployment. Regardless of their qualification and experience, many PWE claim to have been denied the same opportunities given to other people, even at present, when there are many suitable jobs for them to choose from. Human resource personnel, however, need reliable information about the PWE before they can be hired. Inverse Ability Test of Epilepsy (*i*-ATIE), a psychometric test was developed to meet their need for this purpose and was constructed by combining Howard Gardner's Multiple Intelligence theory with statistical procedures. The test development started with Fuzzy Inverse ATIE (FIA) algorithm, where this algorithm was incorporated into a crisp Logistic Regression model to obtain the best intelligence parameters that would be garnered to maximize the employment probability of people with epilepsy (PWE). A computer programme using C-Sharp programming language was developed to execute the FIA. Then, the model has been coded to become a software. *i*-ATIE is able to measure the level of perceived intelligence of the PWE quantitatively and able to identify the skills that they are still lacking and need to be improved. With the advent of this psychometric test, it would now be possible to develop a tangible programme to enhance the employability of PWE that are problem-specific.

Keywords: Fuzzy Theory; Multiple Intelligence Theory; People with epilepsy

1. Introduction

Epilepsy in Malaysia is a subject that has not been sufficiently explored. The majority of People with Epilepsy (PWE) in Malaysia are reluctant to disclose their identity. As a result, it is difficult to obtain accurate information and their cooperation in the course of conducting studies related to epilepsy. As a consequence, there has been a dearth of studies on the malady in Malaysia. Historically, epilepsy is an ancient illness, with different cultures handling it differently. The prevalence of epilepsy is 3 to 9 per 1,000 people in the population (Yu et al., 2009). The level of awareness about this illness in Malaysia is still low. They still have the wrong perception of the malady, believing that it is hereditary, contagious and related to evil spirit (Ab. Rahman, 2005).

People with epilepsy face numerous obstacles and many are being discriminated in the workplace withrespect to positions and pay (Jacoby, Gorry & Baker, 2005). Ignorance about the illness on behalf of the management and colleagues have often been the cause of PWE not being able to keep their jobs, apart from the discrimination arising thereof (Baker et al., 2005). Thus, a study is needed to identify possible remedial measures that would enhance the usefulness of PWE to potential employers. The effort of developing the new method of measuring the PWE's intelligence skills should be able to create awareness among the public, especially the employers, of the potential of PWE for employment. As it is, they are being disadvantaged because of the stigma associated with this illness and negative perception on the part of the society.

Research has shown that intelligence, be it internal or external, physical or emotional, is very important in reaching important life goals(Bar-On et al., 2003). Human ability or human intelligence in Malaysian society changes with time. To many Malaysians, intelligence, just like in other cultures, is regarded as an important asset in achieving one's dream, especially in determining one's hierarchy in the society. All men and women were born with special gifts from God. These gifts or special abilities are different from person to person. From the Western traditional point of view, these special gifts or intelligences are contained in the individuals' general intellect, and with it the individuals comprehend, examine and respond to outside stimuli. The ability of an individual to make use of these intelligences manifests when solving complicated mathematical problems, or being an effective leader in an established organisation. Therefore, intelligence is a singular collective ability to act and react in response to the surroundings.

Multiple Intelligence Theory was first introduced by Howard Gardner in 1983 in his book, Frames Of Mind (1983). Gardner viewed intelligence as the "ability to solve problems, or to create products that are valued within one or more cultural settings" (Johnson & White, 2002; Gardner, 2004a). Initially formulated as a list of seven intelligences in 1983, an eighth intelligence (naturalist or nature smart) was added later in 1997, followed by spiritualist. This present study uses only the first eight intelligences namely Linguistic, Logical-mathematical, Musical, Bodily-kinaesthetic, Spatial-visual, Interpersonal, Intrapersonal and Naturalist. According to Gardner (2004b), if a person focuses on any field or type of intelligence, he/she can develop intelligence in it and that intelligence can be shaped with effort. He also suggested that there were many factors affecting one's intelligence. These included biological and cultural factors, historical and cultural elements, opportunities, family, geographical factors and sociality factors. People who believe in the power of effort and that intelligence can be developed may achieve more in life.

One method of effectively measuring intelligence which has been used for centuries is psychometric test. A fuzzy model was built and used to develop a new measuring tool in order to determine the most appropriate parameters of the PWE's eight intelligent skills. A logistic regression model was estimated to determine the probability of PWE getting employed and then was incorporated into the fuzzy model.

The fuzzy set theory was introduced by Zadeh (1965) through the concept of degree membership for a set in a closed unit interval [0,1]. The applications of fuzzy theory can be found in various applications across many disciplines (Gardner, 1983). Philosophers, logicians and mathematicians have long been associated with the notion of a crisp set theory. For those who are in the field of science and engineering, precision, specificity, sharpness, consistency and speciality are crucial. The crisp set theory (classical set theory) has been the main tool of science and the approach is considered precise, encompassing two logical values of yes or no. Then in

1965, Zadeh came up with a completely new and elegant approach in his revolutionary paper, Fuzzy Sets (Zadeh, 1965). This new mathematical approach was not readily accepted, until it attracted the attention of many researches and practitioners. Now, it is one of the most successful mathematical approaches to resolve imperfect knowledge or vagueness that are accepted world-wide.

2. The Development of Inverse Ability Test in Epilepsy

This section explains the development process of a new tool for measuring the multiple intelligence of PWE quantitatively namely, inverse Ability Test in Epilepsy (*i*-ATIE). The process is divided into five stages which describe how *i*-ATIE , with the injection of fuzzy algorithms, had been developed from its initial psychometric test, Ability Test in Epilepsy (ATIE) in 2008 and finally turned out to be a useful new software.

Stage 1: Early Development

In 2008, a psychometric test, Ability Test in Epilepsy (ATIE) was developed and its main objective was to measure the eight types of multiple intelligences of epilepsy patients (Zimmermann, 2001). The eight intelligences are musical, bodily/kinaesthetic, math-logic, spatial, linguistic, interpersonal, intrapersonal and naturalist (Johnson&White, 2002; Gardner, 2004a). These were selected based on past studies and discussions with epilepsy experts, as well as interviews with the patients and their caretakers. The main objective of the instrument was to gauge the patients' own perceptions about their mental ability or level of intelligence. In the test, it is assumed that the patients are capable of describing their true selves. ATIE was designed to be capable of comparing the intellectual ability of PWE with that of other people. The test was also designed to help in the diagnosis or assessment of major psychological disorders and place them accordingly at the workplace. It requires subjects to have the mental ability of at least primary six pupils (Malaysian School System of Education).

Subjects

In order to develop both ATIE and *i*-ATIE and also the logistic regression model (that will be discussed in Stage 2), the data based on the subjects comprising 147 outpatients at the Neurology Department, Kuala Lumpur General Hospital (HKL), were randomly selected and examined. They consisted of both employed and unemployed, and were classified as either partial or generalized epileptic. The subjects were selected based on the following selection criteria (Awang, 2008):

i. 16 to 50 years old
ii. Confirmed epileptic by clinical history
iii. Having experienced at least one seizure according to ILAE definition (Awang, 2012)
iv. Not suffering from any other neurological disorder
v. Capable of being independent, not registered with the Social Welfare Department as mentally challenged, or had not been referred to psychiatrists for having abnormal neurological disorder
vi. Currently employed or are awaiting employment.

Test Format

The test was divided into nine sections, comprising a profile and the items to measure eight intelligences as shown in Table 1.The first section is the profile section that contains the demographic characteristics of the respondents (Items 1-15), followed by section on the respondents' illness (Items 16–18). The next eight sections contain 11 items for musical intelligence and 10 items for seven other intelligences for self-assessment by the subjects. The reliability coefficients (Cronbach's α values) obtained for the individual intelligence range from 0.86 to 0.94, implying that all the questions/statements used in the questionnaire reliably measure the perceptions of the participants with respect to the eight factors (Fisher et al., 2005). Ten subjects were chosen for the re-test. The correlation coefficients of test and re-test responses range from 0.65 (math-logic) to 0.96 (verbal), implying that the questionnaire is highly reliable. This research instrument enables the study to be carried out quantitatively, facilitating the use of statistical analysis to reach its conclusions.

Table 1: The Content of ATIE

Section	Item	Number of Items
1	Demographic Information	15
	Information on illness	3
2	Musical	11
3	Bodily Kinaesthetic	10
4	Math-logic	10
5	Spatial	10
6	Linguistic	10
7	Interpersonal	10
8	Intrapersonal	10
9	Naturalistic	10

Scores and Number of Intelligence

To measure the respective intelligence, a 5-point Likert scale was used, ranging from 1 (not at all like me) to 5 (definitely me). The subjects were asked to choose the score that best described themselves and their abilities. The test score was calculated by adding all the scores in each item for each section. The total score for an individual subjects was the mean of all the scores for each section, and this reflected his/her intelligence level in a particular section.

Before the number of intelligence skills was determined, the level of intelligence for each type of intelligence was first ascertained. The subjects were classified into five levels based on their scores in ATIE, as described in Table 2. The scale ranges from 0 to 5 and is adopted from The Professional Manual developed by the Multiple Intelligence Developmental Assessment Scales (Shearer, 2007). Those who are in the high or very high category are deemed to have that particular intelligence or skill. For example, if a person's average score in spatial skill was in the range of 3.1 to 5.0, he/she would be presumed to have spatial intelligence. If the average score was 2.9, he/she would be deemed to have a mediocre spatial intelligence. From the five levels, the intelligences were again classified into three final categories: none or weak, mediocre and high, as illustrated in Table 2. Those who had high scores in more than one section in ATIE were considered to have multiple intelligences.

Table 2: Level of Intelligence

Score range	Score Level	Intelligence Level
0.0 to 1.0	None	None/Weak
1.1 to 2.0	Very Low	
2.1 to 3.0	Mediocre	Mediocre
3.1 to 4.0	High	High
4.1 to 5.0	Very high	

Stage 2: Fuzzy Inverse ATIE (FIA)

In order to help the PWE, they first have to undergo ATIE. Then, based on the results from ATIE, the measured intelligence parameters are incorporated into fuzzy algorithm, called a Fuzzy Inversed ATIE (FIA), to produce a combination of the eight intelligence skills that would maximize the probability of employment of the PWE concerned. FIA also helps to identify existing skills of the PWE that need improvement.

Logistic Regression

In the development of the fuzzy model, a fuzzy algorithm called a Fuzzy Inversed ATIE (FIA) was created by adopting and modifying fuzzy algorithm introduced by Ahmad et al. to reduce the crosstalk in micro-strip lines (Ahmad et al., 2004). Essentially, the model was first obtained from logistic regression involving eight intelligences as the independent variables, then integrated with the modified algorithm to yield a fuzzy model, FIA.
The logistic regression model can be written as:

$$Z = c_o + c_1X_1 + c_2X_2 + c_3X_3 + c_4X_4 + c_5X_5 + c_6X_6 + c_7X_7 + c_8X_8 \quad (1)$$

Where:
Z is the odds of employment status (1=employed; 0 =unemployed), c_o is a constant and
X_1 = music score; X_2 = kinaesthetic score; X_3 = math-logic score
X_4 = spatial score; X_5 = verbal score; X_6 = interpersonal score
X_7 = intrapersonal score; X_8 = naturalist score

Following this, fuzzy algorithms involving sixteen steps as follows (Awang et al., 2013) were applied:

FIA Algorithms

1. *Algorithm I: Determination of Crisp Intelligence Parameters*
   Algorithm I consists of Step 1 and 2(Awang et al., 2013).
   Step 1: Find a crisp model from Logistic Regression approach.
   The Logistic Regression Model consists of

$$P(Y = 1) = \frac{1}{1+e^{-z}} \quad (2)$$

where

$z = c_0 + c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + c_6x_6 + c_7x_7 + c_8x_8$

Step 2: Let $Z_x: I_1 \times I_2 \times \ldots \times I_i \rightarrow R$ be intelligence parameter ($i \in N$) such that $r = Z_x(x_1, x_2, x_3,\ldots,x_n)$.
In this step, the intelligence parameter contains all input parameters as its variables are determined.

2. *Algorithm II: Fuzzification Process*

Algorithm II consists of Step 3 to Step 7(Awang et al., 2013).

3. *Algorithm III: the Determination of Optimised Fuzzy Value, f^**

This algorithm consists of Step 8 to Step 10(Awang et al., 2013).

4. *Algorithm IV: Defuzzify*

Algorithm IV consists of Step 11 to Step 15(Awang et al., 2013).

5. *Algorithm V:Recalculate the Logistic Regression Parameter*

The final algorithm consists of Step 16 (Awang et al., 2013).

Step 16:Insert the newly found Z into the Equation in Step 1.
This last step is to find P(Y) using the optimised *Z*. If P(Y) is close to 1, then z has optimised P(Y).

These algorithms are applied to determine the eight intelligence parameters of employability and then were coded using the C# programming language as in Stage 3.

Stage 3: C-Sharp (C#) Simulation

In order to determine the ideal combination of eight intelligences, the fuzzy algorithms, FIA, were coded in C-Sharp programming language.

Stage 4: Probability of Employability

Fuzzy algorithms described in Stage 2 are to determine how the chances of PWE getting hired could be improved. According to Gardner, a person's intelligence can be enhanced if the person focuses and practises regularly (Gardner, 1983). PWE need to undergo ATIE, have the result analysed using the Fuzzy Inverse ATIE (FIA), and their weaknesses identified. Based on this diagnosis, the PWE concerned could then embark on specific remedial actions to overcome their weaknesses and improve their chances of being hired.

The process of developing an employability model for PWE has been demonstrated in Stage 2 and based on the results of the logistic regression and the fuzzy model, the optimal combination of the eight intelligences was derived. Since the probability of employability *P(Y=1)* was close to

1, one may conclude that the approach adopted by this study would help to enhance the likelihood of a PWE being employed. The model has been coded in C# programming to enable it to be conveniently estimated. Table 3 shows results of 20 selected patients.

Table 3: Simulation Results for 20 Patients

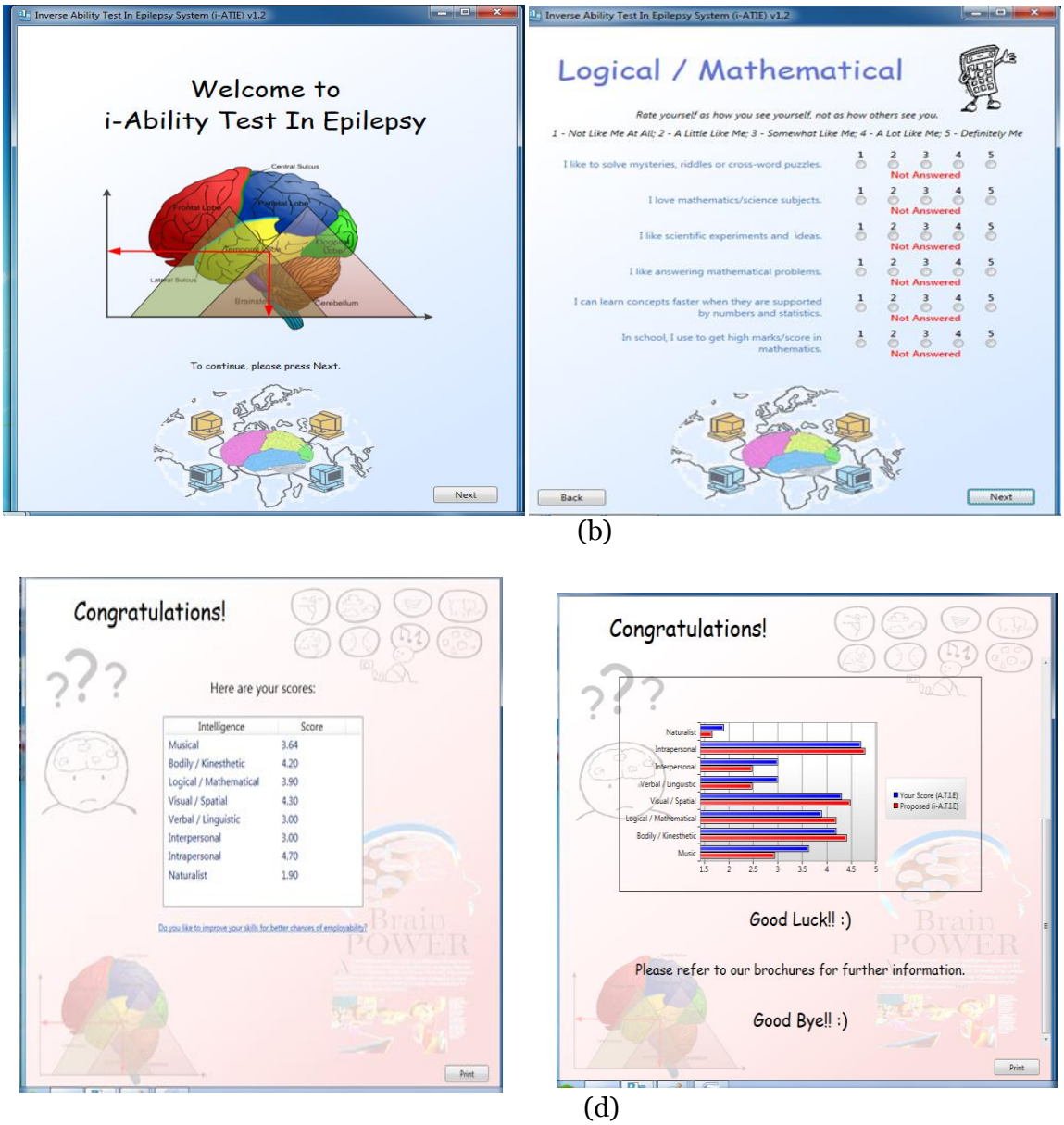
Patient ID	Actual P(Y=1)	Improved P(Y=1)	Patient ID	Actual P(Y)	Improved P(Y=1)
1	0.841	0.943	11	0.741	0.933
2	0.876	0.948	12	0.867	0.946
3	0.683	0.928	13	0.774	0.936
4	0.885	0.949	14	0.859	0.945
5	0.772	0.936	15	0.605	0.923
6	0.865	0.946	16	0.572	0.921
7	0.655	0.927	17	0.839	0.943
8	0.683	0.928	18	0.766	0.935
9	0.778	0.936	19	0.890	0.950
10	0.731	0.932	20	0.595	0.923

From Table 3, it can be concluded that through the suggested combination, Patient ID 1 is capable of increasing the employment probability from 0.841 to 0.943 by improving his/her kinaesthetic, math-logic, spatial and also intrapersonal skills as suggested from *i*-ATIE results.

Stage 5: i-Ability Test in Epilepsy (*i*-ATIE)

Based on all the processes discussed in Stage 1 to Stage 5, a new software namely *i*-ATIE was built to help not just the employers but also the PWE to identify the potential capabilities of the PWE for the hiring processes and job placement purposes.

This new measuring tool, *i*-ATIE, not only can measure the level of intelligence of PWE quantitatively based on the Howard Gardner's Multiple Intelligence, but it also can suggest the potential skills of PWE that need improvement so that their chances of securing suitable employment would be improved. The following figures, Figure 2(a) to 2(d), show some of the outputs from the *i*-ATIE. At the end of the test as illustrated in Figure 2(c), subjects will be given their true scores based on their answers and also proposed scores based on the Fuzzy Inverse ATIE algorithm. The proposed scores provided contain an ideal combination of eight intelligences that improve the probability of employment. For example, according to Figure 2(d), Patient A can improve the probability of employment by improving his/her kinaesthetic, math-logic, spatial and also intrapersonal skills.



(a) (b)

(c) (d)

Figure 2: Examples of *i*-ATIE output

3. Conclusion

This paper has introduced a new measuring method for identifying the actual strengths and weaknesses of people with epilepsy (PWE)'s intelligence ability namely Inverse Ability Test in Epilepsy (*i*-ATIE). With this, they would be able to identify a suitable career. *i*-ATIE adopts Howard Gardner's theory of Multiple Intelligence (MI). Fuzzy algorithm was built in order to improve the probability of PWE of getting hired based on the fuzzy model developed, where an ideal combination of eight intelligences is given.

This paper has introduced a new methodology based on a fuzzy model that is useful in helping to maximise the chances of employment for PWE by using the best combination of the eight

skills based on the results of ATIE . Fuzzy Inverse ATIE (FIA) algorithm was developed and it was then incorporated into a crisp Logistic Regression model to obtain the best intelligence parameters that would be garnered to maximize the employment probability of PWE. FIA also helps to identify existing skills of the PWE that need improvement.

After identifying the existing skills, the next stage was to determine the best combination where a computer programme has been developed using C Sharp (C#) programming language (Version 4). With the suggested combination simulated by the programme, it is now possible to improve the skills of PWE tangibly, thereby increasing their chances of securing suitable employment. Finally, *i*-ATIE software was built based on all the procedures and stages discussed in this paper.

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