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Evaluation of the Performance of Multiple Intelligence for People with Epilepsy

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Abstract One's intelligence can be improved via regular practice and focus. This paper aims to evaluate and rank multiple intelligences for People With Epilepsy (PWE). The proposed method is to rank the intelligences which were obtained from $ATIE^{©}$, a psychometric test based on the Howard Gardner's Multiple Intelligence (MI). The performance evaluation and ranking of intelligence parameters can be used to assist PWE identify their levels of competencies, strengths, and weaknesses. The study has determined the priority of eight intelligence parameter skills by considering PWE's demographics. The results of this work can be used to enhance the employability of PWE.

Keywords Multiple Intelligence; People With Epilepsy; Data Envelopment Analysis; Analytic Hierarchy Process.

2010 Mathematics Subject Classification Give 2010 AMS classification of the manuscript.

1 Introduction

Intelligence is defined as a distinct collective ability which can act and react in response to the surrounding environment. The existence of one or more intelligences was a question during last two centuries. Howard Gardner, who is a contemporary psychologist, believes on the multiple intelligences theory in which any person has a combination of several intelligences with different strengths. Gardner presented his first Theory of Multiple Intelligence in a book, "Frames of Mind: The Theory of Multiple Intelligence" [1]. He introduced musical, kinaesthetic, verbal, math/logic, spatial, interpersonal, and intrapersonal as seven elements of intelligence in 1983. Then, he added the "naturalist or nature smart" as the eighth intelligence in 1997.

Epilepsy, which is one of the oldest diseases in history, has affected numerous people for several centuries [2, 3]. Epilepsy is not a mental disorder, but it is related very much to the brain. Epilepsy can attack any people in any social position and nothing to do with one's level of intelligence. Various studies have been performed related to the effects, types of epilepsy, and the quality of life of people with epilepsy (PWE).

Unfortunately, PWE lose their self-confidence, sense a large gap between themselves and other people, and leave their normal activities in the society. Therefore, employment is one of the most challenging issues for PWE. Based on the studies, PWE show high unemployment rates, underpaid, and cannot keep their jobs because of the stigma, severity of seizure and other psychological deficiencies. However, there are numbers of PWE, who have regular education and have successful careers in various fields.

There is a study that focused on identifying intelligence profiles of PWE in order to improve the probability of employment. Awang et al. [4] explored the attitudes and perception of human resource personnel toward the epilepsy and unemployment of PWE. Awang et al. [5] classified PWE's intelligence patterns and characteristics based on a developed intelligence scale namely Ability Test in Epilepsy ($ATIE^{©}$).

The problem in this study is to rank the intelligence parameters which need to be improved based on the demographic aspects and the illness background of the PWE such as educational level, age, employability status, onset age, gender, seizure type, ethnicity, and marriage status.

The remainder of this paper is organized as follows. In the next Section, Awang's work is briefly reviewed [4–7]. Section 3 introduces the Data Envelopment Analysis (DEA) and Analytic Hierarchy Process (AHP) methods. Section 4 proposes a framework for ranking the multiple intelligences for people with epilepsy. Section 5 presents the results. Finally, Section 6 concludes the paper.

2 Review of ATIE

Ability Test in Epilepsy ($ATIE^{©}$), a psychometric test, was developed based on the Multiple Intelligence (MI) theory proposed by Howard Gardner to measure eight types of intelligence skills [7]. In this test, 5-point Likert scoring system was used in which the score domains from 1-not at all like me to 5-definitely me. The research subjects were needed to respond to items that best describe their views, feeling and opinions towards their mental capacity or level of intelligence. Based on the test scores, they were classified into eight types of intelligence [5]. Based on $ATIE^{©}$, inverse Ability Test in Epilepsy (i-ATIE) system was designed. This system was developed based on Fuzzy Inverse ATIE (FIA) algorithm. Then, the algorithm was incorporated into a crisp Logistic Regression model in order to get the best intelligence elements which would be obtained to maximize the employment chances of PWE.

3 Review of DEA and AHP

3.1 Review of DEA

Data Envelopment Analysis (DEA) gives a systematic methodology to analyze productive efficiency [8]. In the relatively short span of 25 years, DEA has established itself as a popular analytical research instrument and practical decision support tool. An increasing number of applications is an evidence of its popularity among researchers in Economics, Econometrics and Operations Research, Management Science, as well as practitioners in the business community and government institutions.

DEA is a nonparametric method which measures the efficiency of Decision Making Units (DMUs) with common input and output terms [8]. The DEA model formulated by these scholars was called the CCR (Charnes, Cooper, and Rhodes) model. In 1984, the model was further improved by Banker et al. [9] and named it as BCC (Banker, Charnes, and Cooper) model. The basic DEA models divide DMUs into efficient and inefficient categories.

The original CCR model which was introduced by Charnes et al. in 1978 [8] evaluates the relative efficiency of DMU_o from a set of DMU_j $(j = 1, \ldots, n)$ with x_i $(i = 1, \ldots, m)$ and y_r $(r = 1, \ldots, s)$ as input and output vectors. The input oriented CCR model for assessing the relative efficiency of DMU_o with the infinitesimal ε is shown as follows:

$$
\begin{aligned}
Min \quad & \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+) \\
s.t. \quad & \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{io}, \quad i = 1, \ldots, m, \\
& \sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro}, \quad r = 1, \ldots, s, \\
& \lambda_j,\ s_i^-,\ s_r^+ \geq 0, \quad j = 1, \ldots, n,\ i = 1, \ldots, m,\ r = 1, \ldots, s.
\end{aligned} \tag{1}
$$

where θ represents efficiency score and s_i^- and s_r^+ are input and output slacks.

Definition 1 (CCR-Pareto-efficiency) *[8] A DMU_o is CCR-Pareto-efficient if and only if it satisfies the following two conditions:*
(i) $\theta^*_{CCR} = 1$,
(ii) $s_i^{-*} = 0, \forall i \in \{1, \ldots, m\}$ *and* $s_r^{+*} = 0, \forall r \in \{1, \ldots, s\}$ *in all optimal solution.*

In basic DEA methods, all the input and output data are considered to be quantitative, with numerical values. In reality, there are issues where the data are introduced by qualitative factors, which only have ordinal relations, without any exact numerical values.

3.2 Review of AHP

There exist different mathematical methods for evaluating the systems with qualitative and quantitative data in the literature, such as analytic hierarchy process (AHP) [10], fuzzy AHP [11,12], fuzzy goal programming [13], fuzzy analytic network process (ANP) [14], and Multi Criteria Decision Making (MCDM). By using these methods, both qualitative and quantitative factors can be considered in order to evaluate the systems. One of the most effective techniques is the AHP. This method mimics the human's brain process for solving complicated and fuzzy problems which helps to simplify the decision making problems [15].

Saaty [16] was the first person who introduced the Analytic Hierarchy Process (AHP) in 1977. He developed AHP in 1980 [17]. AHP has proven to be a very effective decision-analysis and multiple criteria decision making tools in the last decades. Forecasting, selecting the best alternatives, investment decisions, resolving conflicts, resource allocations, and socioeconomic planning issues are different applications of this technique [18,19].

Decomposition, comparative judgments, and hierarchical composition or synthesis of priorities were introduced as the basic principles of AHP [20]. To demonstrate a decision problem in AHP, the structure in a hierarchical fashion is used in which the ultimate goal is placed at the first level of the hierarchy. The criteria, sub-criteria, and alternatives are located at the next levels of the hierarchy.

The decision maker constructs various comparison matrices at different levels of the hierarchy in order to make comparative judgments. One of these matrices, which are constructed at the upper levels of the hierarchy, includes the weights of criteria considering their influence on or contribution to the ultimate goal. Another matrix, which is also constructed at the upper levels of the hierarchy, includes the weights of sub-criteria with respect to their importance for the criteria. At the lowest level of the hierarchy, each pair of alternatives is compared with respect to each criterion or sub-criterion immediately above and constructs the covering criteria matrix.

4 Ranking the Multiple Intelligence for People With Epilepsy

4.1 Problem Statement

The problem in this study is to rank the intelligence parameters which need to be improved based on the demographic aspects and the illness background of the PWE such as educational level, age, employability status, onset age, gender, seizure type, ethnicity, and marriage status. As already mentioned, in Awang's work [5, 7], she characterized several intelligence parameters which the PWE could improve without considering the patient capabilities and other specifications which some of them were qualitative and quantitative. So, this is the limitation of Awang's work. This study presents a method to rank intelligence parameters which consider all the above aspects and specifications which include qualitative and quantitative criteria. Based on the final ranking results, it can be suggested that which intelligence parameters need to be improved first.

4.2 Ranking Framework

There exist various evaluation methods for jointly evaluating both quantitative and qualitative criteria. The proposed scheme in the [21] is considered as the framework for ranking the multiple intelligence parameters. Based on this framework, the ranking will be performed in two different steps.

Step 1. Step 1 is to identify the effects of the demographic aspects such as educational level, employability status, gender, seizure type, ethnicity, and marriage status on the intelligence parameters. The process will be done based on AHP with four steps: problem modeling, weights valuation, weights aggregation, and sensitivity analysis.

Step 2. At this stage the integrated AHP/DEA model is applied in order to derive the most favorable AHP/DEA ranking method for the intelligence parameters. The efficiency of DMUs obtained by adjusting the Russell measure [22]. To perform this step, each patient is considered as a DMU. Then, the age of each patient is considered as the input for each DMU. The onset age and the obtained weights in step one for each intelligence parameter considering the effects of the demographic aspects are considered as the output for each DMU. The output of this step will give the prioritized ranking for the intelligence parameters considering the effects of the demographic aspects.

Steps 1 and 2 above lead to a systematic ranking procedure of PWE's intelligence parameters.

5 Results

In this part the results of the ranking of the intelligence parameters is presented by considering the demographic aspects. The ranking model ranks the intelligence parameters of all the patients as DMUs and gives score to their intelligence. There are 158 data of epileptic patients used to measure the relative performance of their each perceived intelligence parameters. However, in this study, the performance of each intelligence parameters for the first 30 epileptic patients are presented and interpreted.

After calculating the total intelligence parameters scores for each patient in Step 1, each epileptic patient is considered as a DMU. The patient's age of onset and the total score of each intelligence parameter are considered as two outputs. The patient's real age is also determined as input for this DMU. Using the Russell measure [22] model, the relative performance of each DMU in each category of intelligence parameters is determined. The results are shown in Table 1.

For example for DMU_7 in Table 1, the Patient number 7 has a set of eight relative Russell efficiency scores for each own intelligence parameters, which it can be prioritized for them as high to low intelligence parameters respectively. The relative musical Russell efficiency score is 0.49696 among all patients, and for body, math, visual, and so on, this patient has got the scores 0.49874, 0.50887, 0.50363,..., respectively. The priority of intelligence parameters for Patient number 7 based on relative scores is as below:

Mathematical $\succ$ visual $\succ$ Interpersonal $\succ$ Intrapersonal $\succ$ Naturalist $\succ$ Body $\succ$ Musical $\succ$ verbal

where symbol 'a $\succ$ b' represents that 'a' has higher performance and better rank compare to 'b'. Therefore, the rank of mathematical intelligence is 1 and the rank of verbal intelligence is 8 for this patient. The ranking shows that Patient number 7 is strong in mathematical intelligence but weak in verbal intelligence. The ranking results are shown in Table 2.

Consider DMU_{18} in Table 2. As can be seen, this patient has ranked 1^{st} in mathematical intelligence, 5^{th} in interpersonal intelligence, and 8^{th} for naturalist. The ranking order of the intelligence parameters for this patient is as follows:

Mathematical $\succ$ visual $\succ$ Musical $\succ$ Body $\succ$ Interpersonal $\succ$ verbal $\succ$ Intrapersonal $\succ$ Naturalist

These priorities are different from patient to patient.

6 Conclusion

Demographic information such as educational level, age, employability status, onset age, gender, seizure types, ethnic, and marital status of epileptic patients are essential in order to explore PWE's potentials. Having different background, the intelligence parameters that PWE need to improve are also varies. Therefore, a systematic ranking procedure of PWE's intelligence parameters which need to be improved is needed. The performance evaluation and ranking of intelligence parameters can be used to assist PWE identify their levels of competencies, strengths, and weaknesses. The study has determined the priority of eight intelligence parameters skills by considering PWE's demographic and used this priority to enhance the employability of PWE. One way to assist PWE to be competitive in the job market is by promoting their inherent skills. With this assessment, it is now possible to improve the skills of PWE. Employment is one of the most challenging issues facing PWE. The majority of PWE under study have jobs but only about one-third among them holds jobs that are commensurate with their actual capabilities. With this knowledge from the performance evaluation and ranking of the intelligence parameters for these PWE under study by considering their demographic aspects, they could identify their strengths and weaknesses in the context of employability in the job market and could improve their inherent skills and seek suitable employment.

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Table 1: The result of applying the Russell model

Russell Efficiency DMU	Music.	Body	Math.	Visu.	Verb.	Inter.	Intra.	Natural.
1	0.46352	0.46289	0.47133	0.47104	0.46245	0.46743	0.46689	0.46238
2	0.08318	0.08326	0.08340	0.08345	0.08330	0.08373	0.08380	0.08391
3	0.64411	0.64459	0.64841	0.65559	0.64240	0.64692	0.65417	0.65145
4	0.66361	0.66104	0.66344	0.67014	0.66034	0.66395	0.66890	0.66985
5	0.47266	0.47403	0.48176	0.47777	0.46941	0.47667	0.47666	0.47478
6	0.47927	0.47895	0.48703	0.48179	0.47458	0.48232	0.48065	0.48082
7	0.49696	0.49874	0.50887	0.50363	0.49273	0.50219	0.50219	0.49972
8	0.40742	0.40689	0.41400	0.41375	0.40651	0.41071	0.41026	0.40646
9	0.55365	0.56117	0.56226	0.56170	0.54947	0.56265	0.56673	0.56343
10	0.79952	0.78087	0.81301	0.79693	0.78302	0.79375	0.78336	0.78634
11	0.52846	0.52281	0.53126	0.52941	0.52301	0.53039	0.52572	0.52152
12	0.53429	0.51632	0.53330	0.53164	0.52301	0.52806	0.52249	0.52329
13	0.17679	0.17574	0.17698	0.17735	0.17698	0.17727	0.17702	0.17719
14	0.62091	0.62444	0.62481	0.63136	0.62122	0.62834	0.63139	0.62483
15	0.54831	0.54785	0.56372	0.55794	0.54116	0.55088	0.55480	0.55502
16	0.64070	0.63993	0.65619	0.65607	0.63965	0.64921	0.64834	0.63967
17	0.48265	0.48550	0.48873	0.48900	0.47839	0.48542	0.49131	0.49201
18	0.51272	0.51193	0.52444	0.51925	0.50981	0.51043	0.50977	0.50724
19	0.36890	0.36869	0.37406	0.37058	0.36577	0.37093	0.36982	0.36993
20	0.33064	0.32821	0.32864	0.32841	0.32237	0.32893	0.32784	0.32582
21	0.68860	0.68913	0.68784	0.69386	0.68739	0.69371	0.69416	0.69120
22	0.37040	0.37269	0.37147	0.37501	0.37481	0.37576	0.37663	0.37630
23	0.73988	0.73227	0.74931	0.74882	0.73422	0.73916	0.74014	0.74034
24	0.35429	0.35593	0.35504	0.35781	0.35781	0.35862	0.35952	0.35927
25	0.74599	0.74541	0.76012	0.75056	0.73747	0.75152	0.74849	0.74880
26	0.72627	0.73064	0.73004	0.72851	0.72041	0.73263	0.73404	0.73515
27	0.63652	0.63739	0.64000	0.63957	0.63001	0.63768	0.64266	0.64674
28	0.32578	0.32786	0.32715	0.32841	0.32824	0.32963	0.33046	0.33090
29	0.59027	0.58752	0.60022	0.59448	0.58286	0.59052	0.59191	0.59501
30	0.63167	0.63075	0.64312	0.64268	0.63011	0.63740	0.63660	0.63000

Table 2: The result of ranking intelligence parameters for each patient

Rank DMU	Music.	Body	Math.	Visu.	Verb.	Inter.	Intra.	Natural.
1	5	6	1	2	7	3	4	8
2	8	7	5	4	6	3	2	1
3	7	6	4	1	8	5	2	3
4	5	7	6	1	8	4	3	2
5	7	6	1	2	8	3	4	5
6	6	7	1	3	8	2	5	4
7	7	6	1	2	8	3	4	5
8	5	6	1	2	7	3	4	8
9	7	6	4	5	8	3	1	2
10	2	8	1	3	7	4	6	5
11	4	7	1	3	6	2	5	8
12	1	8	2	3	6	4	7	5
13	6	7	5	1	5	2	4	3
14	8	6	5	2	7	3	1	4
15	6	7	1	2	8	5	4	3
16	5	6	1	2	8	3	4	7
17	7	5	4	3	8	6	2	1
18	3	4	1	2	6	5	7	8
19	6	7	1	3	8	2	5	4
20	1	5	3	4	8	2	6	7
21	6	5	7	2	8	3	1	4
22	8	6	7	4	5	3	1	2
23	5	8	1	2	7	6	4	3
24	8	6	7	4	5	3	1	2
25	6	7	1	3	8	2	5	4
26	7	4	5	6	8	3	2	1
27	7	6	3	4	8	5	2	1
28	8	6	7	4	5	3	2	1
29	6	7	1	3	8	5	4	2
30	5	6	1	2	7	3	4	8