Modeling Of Multiple Intelligence Theory With Bayes Theorem

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Abstract: - In this work, multiple intelligence theory proposed by Gardner, a professor of education at Harvard University, is tried to be modeled by Bayesian Theorem under two hypotheses. Howard Gardner initially formulated a list of seven intelligences, and then added two more. As a different approach, if set theory for multiple intelligences is used, the structure of multiple intelligences to set theory under four properties of intelligence algebra can be generalized. Assuming that the number of intelligences increases, n, Boolean algebra in set theory can be applicable. At this point, Bayesian theorem, application of conditional probability, generates a good structure for multiple intelligences. In this work, Bayesian Theorem was applied to two hypotheses, mutually intersections of n intelligences are empty and non-empty sets, and using conditional probability, it can be shown that multiple intelligences and Bayesian Theorem are in good harmony or multiple intelligences can be clarified by Bayesian theorem.

Key-Words: - Multiple intelligences, Bayesian Theorem, Modeling.

1 Introduction

Intelligence in old periods was rather defined as "speed thinking". Even, humans called people who exhibited superior success in daily life as "superior intelligence". Intelligence is the integration of abilities and skills peculiar to each person in order to be able to adapt to life and changes in the changing world. According to Binet, intelligence is the capacity of good reasoning, good judging and self-criticizing [1]. According to Wechsler, intelligence is the capacity used by an individual to behave purposeful, think intelligently and cope with his environment effectively [2]. According to Woolfolk, intelligence is the ability of an individual to use his inherited or learned mental functions to acquire knowledge, remember, recall, solve problems or adapt to world [3]. According to Piaget, intelligence is a definite harmonized behavior model that means organization of action with thought and its reorganization [4]. According to Gardner, intelligence is the integration of abilities and skills peculiar to each person in order to be able to live in the changing world and adapt to changes [5]. Gardner grouped intelligence in eight kinds; verbal, musical, visual, logical, mathematical, bodily, interpersonal, intrapersonal and naturalist. Thorndike grouped intelligence in three kinds; abstract, mechanical and social [6]. Guilford determined 120 intelligence factors. According to the Group Factor Theory of Thurnstone, intelligence can be divided into primary abilities in some definite number. "The primary ability" term contains seven factors; numeric problem solving, oral recognition, memorizing, general reasoning, oral smoothness (word producing etc), recognizing shape relations, sensitive speed. According to Stenberg, intelligence consists of various combinations. These are; experiencing and learning ability from life, abstract thinking or reasoning ability, adaptation ability to caprices of changing and unclear world, and fast performing ability of the works that must be performed and motivation ability [7]. While psychologists define intelligence as a capacity, educators define it as ability [8]. "Frames of mind": The theory of the multiple intelligences" (Thinking style: multiple intelligence theorem) suggested by Harward Gardner in 1983 eliminated the influence of intelligence on societies and education that lasted for years; that is the traditional intelligence test and intelligence definition that only considers the language and mathematic intelligence [9]. Gardner defended that intelligence has eight directions instead of two. So he claimed that not only the people who are successful in language and mathematic but also people who are successful in music, sport, dance, communication, nature, painting are intelligent [10].

2 Modeling of multiple intelligences

Intelligence is the capacity to solve problems in different cases experienced throughout of life and to create new products. For this reason, intelligence must be defined with clear dimensions as in mathematical operation. A mathematical operation requires

mathematics to establish a system and can be defined as a system in that matter as it ensures the features of system, so intelligence can also be defined with its clear dimensions. Gardner stated that each of abilities can not be considered intelligence and in order abilities can be defined as intelligence, 4 features must exist. These are:

1. to have a series symbols
2. to include a value in cultural structure (or to have value in society)
3. to be able produce a service or goods through its intervention (to make production through the ability used)
4. to be able to solve a problem inside it (to be able to produce solutions to problems included in the ability principle content it contains) In this case, 8 intelligence kinds defined by Gardner within such features can be evaluated separately from each other. They are defined as follows:

B_1 = Verbal/Linguistic Intelligence
B_2= Mathematical / Logical Intelligence
B_3= Visual/Spatial Intelligence
B_4= Musical/ Rhythmical Intelligence
B_5= Bodily/Kinesthetic Intelligence
B_6= Social/Interpersonal Intelligence
B_7 = Intrapersonal Intelligence
B_8= Naturalist Intelligence [11, 12, 13, 14, 15, 16]. However, if we consider intelligence as theoretical sets, we must accept that sets may be extended on condition they will have the above said features.

In that case, B_9, B_{10}, ..., B_n (n= finite) can be accepted as separate intelligences. Gardner explained in an article in 2003 that there were new intelligences and he worked on them [11]. According to the multiple intelligences theorem, an individual owns all the intelligences and uses them in some definite rates. Then, the total intelligence of an individual will be combination of B_1, B_2, ..., B_n intelligences.

$$U= B_1 \cup B_2 \cup B_3 \cup \cdots \cup B_n \quad (1)$$

Besides, each of intelligences is a separate ability having 4 features; situation of intelligences in respect to each other can be established on two hypotheses. First of them depends on the hypothesis that mutual intersections are empty set.

$$B_i \cap B_j = \{\} \text{ for } \forall\ i \neq j \quad (2a)$$

Second one depends on the hypothesis that mutual intersections are not empty set.

$$B_i \cap B_j \neq \{\} \text{ for } \forall\ i \neq j \quad (2b)$$

2.1 Hypothesis 1: For **B_1, B_2, ... , B_n intelligences of each individual,** $B_i \cap B_j = \{\}$ for $\forall\ i \neq j$.

The basic thought in hypothesis 1 is depended on the view of Gardner. Neuro psychology and development expert Garner who examined damaged brains after an accident or disease observed separate abilities that worked independently from each other in a manner when one of them was damaged others remained healthy. It was concluded that human brain consisted of different sections each having special functions. As a result of the research findings on mental disorders resulting from brain damages it was concluded that when some section of human brain was damaged, people could show performance in some definite fields and continued their life with the remaining sections of their brain. Losing of one of the abilities because of damage on brain or its isolation is independent from other abilities [17]. Depending on this thought, we can say that intelligences are separate from each other. As the intelligence levels in B_1, B_2, ..., B_n intelligences of different individuals will be different, for instance intelligence levels for X individual in age of k can be shown as $P(B_{k1})$, $P(B_{k2})$, $P(B_{k3})$,..., $P(B_{kn})$. Total intelligence of X individual in age of k is;

$$U_k= B_{k1} \cup B_{k2} \cup B_{k3} \cup \cdots \cup B_{kn} \quad (3)$$

And total intelligence level of x individual in age of k is;

$$P(U_k) = P(B_{k1}) + P(B_{k2}) + P(B_{k3}) +...+ P(B_{kn}. \quad (4)$$

If we try to explain the total intelligence level of X individual in age of k through Bayesian Theorem; whereas S indicates the total intelligence of x individual in age of k and P(S) indicates his intelligence level. His intelligence he used in each intelligence level will be $S \cap B_i$ and his intelligence level will be $P(S \cap B_i)$. Then, the total intelligence used by x individual in age of k is;

$$S = (S \cap B_1) \cup (S \cap B_2) \cup (S \cap B_3) \cup \ldots \cup (S \cap B_n) \quad (5)$$

his intelligence level is:

$$P(S) = P(S \cap B_1) + P(S \cap B_2) + P(S \cap B_3) + \ldots + P(S \cap B_n) \quad (6)$$

The individuals who are criticized with some definite intelligence level in the social evaluation (no numeric intelligence) are in fact considered with their intelligence levels they got from abilities not with the potential intelligences they own. That case is the part of intelligence level owned by X individual in age of k and the conditional probability is:

$$P(S/B_i)=\frac{P(S\cap B_i)}{P(B_i)} \quad (7)$$

This rate expresses which percentage is explained or which percentage is shown from B_i intelligence in total S intelligence used by X individual in age of k. Then, this demonstrated intelligence level is not the intelligence of individual but it is his B_i intelligence share in his S total. This event is shown with Venn diagram in Fig. 1.
Let's try to explain the above statement for B_3 intelligence by using Fig. 1. The rate of B_3 intelligence of individual in S total intelligence can be defined as the ratio of A(EFGH) to A(ABCD).

$$P(S/B_3)=\frac{A(EFGH)}{A(ABCD)} \quad (8)$$

If we reconsider the (7) equation that is the explanation of intelligence with conditional probability; the rate will be;

$$P(S/B_i)=\frac{P(S\cap B_i)}{P(B_i)} \quad (9)$$

If we draw $P(S\cap B_i)$ from that equation, it will be;

$$P(S\cap B_i)=P(B_i)P(S/B_i) \quad (10)$$

S indicates the total intelligence of X individual in age of k and P(S) indicates the measure of his intelligence. Then;

$$P(S)=\sum_{i=1}^{n}P(S\cap B_i) \quad (11)$$

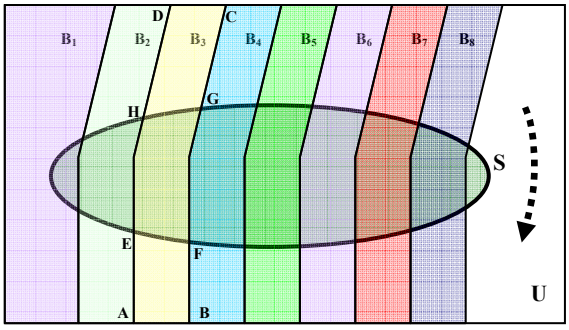

Fig.1 Indication of intelligences separately from each other

If (10) equation is written in place of (11) equation, then;

$$P(S)=\sum_{i=1}^{n}P(S\cap B_i)=\sum_{i=1}^{n}P(B_i)P(S/B_i) \quad (12)$$

Now, by considering the intelligences acquired from abilities, let's try to find the intelligence of individual belongs to only one of the abilities from the intelligence used by x individual in age of k. Total of intelligences owned by X individual in age of k belong to all the abilities he have was S. In case S is known, its share in B_i can be found with conditional probability in the following equation;

$$P(B_i/S)=\frac{P(S\cap B_i)}{P(S)} \quad (13)$$

If $P(S\cap B_i)$ is drawn from (13) equation, then;

$$P(S\cap B_i)=P(S)P(B_i/S) \quad (14)$$

If the equations (10) and (14) are equalized;

$P(S\cap B_i)=P(B_i)P(S/B_i)$ and $P(S\cap B_i)=P(S)P(B_i/S)$,

$$P(S)P(B_i/S)=P(B_i)P(S/B_i) \quad (15)$$

If $P(B_i/S)$ is drawn from here, then;

$$P(B_i/S)=\frac{P(B_i)P(S/B_i)}{P(S)} \quad (16)$$

This statement shows that Bayesian Theorem is compatible with the multiple intelligences or multiple intelligences can be explained with Bayesian Theorem. As in fact the intelligence level used by X individual in age of k consists of his abilities is different from his actual intelligence level, this supports that the intelligence suggested by Gardner can be changed and developed. When P(S) intelligence level can be extended, $P(B_i)$ intelligence level will also be extended.

Example: To be able to be a teacher, 25% B_1 intelligence, 30% B_2 intelligence, 10% B_3 intelligence and 35% B_4 intelligence are required. Mr. Kaya is known as a teacher. Mr. Kaya uses 2% of B_1 intelligence, 7% of B_2 intelligence, 5% of B_3 intelligence and 12% of B_4 intelligence. Mr. Kaya exhibits behavior like a teacher. What is the probability of such behavior that may result from B_3 intelligence?
Let's consider the behavior exhibited by Mr. Kaya is S.

$$P(B_3/S)=\frac{P(B_3)P(S/B_3)}{P(S)}$$

$$=\frac{P(B_3)P(S/B_3)}{P(B_1)P(S/B_1)+P(B_2)P(S/B_2)+P(B_3)P(S/B_3)+P(B_4)P(S/B_4)}$$

$P(B_1) = 0.25,\quad P(B_2) = 0.30,\quad P(B_3) = 0.10,\quad P(B_4) = 0.35,$
$P(S/B_1) = 0.02,\quad P(S/B_2) = 0.07,$
$P(S/B_3) = 0.05,\quad P(S/B_4) = 0.12,$

$$P(B_3/S) = \frac{P(B_3)P(S/B_3)}{P(B_1)P(S/B_1)+P(B_2)P(S/B_2)+P(B_3)P(S/B_3)+P(B_4)P(S/B_4)}$$

$$\frac{(0.10)(0.05)}{(0.25)(0.02)+(0.30)(0.07)+(0.10)(0.05)+(0.35)(0.12)}$$
$$= \frac{5}{73} = 0.0685$$

The probability of behavior exhibited by Mr. Kaya that may result from B_3 intelligence is 6.85%.

2.2 Hypothesis 2: For $B_1, B_2, ..., B_n$ intelligences of each individual, $\forall\ i \neq j$ için $B_i \cap B_j \neq \{\}$.

When we examine the principles of multiple intelligence theory;

- People have many different intelligence kinds.
- Each people have a special intelligence mixture consists of actively used intelligences. Each people have a peculiar intelligence profile.
- Each of intelligences has a different development process.
- All the intelligences are dynamic.
- Intelligences can be defined and developed.
- Each people have the chance to develop and recognize his own intelligence.
- Development of each intelligence can be evaluated within itself.
- Each of intelligence has a different system with respect to memory, attention, cognition and problem solving.
- While using one of intelligences other intelligences can also be used.
- Personal substructure, culture, heritage and beliefs have an effect on development of intelligence.
- All intelligences are different and special sources in way of realization of himself of each individual.
- All the scientific theories that evaluate human development support the intelligence theory.
- There may be intelligences different from the existing intelligence kinds.
- Of one of the statements above, the statement "While using one of intelligences other intelligences can also be used "means there are common values between two intelligences [18]. Intelligences generally work together by establishing confusing structures. Because none of intelligences in real life works alone except the idiots and brain damaged patients. Intelligences always in interaction. The eight intelligence kinds work together peculiar to each person [19]. From such statements we can say that intelligences can not be separated from each other.

As the intelligence levels of different individuals in their B_1, B_2, ..., B_n intelligences will be different, the intelligence levels of X individual in age of k can be shown as $P(B_{k1})$, $P(B_{k2})$, $P(B_{k3})$,..., $P(B_{kn})$. Total intelligence of X individual in age of k is;

$$U_k = B_{k1} \cup B_{k2} \cup B_{k3} \cup \cdots \cup B_{kn} \qquad (17)$$

Total intelligence level of x individual in age of k is

$$P(U_k) < P(B_{k1}) + P(B_{k2}) + P(B_{k3}) + ... + P(B_{kn}) \qquad (18)$$

If we try to explain the total intelligence level of X individual in age of k through Bayesian Theorem; whereas S indicates the total intelligence of x individual in age of k and P(S) indicates his intelligence level. His intelligence he used in each intelligence level will be $S \cap B_i$ and his intelligence level will be $P(S \cap B_i)$. Then, the total intelligence used by X individual in age of k is;

$$S = (S \cap B_1) \cup (S \cap B_2) \cup (S \cap B_3) \cup \ldots \cup (S \cap B_n) \qquad (19)$$

his intelligence level is,

$$P(S) < P(S \cap B_1) + P(S \cap B_2) + P(S \cap B_3) + \ldots + P(S \cap B_n) \qquad (20)$$

If we consider hypothesis 2 for two intelligences like B_1 and B_2 to explain the statement in simpler way, Fig.2 will establish.

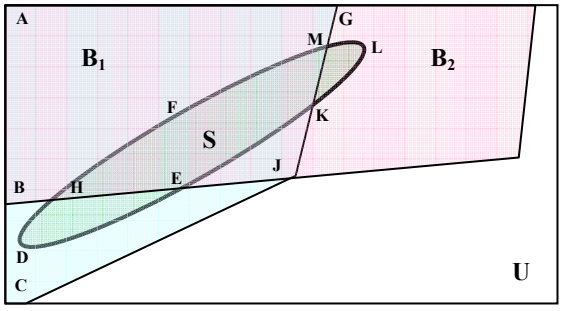

Fig.2 Indication of B_1 and B_2 intelligences

The rate of B_1 intelligence of an individual in his S total intelligence;

$$P(S/B_1) = \frac{P(S \cap B_1)}{P(B_1)} \text{ and } P(S \cap B_1) = P(B_1)P(S/B_1) \qquad (21)$$

If S is known, its share in B_1 will be found from the equation below.

$$P(B_1/S)=\frac{P(S\cap B_1)}{P(S)}=\frac{A(DEKMFH)}{A(S)} \quad (22)$$

If $P(S\cap B_1)$ is drawn from (22) equation, then:

$$P(S\cap B_1)=P(S)P(B_1/S) \quad (23)$$

Similarly, if S intelligence of individual is known, it shares in B_2 intelligence will be found as follows.

$$P(B_2/S)=\frac{P(S\cap B_2)}{P(S)}=\frac{A(HEKLMF)}{A(S)} \quad (24)$$

If we draw $P(S\cap B_2)$ from (24) equation, then;

$$P(S\cap B_2)=P(S)P(B_2/S) \quad (25)$$

As intersection of B_1 and B_2 intelligences is not empty, the intelligence level of intersection will be $P(B_1\cap B_2)=A(BJGA)$ and

$$P(S)=P[(S\cap B_1)\cup(S\cap B_2)]$$

$$P(S)=P(S\cap B_1)+P(S\cap B_2)-P(S\cap B_1\cap B_2)$$

If we show such intelligence levels as an area ;

$$P[(S\cap B_1)\cup(S\cap B_2)]=A(DEKMFH)+A(HEKLMF)-A(HEKMF)$$

If we equalize equations (21) and (23) , then; $P(S\cap B_1)=P(B_1)P(S/B_1)$ and $P(S\cap B_1)=P(S)P(B_1/S)$, then

$$P(S)P(B_1/S)=P(B_1)P(S/B_1) \quad (26)$$

If $P(B_1/S)$ is drawn from here, then;

$$P(B_1/S)=\frac{P(B_1)P(S/B_1)}{P(S)}=\frac{P(B_1\cap S)}{P(S\cap B_1)+P(S\cap B_2)-P(S\cap B_1\cap B_2)} \quad (27)$$

Now, let's try to explain in which percentage the intelligence of X individual in age of k consists of his existing abilities uses his total intelligence. The Venn diagram of intersections of B_1, B_2, ..., B_7, B_8, ... intelligences that are not empty is given in Fig. 3.

If we write (22) equation for any B_i, the following equation is found.

$$P(B_i/S)=\frac{P(S\cap B_i)}{P(S)} \quad (28)$$

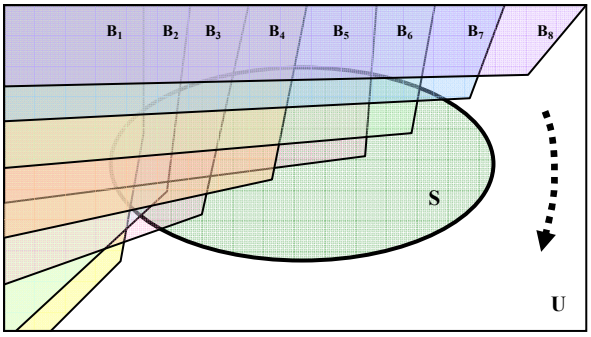

Fig.3 Indication of intelligences of which intersections are not empty

The difficulty here, as it can be seen in equation (22), is that there is no P(S). As the intelligences to be operated increase, the term number in calculation of P(S) will also increase. For example, for B_1 and B_2 intelligences, the term number in calculation of P(S) is $\binom{2}{1}+\binom{2}{2}=3$ and for B_1, B_2, B_3 and B4 intelligences, the term number in calculation of P(S) is $\binom{4}{1}+\binom{4}{2}+\binom{4}{3}+\binom{4}{4}=15$. Similarly, the term number necessary in calculation of P(S) for 8 intelligences is totally 245. In other words; the expression of

$$P(S)=P[(S\cap B_1)\cup(S\cap B_2)\cup(S\cap B_3)\cup.....(S\cap B_7)\cup(S\cap B_8)]$$

must be calculated. This means calculation will be very difficult.

Example: To be able to be an architect, 65% B_1 and 50% B_2 intelligences are required. Mr. Altan is known as an architect and can use B_1 and B_2 intelligences together in rate of 15%. Architect Mr. Altan exhibits a behavior for which he does not use 10% of B_1 intelligence and 5% of B_2 intelligence. What is the probability of that behavior that may result from B_1 intelligence?

Let's consider that behavior exhibited by Mr. Altan is S event.

$$P(B_1/S)=\frac{P(B_1)P(S/B_1)}{P(S)}=\frac{P(B_1\cap S)}{P(S\cap B_1)+P(S\cap B_2)-P(S\cap B_1\cap B_2)}$$

$$P(B_1/S)=.\frac{0{,}55}{0.55+0.45-0.15}=\frac{55}{85}=0.647$$

The probability of that behavior that may result from B_1 intelligence is 64.7%.

3 Conclusion

Although there are many applications of Bayesian Theorem in different fields in literature, such as business, engineering, marketing and so on, multiple

intelligence theory has not been modeled mathematically yet, even Bayesian Theorem. In this study, it is shown that multiple intelligence theory can be modeled mathematically with Bayesian theorem. It is also shown that the number of multiple intelligences is generalized to n. Depending on the hypothesis of Gardner that intelligences must be considered separate from each other, a modeling is made separated intelligences and depending on the hypothesis of Armstrong that intelligences always interacted from each other and eight different intelligences work together peculiar to each individual, a modeling for none-separated intelligences are made. While the modeling process of each of intelligences that is separate from each other is realized very clearly, modeling when intersections of intelligences are not empty requires great number of operations. The modeling is suitable for the intelligences to be established and also supports the statement given by Gardner in 2003 in the article that he continued his studies on multiple intelligences. As no clear opinion was made about which of the hypothesis that were discussed with the other academicians is definitely valid, both of hypothesis are included in the study.

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