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Review Article

New Approaches and Theories in Understanding Intelligence and Cognitive Ability Processes

Hatice YILDIRIM [a,*], Latif Gürkan KAYA [b]

[a] *Mekansal Planlama ve Tasarım Anabilim Dalı, Fen Bilimleri Enstitüsü, Burdur Mehmet Akif Ersoy Üniversitesi, Burdur, TÜRKİYE*

[b] *Peyzaj Mimarlığı Bölümü, Mühendislik Mimarlık Fakültesi, Burdur Mehmet Akif Ersoy Üniversitesi, Burdur, TÜRKİYE*

* *Sorumlu yazarın e-posta adresi: yildirim.tugba@hotmail.com*

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ABSTRACT

This article aims to provide a comprehensive framework for understanding the multifaceted nature of intelligence. The development of the concept of intelligence in the historical process, different theoretical approaches and assessment tools developed based on these approaches are discussed. Intelligence has attracted the attention of researchers throughout history due to its complex and multidimensional nature and has been examined by various disciplines from different perspectives. Approaches to the definition and measurement of intelligence have been discussed in a wide perspective ranging from ancient Greek mythology to contemporary scientific and philosophical frameworks. While intelligence was initially treated as one of the main topics of philosophy, with the development of psychology as a modern discipline in the mid-20th century, it has been the subject of extensive research in this field as well. Today, thanks to technological advances and advanced imaging techniques, it has also intersected with the field of neuroscience, enabling more in-depth studies on the biological basis of cognitive processes. So, what is the reason why intelligence cannot be defined at a common point? In this study, which answers this question, it is seen that intelligence is not only limited to individual cognitive capacities but also interacts with many variables such as environmental, genetic, psychological and sociocultural factors. A multidisciplinary approach to understanding the complex relationships between individual differences, genetic inheritance, environmental conditions and psychological processes is needed in intelligence-related research.

Keywords: *Cognitive Ability, intelligence, intelligence theories and classification, intelligence measurement methods*

Zeka ve Bilişsel Yetenek Süreçlerini Anlamada Yeni Yaklaşım ve Kuramlar

ÖZ

Bu makale, zekânın çok yönlü doğasını anlamak için kapsamlı bir çerçeve sunmayı amaçlamaktadır. Zekâ kavramının tarihsel süreç içerisindeki gelişimi, farklı kuramsal yaklaşımlar ve bu yaklaşımlara dayalı olarak geliştirilen değerlendirme araçları ele alınmaktadır. Zekâ, karmaşık ve çok boyutlu yapısı nedeniyle tarih boyunca araştırmacıların ilgisini çekmiş ve çeşitli disiplinler tarafından farklı bakış açılarıyla incelenmiştir. Zekânın tanımı ve ölçülmesine yönelik yaklaşımlar, Antik Yunan mitolojisinden günümüz bilimsel ve felsefi çerçevelerine kadar uzanan geniş bir perspektifte ele alınmıştır. Zekâ, başlangıçta felsefenin temel konularından biri olarak ele

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alınırken 20. yüzyılın ortalarında psikolojinin modern bir disiplin olarak gelişmesiyle birlikte bu alanda da kapsamlı araştırmalara konu olmuştur. Günümüzde ise teknolojik ilerlemeler ve gelişmiş görüntüleme teknikleri sayesinde nörobilim alanıyla da kesişmiş, bilişsel süreçlerin biyolojik temelleri üzerine daha derinlemesine çalışmalar yapılmasına imkân tanınmıştır. Peki zekânın ortak bir noktada tanımlanamamasının nedeni nedir? Bu soruya da cevap niteliğinde olan bu çalışmada görülmektedir ki zekâ, yalnızca bireysel bilişsel kapasitelerle sınırlı kalmayıp çevresel, genetik, psikolojik ve sosyokültürel faktörler gibi birçok değişkenle etkileşim içindedir. Zekâyla ilişkili araştırmalarda; bireysel farklılıklar, genetik miras, çevresel koşullar ve psikolojik süreçler arasındaki karmaşık ilişkilerin anlaşılmasına yönelik çok disiplinli bir yaklaşımın ele alınması gerekmektedir.

Anahtar Kelimeler: *Bilişsel Yetenek, Zeka, Zeka Kuramları ve Sınıflandırılması, Zeka Ölçme Yöntemleri*

I. INTRODUCTION

The word "genius", which was considered synonymous with the concept of creativity between the XVIIth and XXth centuries, was expressed by the word "genius" in English and Latin. Its original origin is the Greek word "ginesthai", which means "to come into existence out of nothing, to be born". Today, the word genius is used to refer to people with creative and extraordinary intelligence [1].

In the history of mankind, it is seen that issues related to intelligence were first addressed in Greek mythology and were considered as a part of philosophy at the end of the eighteenth century. In the XXth century, with the emergence of psychology as a science, it became one of the most important research topics of the period [2].

Sir Francis Galton (1822-1911) was one of the first researchers to study intelligence. Since he was the cousin of Charles Robert Darwin (1809-1882), the founder of the theory of evolution by natural selection, he was influenced by heredity studies and conducted studies on the inheritance of intelligence between individuals [2, 3, 4]. He argued that the differences between individuals are due to intelligence transmitted through heredity [3, 5] and did not focus on the relationship between intelligence and environmental factors [6].

II. INTELLIGENCE

A. DEFINITION OF INTELLIGENCE

Intelligence consists of the ability to understand, comprehend, associate, integrate, evaluate and interpret parts or information in the learning process [4, 7]. In the psychometric approach, one of the sub-branches of psychology, the definition of the concept of intelligence and the measurement of cognitive abilities related to intelligence are discussed. Different theories have been developed by researchers working in this field [8].

When traditional definitions of intelligence are examined, it is seen that the ability to adapt to the environment is emphasized rather than shaping the environment. Until the mid-20th century, it was stated by different philosophers that intelligence is the power to solve all kinds of problems. The first intelligence test was introduced by Binet in 1908. Binet described intelligence as the ability to adapt to the environment and to judge [9].

The editors of the "Journal of Educational Psychology" organized a symposium in 1921 by inviting 14 scientists who were experts in their fields to work on the definition of intelligence in a common framework, theories about intelligence and how intelligence can be measured [10, 11]. Most of the conceptual definitions of intelligence produced as a result of this symposium are different from each other. In the definitions of intelligence, learning capacity and the ability to adapt to the environment were emphasized. The same study was conducted again by Sternberg and Detterman (1986) [12] with

24 researchers who were experts in their fields [5, 11, 13]. Unlike the first study, the concept of "metacognition" was included in the definition of intelligence in addition to learning capacity and adaptation to the environment [2, 5].

B. THEORIES AND CLASSIFICATION OF INTELLIGENCE

Theories of intelligence have been a core subject of psychology and brain sciences, aiming to understand the diversity of intellectual abilities and the neurobiological mechanisms underlying these abilities. Various theories have been proposed over the years to explain nature and structure of intelligence.

Since many researchers from different disciplines have been working on the subject from past to present, independent qualities have been put forward in the definition and theories of intelligence. The biggest reason why intelligence cannot be defined on a common axis and has become a subject of debate is that it is influenced by social, environmental or genetic external factors and is multifaceted. The field of study of the researcher who developed the definition of intelligence, the environment in which the researcher lived and the cultural characteristics of the period in which the researcher lived are other factors affecting the concepts related to intelligence [5].

In his study, Gardner (2011) [14] analyzed many theories about intelligence and based on the information contained in these theories, he determined the following three most commonly used characteristics of intelligence;

- ✓ Learning capacity: The capacity of the individual to benefit from the training provided,
- ✓ The sum of learned knowledge: All the concepts and information learned within one's own abilities,
- ✓ Adaptability to the demands of the environment: The ability to successfully adapt oneself to one's environment and the changes in it.

Theories of intelligence are generally analyzed in four subgroups (Figure 1).

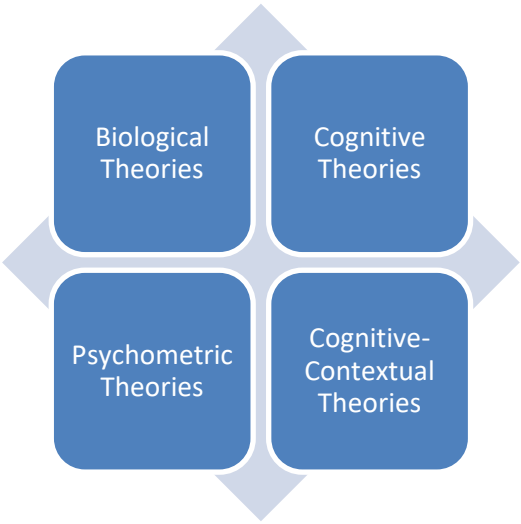

Figure 1. *Theories of intelligence [14]*

Psychometric theories try to analyze the structure of intelligence in general. Charles Spearman, one of the pioneers of theory, developed intelligence models for both children and adults. He showed that individuals with high mathematical and spatial skills but weak verbal skills can also have high general intelligence. In the intelligence model developed by Charles Spearman, there are two basic components: the s-factor and the g-factor. Specific factors related to a person's experiences or skills in a particular field are the s-factor. The concept that expresses a general measurement of intelligence is the g factor [15]. In the psychometric approach, it is argued that the higher the performance of a person above the

calendar age, the higher the level of intelligence. For this purpose, intelligence age and calendar age calculations are made in the evaluation of intelligence [13]. Since statistical methods such as correlation and factor analysis are used in these calculations, they are considered within psychometric theories [5, 16].

In cognitive theories, in which the processes of intelligence are examined, it is argued that the processes of using intelligence are realized faster and more effectively in intelligent people. The pioneers of this theory are Piaget (1972) [17], Vygotsky (1978) [18], Feuerstein (1980) [19] etc.

Piaget (1972) focused on the maturation of intelligence over time as a result of its interaction with the environment rather than individual differences in intelligence studies [5]. Vygotsky (1978), one of the pioneers of cognitive theory, stated that cognitive development is primarily influenced by the family environment and the first education provided by the immediate environment. For this reason, he believes that if the child does not receive adequate support in the family environment where he/she receives his/her first pre-school achievements, he/she will not be successful in the future [18].

The theory that deals with the relationship between environmental contexts and cognitive processes is Cognitive-contextual theories [11]. In this theory, environmental and cultural factors are needed in addition to cognitive processes for the acquisition of various skills [16]. Examples of cognitive contextual theories are Robert Stenberg's "Successful intelligence theory" and Howard Gardner's "Multiple intelligence theory" [2, 5].

Biological theories are not related to the structure, components and information processing processes of intelligence that the other three theories emphasize. It argues that the brain structure and functions should be examined in order to fully define intelligence [5, 14]. In other words, the ability that is characterized as IQ and tried to be measured by intelligence tests depends on the prefrontal cortex (PFC) and neocortex performance of the brain [2, 11]. Unlike traditional theories of intelligence, other theories in the literature in the historical process are summarized below.

B. 1. Charles Spearman Dual Factor Theory (Two Factor Theory)

In 1904, Spearman found a significant correlation in the test results of a group of students in different courses and developed the factor analysis method. In his other studies, he characterized intelligence as the ability to achieve success in different fields. He states that in studies that require a mental focus, it is necessary to have both general ability and a special ability required for this study. While different cognitive tasks are performed within the mental skill factor, specific factors include specialized mental skills in mathematics, verbal or mechanical fields. Of these two abilities that make up intelligence, "general ability", i.e. "general ability", is called "g", while "special ability", i.e. "special ability", is called "s" [20, 21]. According to Charles Spearman, an individual's general intelligence level can be assessed by measuring general ability. In the graphical model proposed by Guilford in 1953, the "g" factor is depicted as a large central circle, while the "s" factors are presented as small circles arranged around this center (Figure 2). Each ellipse symbolizes a mental test. The intersection ratio of the ellipses with the "g" factor expresses the dependence of the tests on the "g" factor. According to the basic inferences of the model, tests a and b in Figure 2 are highly correlated since they share the "g" factor to a great extent. On the other hand, since tests a and c have a low level of "g" domain, the correlation between them is quite low. In this context, Spearman defined the underlying element of intelligence as the "general factor" (g) and suggested that differences in intelligence between individuals are largely determined by the amount of "g" possessed [22].

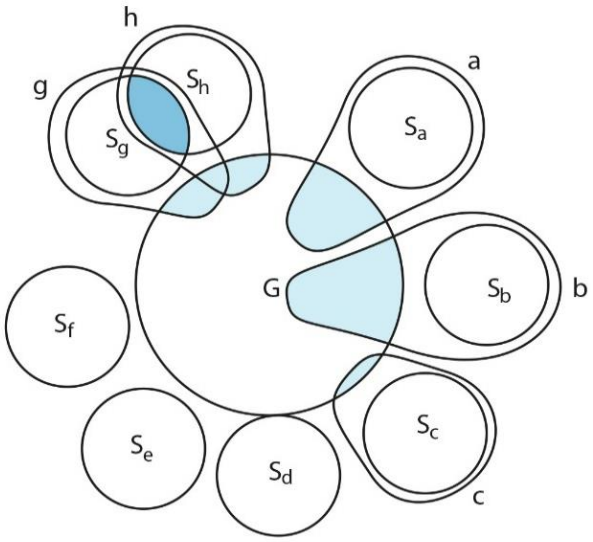

Figure 2. *Graphical Representation of the Group Factor in Spearman's Two-Factor Theory (Guilford, 1953, p.475; re-visualized by the authors) [22]*

Inspired by these theories developed to measure general intelligence level, the Standford Binet Intelligence Test was developed in 1916 and the Raven Standard Progressive Matrices Test was developed in 1947 [23].

Charles Spearman, who argues that intelligence is positively correlated with many concepts, shows that intelligence does not originate from a single source but from a multi-structured and complex brain structure, although it has been criticized by researchers [24].

B. 2. Multifactor Theory (Multiple Factor Theory)

According to the Multifactor Theory (MFT), intelligence is not a single dimension but a multi-dimensional structure. Edward L. Thorndike (1909) [25], one of the pioneers of this theory, states that subcomponents such as intelligence level, intelligence breadth and intelligence speed, which reveal the multidimensional structure of intelligence, should be measured in order to measure intelligence capacity [26, 27]. Thorndike divided intelligence into three as abstract, practical (mechanical) and social (social). The ability to think using symbols refers to abstract intelligence; the ability to use machines, devices or tools refers to practical (mechanical) intelligence; and the ability to establish successful interpersonal relationships in the social environment refers to social intelligence [28].

B. 3. Mental Abilities (Group Factor) Theory

Thurstone (1887-1955), in his studies conducted with his students at the University of Chicago, revealed that intelligence is multidimensional according to the results of factor analysis [29]. Thurstone found twelve factors and named seven different main mental factor areas. These are word fluency, numerical ability, verbal comprehension, perceptual speed, memory, visual ability, deductive and inductive reasoning [26].

B. 4. Cattell-Horn-Carroll Theory

The theory was introduced by Cattell in 1943 and later updated by his student Horn. The Cattell-Horn-Carroll Theory was formed by combining Cattell and Horn's theory of fluid and crystallized intelligence with Carroll's three-tier theory (30). According to the Cattell-Horn-Carroll Theory, intelligence is divided into Fluid Intelligence and Crystallized Intelligence (31). Fluid intelligence is the intelligence inherited from our ancestors through our genes and is the ability to solve problems independently of the

environment. Crystallized Intelligence, on the other hand, is the body of knowledge gained as a result of environmental and cultural interactions and varies according to how effectively the person can use these gains [32].

Cattell emphasizes that fluent intelligence is related to neural and biological processes in the brain and states that fluent intelligence plays an important role as the neural substructure of learning. Therefore, it can be said that fluent intelligence is directly influenced by genetic factors. Although crystallized intelligence is not directly affected by genetic factors, it is thought to be indirectly affected in the development of social and cultural aspects of fluent intelligence [33].

This theory is one of the basic theories on which many IQ tests are based today. It is also emphasized that the Cattell-Horn-Carroll theory is a bridge between theory and practice [34, 35].

There are three main factors in the structural model of the theory: fluid intelligence, crystallized intelligence and general intelligence factor (g). These factors are then divided into sub-factors in the second and third layers. For example, the fluency factor consists of the sub-factors processing speed, processing capacity and processing flexibility. The crystallized intelligence factor is divided into sub-factors such as language skills, vocabulary and general culture. There are 84 first-order factors in the theory [36, 37].

B. 5. Vernon's Hierarchical Theory

British psychologist Philip Vernon (1961) proposed that intelligence is a set of skills that differ in various dimensions. Intelligence is divided into 4 different levels of ability. Level 1 is the highest level and relates the differences between individuals to Spearman's 'g' for general intelligence. The next level, level 2, is divided into the main group factors of practical, mechanical and physical abilities, which include abilities such as abstract-numerical, mechanical knowledge, and understanding of spatial relationships. Level 3 includes minor factors. At the 4th level, which is the lowest level, specific characteristics “s” are included [27, 38].

B. 6. The Structure of Intelligence Theory

The Structure of Intelligence Theory was developed by Guilford with the development of Thurstone's theory of mental abilities. According to the structure of intelligence theory, intelligence consists of three basic dimensions: operations, contents and products. According to Guilford (1967) [39], operations are divided into five components, content into four components and product type into six components. These sub-components can be combined with each other in different combinations to create different capabilities [40]. When all combinations are cross classified, 120 different factors are formed [2].

B. 7. Levels of Cognitive Functioning (LCF)

Reuven Feuerstein's “Levels of Cognitive Functioning” (LCF) theory was first developed by Feuerstein in the late 1950s and expanded with new studies in the 1960s and early 1970s. LCF theory states that there is a continuity in the development of cognitive functions and how individuals' cognitive functions can be used in the learning process thanks to this continuity. LCF theory defines different levels of the human mind and identifies the characteristics of mental functions at each level. According to the theory, the development of mental functions is a result of environmental factors and learning rather than innate potential. In LCF theory, there are six levels of mental functions [19]:

- ✓ Detection
- ✓ Attention
- ✓ Memory
- ✓ Logical thinking
- ✓ Abstraction

- ✓ Processing speed

Each of these levels builds on the development of previous levels and forms the basis for the development of the next level. For example, individuals at the perception level must first learn to recognize the stimuli around them to move to the attention level. LCF theory is designed to improve the mental functions of individuals by using it in education and learning processes. The aim of the theory is to increase the learning potential of individuals and to help them use their mental functions more efficiently [19].

B. 8. Multiple Intelligence Theory

The Theory of Multiple Intelligences, proposed by Howard Gardner in 1983, claims that intelligence is basically a result of problem solving and creating products in a rich environment. According to Gardner (1983) [41], intelligence is too complex to be explained by a single factor and can consist of many different areas. Therefore, intelligence cannot be measured objectively with specific instruments. Gardner (1983) defined seven different dimensions of intelligence in his book "Frames of Mind". In his 1999 publication "Intelligence Reframed", he divided intelligence into eight different types by adding a new dimension of intelligence: logical-mathematical intelligence, verbal-linguistic intelligence, visual-spatial intelligence, musical-rhythmic intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence, social intelligence, and naturalistic intelligence [16].

B. 9. Piaget's Theory of Intelligence

In accordance with the values of the period, Piaget defines intelligence in general as "the ability to know" [17]. Calling his theoretical framework "genetic epistemology", Piaget points to the developmental characteristics of the individual, while epistemology provides a framework for determining the nature, scope and validity of knowledge. With this approach, Piaget emphasized that intelligence has a biological dimension and argued that intelligence is also related to logical processes [42, 43].

Piaget often mentioned the concepts of assimilation, accommodation and schema when explaining intelligence and knowledge. Assimilation and adaptation are seen as complementary functions that emerge depending on the interaction of the organism with the environment [43]. Assimilation can be defined as the process of internalizing information in general. When the organism encounters a new situation, it explains this situation using its existing schemas. These schemas are the structures that the organism creates to make sense of the environment and they develop with experiences. Adaptation is an innate skill and the organism achieves success by trying to adapt to the environment with the schemas it has formed [2, 17, 42, 44].

Although Piaget agrees with other psychologists such as Spearman on the existence of a single general phenomenon of intelligence, he argues that intelligence acquires a general form by passing through certain stages of development. These stages are: Sensory Motor Period, Preoperational Period, Concrete Operations Period and Abstract Operations Period [2, 5, 17, 44].

B. 10. Starfish Theory

In the theory developed by Tannenbaum (1983) [45], five traits related to intelligence are expressed by likening them to starfish. The characteristics at the five ends of the starfish predict the formation of intelligence. These five characteristics are general ability, distinctive special ability, environmental factors, chance factors and other non-mental factors [21, 46]. General ability refers to the area of ability that can be measured by standardized intelligence tests and is used to determine individual differences. Special talent, on the other hand, refers to an individual's superior abilities in a specific field: painting, music, mathematics, etc. These special talents often emerge at an early age and are discovered by their environment. Environmental factors refer to the areas of intelligence that are influenced by an

individual's immediate or distant environment. The luck factor is related to coincidences in life and refers to factors that help potential intelligence to emerge. Other non-mental factors refer to areas such as dedication to work, volunteerism, and self-belief independent of mental factors [46, 47].

B. 11. Differential Giftedness and Giftedness Theory

Gagne (1985) [48], stated that giftedness and giftedness are different concepts. According to the Differential Giftedness and Giftedness Theory, giftedness includes natural abilities based on biological and genetic foundations. He stated that it is innate, transmitted to future generations through hereditary ways and manifested in at least one field. Giftedness, on the other hand, consists of skills developed in a field [49, 50].

Gagne (2000) [51], adopts the idea that the transformation of giftedness into giftedness occurs as a result of a complex process. This theory points to a stage in which the potential of giftedness is transformed into giftedness and performance emerges. While the theory assumes that every gifted individual is gifted, it focuses on the fact that not every gifted individual may be gifted [21].

According to the theory, there are four different areas of giftedness and talent, such as intellectual, creative and sensory areas. However, certain catalysts are required for giftedness to transform into giftedness. These catalysts consist of various factors such as individual factors, environmental factors and chance factors [51].

B. 12. Successful Theory of Intelligence (Triarchic Theory of Intelligence)

In Sternberg's theory of intelligence put forward in 1985, there are three types of intelligence: analytical, creative and practical intelligence [52]. Analytical intelligence includes processes such as logical thinking, reasoning and comparison. Creative intelligence refers to the ability to cope with new situations and to produce extraordinary solutions to problems. Practical intelligence is the use and application of analytical and creative intelligence in daily life [53].

In what Sternberg (1985) [54] calls the Theory of Successful Intelligence, intelligence is divided into three different reasoning processes. Analytical thinking skills, problem solving skills and practical thinking skills are included in the theory that examines intelligence in analytical, synthesizing and practical aspects [55]. Analytical intelligence can be measured by traditional intelligence tests. Creative intelligence includes learning from lifelong experiences and creative thinking skills. Practical intelligence helps the individual to adapt to the socio-cultural environment [8, 56].

Sternberg argues that individuals who can use these three different reasoning processes can be more successful in life [2, 57]. It is emphasized that individuals can achieve success not only in one field of intelligence but also in different combinations of all fields. It is stated that individuals who become prominent in only one field of intelligence may have difficulty in making themselves accepted [2, 58].

Sternberg (1985) put forward his theory, which he called the Successful Intelligence Theory, by suggesting that intelligence is divided into three different reasoning processes. Also known as the Triple Right Foot Theory, it examined intelligence in analytical, synthetic and practical aspects [55]. In the first reasoning process, logical and analytical thinking skills can be used and measured with traditional intelligence tests. The second process includes problem solving, learning from lifelong experiences and creative thinking skills. The third reasoning process consists of practical thinking skills and helps the individual adapt to his/her social and cultural environment and surroundings [8, 56]. Sternberg argues that individuals who use these three different reasoning processes can be more successful in life [2, 57].

B. 13. Triple Circle Model

Following his intelligence studies, Renzulli (1986) [59] developed a theory called the triple circle model. In this theory, he categorized gifted individuals as those who are at the intersection of creativity, motivation (task commitment), and above average general or special abilities [60].While general ability includes abstract thinking, word fluency, memory and reasoning skills, special ability includes above-average ability in specific areas such as painting, music, dance, mathematics and language acquisition. The creativity component refers to an individual's different, innovative and out-of-the-box thinking [61]. Creativity also includes processes that bring originality. Motivation, on the other hand, covers areas other than direct mental functions such as dedication to a task, willingness to undertake a task and patience. According to this theory, a certain level of interaction between these three clusters must take place to achieve superior achievement. For an individual to meet the criteria of superiority, he/she must be 85% more successful than 85% of his/her peers in all these areas and at least 98% more successful than his/her peers in one cluster [62].

B. 14. Pentagon Theory

The theory was proposed by Sternberg and Zhang (1995) [63] and is based on the idea that the use of IQ score alone in determining intelligence is insufficient [46]. Each corner of the pentagon shape, which gives its name to the theory, is evaluated as extraordinary, rarity, evidence, productivity and value criteria [63].

According to this theory, the concept of exceptionalism requires the individual to be different and unique from society. In the concept of exceptionalism, the individual is expected to make a difference in terms of mental capacity. The criterion of rarity means that the individual has rare talents. The criterion of productivity means that the individual should produce a unique product in the areas in which he/she has talent. Evidence criterion can be defined as the proof and acceptance of these cognitive characteristics of the individual [63].

C. METHODS OF INTELLIGENCE MEASUREMENT

Tests have been developed for different age groups to measure intelligence. An intelligence scale is defined as a series of questions and problems prepared to measure intelligence [64]. The tests and methods developed to measure intelligence are listed below.

C. 1. Porteus Labyrinths Test

Porteus Labyrinths Test is a performance-based intelligence test developed by Porteus to determine an individual's planning and adaptation skills to innovations. It is administered using only paper and pencil [65]. It was adapted into Turkish by Toğrol (1974) [66]. The test, which is used to evaluate the practical analytical thinking skills of children between the ages of 7 years and 3 months and 15 years, consists of 13 mazes and the person is expected to plan the path to be followed and reach the exit without error [67]. The difficulty level of the test increases towards the 13th maze. The test is administered by certified testers who receive special training [8].

C. 2. Catell 2A Intelligence Test

The other test used to measure intelligence was developed by Cattell and adapted in Turkey by Toğrol (1974) [66].The test, which consists of a total of 50 questions, is administered individually or as a group to individuals aged 14 and over. The administration time of the test is approximately 25 minutes and consists of 4 subscales [8]. During the application period, a series of shapes are given in each scale and it is asked to find the shape that should continue the series or the shape that breaks the series. A score of “1” is received for each question answered correctly and the individual's intelligence score is

calculated by converting the total score. The correlation coefficients of the 2A and 2B forms of the test are above 0.50 [67, 68].

C. 3. Kaufman Brief Intelligence Test (KBIT)

The first version of the Kaufman Brief Intelligence Test (KBIT) consists of verbal (Verbal Knowledge and Puzzles-Vocabulary) and non-verbal (Reasoning Squares) subscales [69]. The vocabulary test, which represents the verbal part, is divided into two subscales: "Part A: Expressive Vocabulary" and "Part B: Definitions". In the verbal knowledge part of the test, the person is shown different visuals (e.g. planet, t-ruler, tennis, etc.) and asked to vocalize them aloud. In the definitions section, the test taker is given various clues and asked to correctly complete the missing word. The test taker is given a clue to define the word (e.g., it is a material used in construction) and a version of the word with some letters missing (e.g., concrete) and is expected to give the correct answer. In order to measure crystallized intelligence as defined by Horn and Cattell (1966) [70], the focus is on language skills and general knowledge acquired through schooling. "Section B: Definitions" section requires literacy skills. Therefore, it can be administered to people at least eight years of age and older. The "Reasoning Squares" subtest, which aims to measure fluent intelligence (nonverbal abilities and immediate problem solving ability), includes abstract patterns and various pictures [71]. In the "Reasoning Squares" subtest, individuals are asked to select the one that is related to the stimulus picture among various pictures shown to them. The first version of the KBIT was translated into Turkish by Savaşan (2006) [72] as part of his master's thesis [73]. Its standardization for Turkey was carried out by Öktem and Uluç within the scope of a project conducted by the Department of Special Education of the Ministry of National Education. It has been stated that it is suitable for both educational, research and clinical evaluation purposes [74].

The test can be administered to people between the ages of 4-90 years and 15-30 minutes should be given according to different age groups. The test can be administered by educators and trained individuals, and formal training is required for the interpretation of test scores [75; 76].

C. 4. Kaufman Brief Intelligence Test - Second Edition (KBIT-2)

The Kaufman Brief Intelligence Test - Second Edition (KBIT-2), which can be administered to individuals between the ages of 4-46, consists of verbal (Verbal Knowledge and Puzzles) and non-verbal (Reasoning Squares) subscales. The administration time of the test varies according to different age groups and lasts between 15-30 minutes [77]. The second version of the test, the first of which was developed by Kaufman and Kaufman in 1990, was published in 2004 [75; 78]. In the second version of the test, individuals are given various visuals and asked to express them aloud, solve puzzles, find the correct visual and find the results associated with the visual stimuli. The test was standardized for Turkey by Öktem and Uluç as part of a project conducted by the Ministry of National Education, Department of Special Education. It was stated that it is suitable for both educational, research and clinical evaluation purposes [74]. The internal consistency coefficient of the test varies between 0.93-0.96; the half-test reliability coefficient varies between 0.95-0.97. It can be used for education, research and clinical evaluation purposes [68, 74].

C. 5. Wechsler Adult Intelligence Scale-Revised Form (WAIS-R)

The Wechsler Intelligence Scale for Adults provides a measure and assessment of the intellectual structure and development of adults aged 16-94. The test is administered individually. It is an intelligence test that evaluates 2 sub-domains (verbal and performance), consists of a total of 11 subscales (General Knowledge, Picture Completion, Number Sequence, Vocabulary, Picture Arrangement, Patterning with Cubes, Arithmetic, Piece Assembly, Judgment, Cipher and Similarities) and takes approximately 1.5-2 hours to administer. The verbal section includes general knowledge, arithmetic, number repetition/number sequence, similarities, and reasoning subtests. The performance section includes picture arrangement, pattern with cubes, picture completion, cipher and piece

combination tests. Three types of intelligence scores are calculated: verbal, performance and total. The first version of the scale was developed by Wechsler in 1939 [77].

Preliminary studies on the standardization of the Wechsler Adult Intelligence Scale Revised Form (WAIS-R) in Turkey were conducted by Sezgin, Baştuğ, Yargıcı Karaağaç, and Yılmaz. The Cronbach-Alpha reliability coefficient of the verbal subscales was between 0.78-0.91; the Cronbach-Alpha reliability coefficient of the performance subscales was between 0.69-0.84; and the Cronbach-Alpha reliability coefficient of the total intelligence section was 0.84. Inter-rater reliability coefficients are also between 0.59-0.99 according to subscales [77].

C. 6. Raven IQ Test

The Raven test was developed by John C. Raven in England in 1936 (79). Raven's Progressive Matrices, simple form or Raven's Matrices, are classified as non-verbal IQ tests used for educational purposes. These tests are among the most comprehensive and widespread tests that can be used in a wide range of age groups, from five-year-old children to elderly individuals [80].

Raven's Advanced Progressive Matrices is a special form of the Raven Matrices test designed specifically to distinguish above-normal intelligence levels. This test is designed as two sets of questions in two different booklets. The first booklet consists of 12 questions designed to distinguish between different levels of intelligence among individuals. The second booklet contains 36 questions designed to distinguish individuals more clearly.

All questions in the second booklet are in the form of rectangular matrices consisting of three columns and three rows and containing organized figures and visuals. The last cell of this matrix is always left blank. The content of the figures in the other eight cells is based on certain abstract rules. The tested individual guesses the content of the ninth cell by discovering these rules through trial and error. Six to eight optional answers are designed for each question (Figure 3).

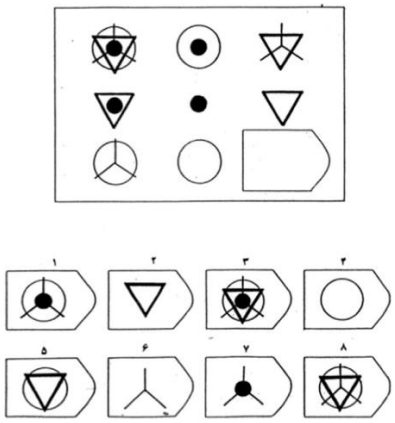

Figure 3. *An example of Raven's progressive matrices [81]*

This test form assesses the individual's abstract reasoning ability, especially the ability to solve/guess the relationship between the components of each question, to identify the basic rules by which the cells are structured, and to recognize the correct answer using these rules [81, 82].

C. 7. Cognitive Ability Measurement Test

Yıldırım (2023) [83], in his Ph.D. thesis entitled "Cognitive Ability-Creativity Relationship in Interior Design and Landscape Architecture Programs and the Effects of Education on Creativity," developed a "Cognitive Ability Measurement Test" to measure cognitive ability in the field of design. In the test designed to assess cognitive ability, coded questions consisting of number and letter sequences,

reasoning square questions, operation and problem questions, visual puzzle questions, weighting questions, numerical and verbal logic questions, three-dimensional (cube) questions, and two-dimensional shape questions were used (Figure 4). Each question is worth 4 points (Table 1) [83].

Table 1. *Cognitive Ability Test content analysis [83]*

	QUESTION TYPES	QUESTION NUMBERS WITHIN THE TEST	OBJECTIVES
COGNITIVE ABILITY MEASUREMENT CONTENT ANALYSIS OF TEST	Number of Sequence Questions	1st, 2nd, and 13th Questions (Total: 3 Questions)	• Visual Perception and Attention • Processing Power • Detailing
	Letter Sequence Questions	7th Question (Total: 1 Question)	• Detailing Through Clues • Detailing • Visual Perception and Attention
	Logical Reasoning (Square) Questions	12th Question (Total: 1 Question)	• Associating Moving Parts
	Operations and Problem Questions	5th and 8th Questions (Total: 2 Questions)	• Processing Ability • Measuring Problem-Solving Skills
	Weight Questions	6th Question (Total: 1 Question)	• Processing Ability • Ability to Form Equations
	Visual Puzzle Questions	4th and 14th Questions (Total: 2 Questions)	• Solving Encoded Visuals Related to Various Shapes • Visual Judgment • Measuring Visual Perception and Attention
	Verbal and Numerical Logic Questions	Numerical Logic Questions: 20th and 21st Questions Verbal Logic Questions: 22nd, 23rd, 24th, 25th Questions (Total: 6 Questions)	• Measuring Thinking Skills and Solving Problems Within Given Time Limits Through Verbal and Numerical Logic Questions
	Three-Dimensional Thinking (Cube) Questions	3rd, 16th, 17th, and 18th Questions (Total: 4 Questions)	• Three-Dimensional Thinking, Perception, and Visualization Ability
	Two-Dimensional Shape Questions	9th, 10th, 11th, 15th, and 19th Questions (Total: 5 Questions)	• Two-Dimensional Thinking, Perception, and Visualization Ability on a Surface

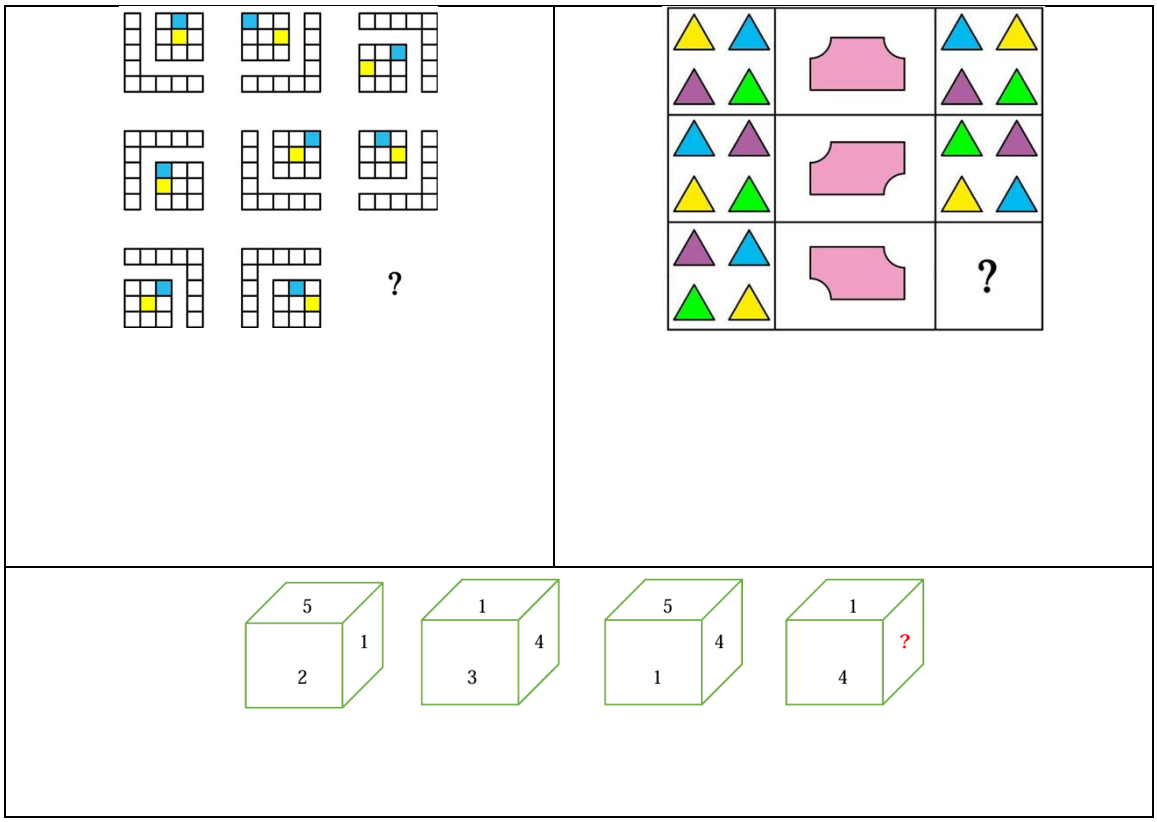

Figure 4. *Sample questions from the Cognitive Ability Assessment Test [83]*

III. CONCLUSION

In conclusion, the concept of intelligence has been analyzed from different perspectives by different disciplines throughout history and has evolved in line with scientific developments. While philosophers have treated intelligence as an abstract concept since ancient times, with modern science, disciplines such as psychology, neuroscience, and cognitive science have begun to study intelligence in a more systematic and measurable way. Francis Galton initiated the first systematic studies of intelligence in the context of individual differences and integrated statistical methods into the measurement of intelligence. Later, Alfred Binet and Theodore Simon developed the Binet-Simon Scale to assess children's cognitive development, laying the foundation for modern intelligence testing. Lewis Terman revised this scale as the Stanford-Binet Test and introduced the concept of IQ into intelligence measurement.

In terms of theories of intelligence, Charles Spearman's theory of general intelligence (g factor) suggests that intelligence consists of a single general factor, while Howard Gardner's theory of multiple intelligence argues that individuals have different types of intelligences. Robert Sternberg, on the other hand, evaluated analytical, creative, and practical intelligence together in his Triadic Theory of Intelligence. The work of these scientists played a critical role in understanding the nature of intelligence and shaped the methods used to assess intelligence.

Scientific developments in measurement techniques have also shaped intelligence research. From the first psychometric tests used to understand cognitive processes to the neurological techniques used today, such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). Modern research takes a more holistic approach, seeking to understand the effects of genetic inheritance, environmental factors, and individual experience on intelligence.

Using the scientific method, intelligence research has progressed through stages of hypothesis development, experimental testing, data analysis, and interpretation of results. This process, which began with philosophical inquiry in the early days, has been supported by experimental methods, strengthened by statistical analysis, and reached a more objective point with advanced imaging techniques today. However, the exact definition and measurement of intelligence is still the subject of ongoing scientific debate. Future interdisciplinary research will contribute to a more comprehensive understanding of intelligence and bring new dimensions to its applications in fields such as education, health, and artificial intelligence.

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