Abstract
This paper reviews the reason for differences in cognitive ability, and how they influence individual’s problem solving skills. It is obvious and undisputable that people think, reason, act, and make decisions differently. Whatever is responsible for this different propensity in intelligence may also be responsible for the discrepancies in problem-solving techniques as well as individual functionality. For example, some people are smart, gifted, creative and talented, while others are inept, unimaginative and dull. Even among identical twins, differences in their problem-solving skills are readily and unmistakably noticed. Can this be attributed to biological, genetic or environmental factors? Researchers are overwhelmingly divided on this issue. However, the component process theory focuses on the human mental developmental processes as major determinant of the possible reason for the differences in cognitive abilities. This paper explores and synthesizes how our knowledge of the component process theory would help clinicians in their prognosis, diagnosis, and treatment of mental or emotional disorders.

Keywords: Nature/Nurture, Cognitive development, Intelligence, Contextual sub-theory, Experiential sub-theory'

Introduction

1 Cyriacus C. Ajaelu, PhD, CHES, MS, MFTh is a Catholic priest, clinical neuropsychologist with specialization in Behavioral Medicine, a public health researcher and trainer, executive clinical director with Mental Health Initiative for Africans in Crisis (MHI International) and the founder of Medical and Behavioral Health Initiative (MHINigeria).
Describe the component process theory of cognitive development. According to this theory, describe mental processes necessary in problem solving mechanism. The word cognition comes from the Latin words to know, which studies the epistemological maturation or the mental activities involved in acquiring and processing information (Kellogg, 1999, p. 4; Tavris & Wade, 1997). The cognitive process addresses issues in thinking, intelligence, memory, language, learning, knowledge representation, consciousness, perception, and method and techniques of acquiring new information. The cognitive processing ability is a multidisciplinary study that involves the fields of cognitive psychology, neuropsychology, psycholinguistics and evolutionary biopsychology, which study the human acquisition of knowledge and expertise, comprehend and production of language, problem solving and decision making skills, and the reason for discrepancies in the broad categories of human cognitive abilities (Damasio, Damasio, & Tranel, 1990; Kellogg, 1999; Eysenck, 1998).

In their explanations of the discrepancies in cognitive development, modern researchers draw enduring ideas from a) mathematics, often represented as the Physical Symbol System Hypothesis (PSSH) or the Universal Turing Machine (UTM), in which human brain and mind are equated with a complex system that is capable of assimilating, storing, processing, and acting upon information physically; b) the humanities, which perceive language as a pathway to understanding the human mind and behavior; and c) life sciences, which study the relationship between the mind and the brain, and the part this relationship plays in human thinking process. It is believed, however, that the study of human thinking processes cover five major mental processes: encoding, memory, evaluation, and mediation, which are essential in problem solving, reasoning, and decision-making techniques. Thinking is a covert set of mental process, which makes use of knowledge acquired through perception, attention, and memory, in solving an eminent problem (Eysenck, 1998).

Nature and Nurture in Cognitive Processes
The concept of nature (a form of reductionism or selectionism) maintains that the cognitive characteristics of each individual can be explained exclusively in terms of biology and heritable propensities (Kolb & Whishaw 1995; Tavris & Wade, 1998). Right from the time classical (Pavlovian conditioning) and operant conditioning (Skinner box) was discovered, researchers have tried to link human cognitive ability to biogenetic phenomenon (Blum, 1978; Candon, 1971; Venon, Jackson, & Messick, 1988; Eysenck, 1998). They maintain that even though humans are innately endowed with the propensity to know (take in, process information, store, and retrieve when needed), yet differences in intellectual abilities can be attributed to genetic
variation and brain damage, caused by diseases or accident, and impaired neurological development (Rosenzweig et al., 1999). The heritability of a trait has been upheld as a major presenting factor in intellectual differences, but since heredity is expressed as a proposition of the total characteristics of human qualities, then only genetic distribution cannot account for the difference in human cognitive ability (Rosenzweig et al., 1999, Tavris & Wade, 1998).

Therefore, several successive processes are necessary to guarantee recall of past event: encoding, consolidation, and retrieving, the process many neuropsychology researchers attribute to neurological and neurochemical effects (Brewer, Zhao, Desmond, Glover, & Gabrieli, 1998). The human cognitive ability studied under nurture perspective reveals behavioral patterns and qualities acquired through environmental influence, which include, socioeconomic, cultural, and belief system (Easterbrook, 1994; Gardner, 1985a; Kellogg, 1995; Tavris & Wade 1997; Walsh & Betz, 1995). But unlike nature argument, which stands out on its own and influences the individual from inside to outside (Gardner, 1985b), nurture argument is an influence which came from outside to control the entire person. Human nurture is studied under psychological, biological, anthropological, sociological, and epistemological ambient. Today, environmentalists have seen the discourse on nurture as an important condiment in the studies of human mental, intellectual, and emotional problems. Therefore, researchers have established that environmental variables can be used to determine cognitive abilities (Maclullich, Seck, Starr Deary, 1998).

**Cognitive development in Perspective.**

In his adaptation theory, Jean Piaget (cf. Piaget, 1960/1984; Tavris & Wade, 1997), proposed that cognitive development is progressive and adaptive because objectively nobody remains the same cognitively, but always in the process of becoming, once touched by internal or external experiences. This is to say that the ability to think and reason begins in early infancy and progresses to adult. Hence, all humans organize their experiences into a coherent set of meaning, which later becomes part of who they are and what they do. The infant is thrown into a web of assimilation and accommodation processes through which perspectives and concepts are formed. According to Piaget (1960), every child goes through four basic stages of cognitive development, namely, Sensorimotor, preoperational (which can be pre-conceptual and intuitive) concrete operational, and formal operational. Piaget’s conceptualization of human cognitive development is indisputable in the present day interpretations of mental ability (Astington & Gopnik, 1991; Flavell, Green, & Flavell, 1990).
Each stage of Piaget’s cognitive development expresses the importance of the environment in the proper acknowledgment, understanding, and labeling of stimuli encoded in images (Flavell, 1993), and any disruption in these stages may radically affect cognitive transition processes. Modern researches, however, have gone beyond Piaget’s conceptualization of cognitive development in attempt to incorporate other factors believed to influence the way people behave, think, conceptualize and understand sentences. Over and above perceptual operations, researchers believe that there are more complex mental operations, which influence the ability to learn, reason, remember events, and form concept of what is perceived. Everything we know about learning and knowledge begin with perception, which involves encoding and storing events or entry of information into short-term memory and ends with deeper and higher order processes that store the information in long-term memory (Kellogg, 1995; Hertel, & Hardin, 1990). Encoding refers to the acknowledgement, understanding, and labeling of stimuli encoded as images. Perceptual processing is limited without the power of attention. When information is receive in an attended mode, better and clear image of the perceptual event is much better formed than when it is received in an unattended mode. Therefore successful encoding is necessary for successful storage and retrieval of information. Without attention at encoding, little if anything persists beyond the short-term memory. This is why children with ADHD or individuals suffering from depression frequently report of difficulties in remembering (Hertel, & Hardin, 1990; Kellogg, 1995). When a child acquires languages, words are used in the encoding process, and individual's success at problem solving is contingent on his ability to encode, store, and retrieve stimuli properly.

Even though Gardner (1985b), Kellogg (1999), and Eysenck (1987) believe that the fundamentals of human cognitive maturation are based largely on interaction with external stimuli, yet it is generally understood that the internal organization and conceptualization of perceived objects are conflicting and complicated. Some researchers believe that some automatic predispositions influence the way individuals respond and processes stimuli (Woodcock, 1990). According to Woodcock (1990), the ability to think and reason begins in early infancy, and the strategies children use to understand concepts and solve problems are not arbitrary or incomprehensible, rather they reflect an interaction between the child’s development stages and his experience in the world. Even though the adaptation and component presses theories have continued to exert profound influences on researchers, yet modern researchers have favored the influence of automatic predisposition in individual’s cognitive abilities. They believe that to understand human cognitive development and factors that influence problem-solving abilities the following dynamics must be taken into consideration: a) genetic, physical, and biological factors;
b) chronological maturity, like the birth-age; c) receptive functions, like the abilities to select, acquire, classify, and integrate wholesomely sensory information; d) memory and learning which refer to information storage that includes, information rehearsal, coding, decisions, and retrieval strategies (Kellogg, 1999; Lezak, 1999); e) thinking concerning the mental organization and reorganization of information; and f) expressive functions that are the means through which information is communicated or acted upon (Lezak, 1999).

This is to say that cognitive developmental processes, more than merely interdependent entities, are irremovable bound together, because acquiring new information (knowledge) may be influenced extensively by circumstances emanating from the environment in which individual was raised or purely automatic disposition. The amount of information an individual is able to acquire within a given period depends essentially on mental maturity. This suggests, therefore, that perceptual and cognitive data processing may differ significantly or moderately across groups and within individuals. In order to determine intellectual differences, psychologists assess individual cognitive impressions or abilities including learning, memory, perception, problem solving, and reasoning ability within age classifications. Such ability is measured under human intellectual performance or IQ (intelligence quotient) (Lezak, 1995; Walsh & Betz, 1995).

**Relationship between Cognition and Intelligence**

Previously, it is maintained that cognition is a mental ability to acquire and process information and this process beings with perception, mental representation (encoding), and progresses toward storage of learned information (Squite & Butters, 1992; Sternberg, 1996). In contrast, intelligence is the ability to act purposefully, to think rationally, and to deal effectively with the environment. It means, therefore, that intelligence is an aggregate of specific abilities manifested as a result of cognitive development (Squite & Butters, 1992). However, the nature and relationship of human intellectual assessment with cognitive functions are not distinct or definite, because as researchers bump into new knowledge about human learning processes, “it becomes more difficult to make theoretically acceptable distinctions between the different functions involved in human information processing” (Lezak, 1995, p.25). Even in laboratory experiments, researchers have noticed that different individuals learn differently depending on varieties of circumstances and situations (Daneman, & Carpenter, 1980; Denckla, 1996; Squite & Butters, 1992).

If human cognitive abilities are the representation of knowledge acquired within a prescribed time, as maintained by Sternberg (1985), then the assessment of human intelligence must
consider myriad of factors. For this reason, cognitive psychologists maintain that the true method of understanding the procedures involved in acquisition of knowledge is to investigate the phenomenon through which humans acquire and process information (Walsh & Betz, 1995). Reacting to this line of thought, Eysenck (1998), Lezak (1995), and Kellogg (1995) observed that to be truly intelligent, an individual should develop an enduring ability that manages and utilizes data, concepts, experiences, and ideas in a proper, quick, effective, and efficient manner (Daneman, & Carpenter, 1980; Denckla, 1996). Since learning conditions cannot be the same for all humans, Kellogg (1995) maintained that the relationship between intelligence and cognitive is like the relationship between the computer and the user. The ability to use the computer depends on the contextual knowledge of the user and the mechanical constitution of the soft and hardware of the computer can affect the user's ability to be effective (Watkins, 1992; Sternberg, 1985).

The overall objective of psychometric instruments, from the time of Binet (1903) to the present, is to measure and determine the general intelligence and the role of the executive function in determining individual’s problem-solving ability and creativity (Jensen & Weng 1994). Most cognitive scientists believe that the notion of intelligence revolves presupposes actuality of executive function (executive processes, executive routines, control processes, and metacomponent) in thinking and reasoning. According to Sternberg and Gardner (1983), Brown, Bransford, Ferrara, and Campione (1983) execution function (EF) represents general intelligence, which can be manifested in a different way and in different degree in a given problem-solving situation. According to Butterfield and Belmont (1977) executive function is intelligence in action, because it consists basically of the necessary processes individuals need in plan, monitor, and revise strategies of information processing. Furthermore, Gardner (1983/1985a), Kellogg, (1999), and Walsh & Betz (1995) link the EF with the mental process that helps the individual to maintain and achieve a set of goal. The net outcome of EF activity has been said to be an alteration in the probability of subsequent responses to an event, thereby altering the probability of later consequences. So all problem-solving techniques involve the EF, irrespective of the number, type, or relative computational power of the discrete subroutines that are executed (Sternberg, 1985; Watkins, 1992;). Since EF is highly overlapping across tasks of a widely differing nature, there is a compelling rationale for concluding that psychometric instruments are a reflection of the operation of EF.

Assessment of Intelligence from Cognitive Perspectives
Due to the complexities of the human cognitive mechanism, modern cognitive theorists are yet to come to arrangement with a definite answer on the actual nature of intelligence and the reason for differences in intelligence. However, with the advent of contemporary cognitive science, the controversy over the nature of intelligence seems to have been superseded by the investigation of components or computational subroutines that are active in human intellectual abilities (Kellogg, 1995). Such approach does not want to give a total credence to either Galton’s (1981) heredity or Binet’s environmental approaches; rather, it tries to mediate the theories with modern scientific methods (Eysenck, 1979). This is because most psychologists who hold strictly to either Galton's or Binet's theories have discovered that the so-called general intelligence is not absolute, and the cognitive skills such as memory and language ability are independent (Kellogg, 1995).

Majority of cognitive scientists, however, believe that 50 percent our cognitive development is affected by heritability of traits and 50 percent by the environment (Kellogg, 1995). Cattell (1963), proposed a different way of looking at human intelligence when he conceptualized two distinct but correlated forms of intelligence: crystallized and fluid intelligence (Eysenck, 1998, p. 422). By crystallized intelligence, he meant a mental ability to retrieve and use previously learned knowledge and skills to solve known problems with the knowledge, while fluid intelligence is the mental ability to solve a novel problem (Kellogg, 1995). So both Crystallized and fluid intelligence are involved in the tasks that require the exercise of cognitive ability, but fluid intelligence involves a higher production of unique or novel ideas in responding problems (Boden, 1992; Hayes, 1981). As a matter of fact, fluid intelligence declines with age, while crystallized intelligence is often maintained until 85 years where health problem did not impede cognitive ability.

Although Gardner (1983) and Sternberg (1988) accepted Cattell’s hierarchical approach to human intelligence, maintain that the concept of human intelligence must encompass many more components. For this reason, Sternberg (1977/1983/1988) proposed triarchic approaches, which focused on the component combination of intelligence. He suggested of a theory that considers the relationship of human intelligence and the totality of human life (Eysenck, 1998; Kellogg, 1995). In his triarchic theory, Sternberg (1988) divided intelligence into three entities; namely, the componential, the contextual, and the experiential. Componential sub-theory reflects intelligence that deals with the individual’s internal world, which may include all the cognitive processes and structures used in intelligent behaviors. In this way, he defined “component” as “an elementary information process that operates upon internal representation of objects or symbols” (1985, p.97). With the concept of componential intelligence, Sternberg distinguished
metacomponents, performance component, and knowledge-acquisition components (Kellogg, 1995). Metacomponents control the course of action in thinking and monitor the success in the selected path. Like metacognition, it is the central feature in human consciousness and awareness. Metacomponents is essential to skill in problem solving, strategy selection, and modification in memory, language use, and social cognitive processes (Kellogg, 1995).

a) Contextual sub-theory
One of the weaknesses of the traditional approach to intelligence and intelligence testing is the assumption that intelligence does not depend on the cultural environment in which people live. This deals with the individual’s external world, and focuses on the processes used to handle environmental demands. The emphasis each culture, as well as each family, places on knowledge may differ significantly from culture to culture and from family to family. Such emphasis may determine the type of intelligence a group of people or individuals will develop. In other words, intelligence is a relativistic concept.

b) Experiential sub-theory
Sternberg argues that intelligence can be assessed either when a task is relatively novel or when familiarity with performance of a task has led to automatic performance component (Brown, 1991; Eysenck, 1998; Howe, 1990, p. 499; Kline, 1991). It indicates how much an individual can cope with novel tasks in a flexible, creative, and original fashion. The distinction between the ability to handle relatively novel situations and the ability to develop automatic processes is similar to the crystallized and fluid intelligence proposed by Cattell (1963). Gardner (1983, 1995b) proposed a complex and multidimensional approach comprising seven different intelligences processes (Eysenck, 1998).

a) Spatial intelligence, the ability to manipulate and move around objects. It is also called navigational ability because it is the skill needed to locate places and interpret events and paintings
b) Musical intelligence: involves that ability to create and respond to rhymes and notes. It is important for the playing of musical instruments, singing, or listening to music.
c) Linguistic intelligence: the form of intelligence used in the acquisition and comprehension of languages, including the production of spoken and written language.
d) Logical-mathematical intelligence: the ability to solve abstract problems of a logical and/or mathematical nature. It also includes logical and statistical reasoning
e) Interpersonal intelligence: this is an intellectual ability to interact with others in sympathetic, considerable, and sensitive manners. It includes the ability to understand people’s feelings and their behavior.

f) Intrapersonal intelligence: this involves the introjections or the ability to reach into one’s own self for counseling and correction.

g) Bodily-Kinaesthetic intelligence: this type of intelligence involves motor or bodily control, like movement in walking, dancing, or sports.

There are factors responsible for the way each of the intellectual categories is developed in the individual. A range of factors must be taken into account because some people can be very good in one or two intelligences, but very poor in another.

Factors Affecting Cognitive Process

The values of intelligence must not be viewed only through the lenses of a particular culture, rather, the effort to identify the knowledge that varies between but not within large cultural groups will lead to the conceptualization of cultural knowledge as paradigm that infuses intellectual constructs and the method of applying them to all aspects of life. Such conceptualization has exposed the view that the constructive value of human intelligence is in the eyes of the beholder (Tavris & Wade, 1998). One of the errors of traditional approaches to intelligence is the presumption that cognitive ability is not affected by cultural environment. Such assumption is fundamentally wrong. This is because each cultural environment measures problem-solving skill from the community experience and survival factors (Wagner & Sternberg, 1986). According to Simonton (2000), it is obvious that the essential cumulative factors in understanding human intelligence and creativity is not a mere theory of heredity.

Comprehensively, individual’s cognitive ability, thought processes and creativity encompasses personality, social context, interpersonal environment, disciplinary environment, and socio-cultural environment. Positive psychological experiences are required to nurture the development of expertise, skill, and knowledge structures. The acquisition of insight or skill to problem solving, creativity and expertise is governed by numerous factors, which may be connected to genetic identity, but may solely depend on cultural environment. Modern researches have shown that the aggregate of intellectual concepts projected by Galton (1981) is simplistic and therefore limits the threshold of intelligence or creativity (Gardner, 1993; Hayes, 1989; Simonton, 2000). The expansion of this threshold by Cattell, Sternberg, and Gardner (as we have seen) restructured the study of general intelligence and the standardization of IQ apparatus. It was Gardner who took the concept of intelligence to unimaginable levels when he proposed what he referred to as
the multidimensional intelligences in which he “included abilities that are not a standard part of psychometric tests (e.g., musical, bodily kinesthetic, interpersonal, and intrapersonal intelligences) (Simonton, 2000). Gardner (1993) further maintained that intelligence is associated with a specific manifestation of creativity.

The individual personality has been neglected whenever the issues of intelligence are raised. This negligent has limited the way intelligence processes are interpreted. Cognitive processes are believed to begin (but do not end) with perception, rather “perception is direct in the sense that the informational structure of an object or event determines entirely what it is that a person will see or hear” (Kellogg, 1995, p. 33). What is this informational structure? It is, according to him, “the „higher order” invariant structure that the perceiver „picks up” directly through interaction with the environment” (Kellogg, 1995, p.33). What Gibson set out to accomplish is that biogenetic factors related to perception cannot not be activated if there is no physical stimulus energy available in the environment as a way of understanding the process of perception (Kellogg, 1995; Ward, Smith, & Vaid, 1997).

Sensation and perception, as well as other cognitive functions, are very central to the informational processing systems because it is through this process that pattern recognition processes are formed (Kellogg, 1980). The part played by environment in cognitive development has been an essential discourse in the field of learning and developmental psychology (Simonton, 2000). Disciplinary, social, interpersonal, socio-cultural, and physical environments have been seen as undeniable factors in acquisition of general intelligence, creativity, and excellence. This approach maintains that the IQ of any individual depends, among other thing, on the environment into which one is born, and opportunities that are available. Kellogg (1995) believes that attention and attenuation are crucial to the formation of frame of thought including learning, comprehension, storage of memories, and retrieval of information. Posner and Raichele (1994) maintain that attention operates by changing the relative activity within anatomic areas that perform computations necessary for adaptation, comprehension, storage, and retrieval of information from shot-term or long term memories. Neurologically, the networks of three facets, namely arousal, orienting, and the executive functions responsible for directing attentions are served by the human brain. The executive network is said to coordinate multiple specialization neural processes that direct behavior towards a goal (i.e., perception, thinking, problem-solving, reasoning, etc (Kolb & Whishaw, 1995; Lezak, 1999; Rosenzweig et al., 1999).
In humans, this anatomical network is localized in the anterior cingulated gyri, left lateral frontal lobe, and basal ganglia (Lezak, 1999; Posner & Raichele, 1994; Rosenzweig et al., 1999). Inadequate executive function is now considered as the core feature of attention problems (Denckla, 1995). This does not mean, however, that lack of attention or ADHD strictly leads to low IQ scores (Goldstein, 1987); rather, it can be an environmental factor that can lead to learning and comprehension problems. Simonton (2000) was very clear on the issue of attention and the human IQ when he maintained the view that the acquisition of creative potential basically and fundamentally depends on the “family environment and circumstances that seem to most favor the emergence of creative personalities” (Simonton, 2000, p. 153). Simonton maintained that the birth factor (birth order, social status, family functionality and values), early parental loss, marginality (discrimination, negative profile, and segregation), the availability of mentors or role models, and school environment are situations that can influence intellectual abilities and therefore affect creativity.

Exposure to or inheritance of the best environment or gene is not essentially the prime factor for creativity, smart, or gifted personalities (Simonton, 2000; Tavris & Wade. 1997; Rushton, 1993; Jensen, 1981). To the contrary, exposure to diversifying experiences that help to open other horizons of information and therefore “weaken the constraints imposed by conventional socialization.” (Simonton, 2000, p.153) Furthermore, challenging experiences are also needed to strengthen a person’s capacity to persevere in the face of obstacles (Easterbrook, 1994).

**Conclusion**

Ecological studies tell us that environment is an on-going active in an individual’s life pattern, which invariably influences and affects individual’s cognitive ability (Eysenck, 1987; Kellogg, 1995; Kolb & Whishaw, 1996; Walsh & Betz, 1995). Biogenetic researches, on the other hand, maintain that the DNA, which is a major and important factor in the distribution and characterization of human heredity, neurological and neuorchemical factors can drastically affect and inhibited normal functions of cognitive processes (Kellogg, 1995; Rosenzweig, et al.; Gardner, 1985a; Walsh & Betz, 1995). Interruption of its normal function, no matter how insignificant, may result in some significant alteration in the mental and physical life of the individual, thereby resulting in a low IQ performance (Gardner, 1985a; Lacayo, 1994; Macullich, et el., 1998; Rushton, 1993).

Many researchers believe that effective problem solving technique is an important phenomenon in human survival and progress and therefore conceptualized varieties of nomenclatures by
which human mental and cognitive developments can be determined (Eysenck, 1998; Sarason, Smith, & Diener, 1975). They maintain that problem solving technique can be distorted by poor categorical reasoning performance cause by environmental, biological, and physiological factors. Individual’s aptitude and intelligence are subject to change if cultural conditions evolve, notwithstanding an individual's heritability (Anderson, 1982). As long as cultural and environmental discrepancies exist, the measuring apparatus of human intellectual abilities (IQ test models) that do not take cultural environment into consideration will be doing a great disservice to the populace.

References


Jensen, A.R. & Weng, L.J. (1994). What is a good g? Intelligence, 18, 231-258


