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A study of the formal operational thought ability of college students

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A STUDY OF THE FORMAL OPERATIONAL THOUGHT ABILITY OF COLLEGE STUDENTS

by
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ABSTRACT

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A Study of the Formal Operational Thought Ability of College Students
1998
Dr. Klanderman
Dr. Dihoff
School Psychology

This study was undertaken to measure the formal operational thought capacity of the college student and unveil any gender differences regarding this ability. Formal operational thought is important to the success of every student because it implies the ability of humans to reason scientifically and analytically and to think abstractly.

34 male and 40 female college students were selected from an on-campus apartment facility to be part of the study. The sample ranged in age from 17 to 21 and represented class standings from the freshman to senior level. The subjects included 45 Caucasians, 9 Hispanics, 17 African-Americans, and 3 Japanese.

The measure used to assess the level of formal operational functioning of the sample was an analytical section from a practice form of the GRE, or Graduate Record Examination. The test contained 12 questions. The test was administered to the subjects in their own apartments and they were given 30 minutes to complete the assessment.

Hypothesis one, regarding significant gender difference, was analyzed using a two-tailed independent t-test. Hypothesis two, concerning

overall formal operational ability of the sample, was subjected to frequency analysis.

Results of a two-tailed independent t-test expressed no significant gender difference between the formal operational ability of college males and the formal operational ability of college females. The null hypothesis of hypothesis one was therefore rejected. More than 50% of the test subjects answered at least eight out of the 12 test questions correctly, results which prevented the rejection of the null hypothesis of hypothesis two.

MINI-ABSTRACT

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Results of a two-tailed independent t-test showed no significant gender difference between the formal operational ability of college males and college females. More than 50% of the test subjects answered at least eight out of the 12 test questions correctly on a test which measured formal operational thought ability.

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Need

Developmental psychology contends that the cognitive, or intellectual development of humans throughout childhood and adolescence follows a somewhat regimented pattern. However, within this purview, is the fact that no one theory about our development is unanimously agreed upon. The developmental theories are constantly subjected to further scrutiny and research. Specifically, how the intellectual faculties of children and adolescents develop has broad implications for how they should be educated.

Jean Piaget's theory of cognitive development proposes that children begin to enter a period of intellectual functioning called "formal operations" when they are about age eleven and that they generally complete this transition by age fifteen. But he also believes that this should not be regarded as an absolute. In this case, what are the exceptions and where do they exist? It is essential for educators to know the cognitive developmental level of their students. If a transition to formal operational thought has not been made by the age of fifteen, as Piaget posits, then when, or is it made? Students can not all be taught under the assumption that chronological age exactly parallels mental age. Any deficits in the transition to formal operational thought of a

student must be realized and addressed so they do not falter in their comprehension of what is being taught.

Do college students all have the ability to think at a formal operational level and, if they do, are some more adept at this kind of thinking than others? Also, is there a gender difference concerning the formal operational ability of these college students? Considering the possibility that there may be differences in the cognitive developmental status of these students, further research is warranted. To know these answers would certainly provide beneficial information to educators. We can't assume that all college students are alike in how they process information. Simply because they all achieve a certain score on a standard test in order to be admitted to college does not mean that after that point they should be addressed with the same method of instruction. Learning theorists have shown that students learn in different ways according to their own personal cognitive makeup. This understanding should be infused into the educating of a college student as well as up to that point.

Purpose

This study will be a step towards monitoring the cognitive developmental progress of the college student. Its purpose is to reveal the extent to which the sample, a number of students representing an overall college student population, has or has not successfully made a transition to the level of mental functioning defined by Jean Piaget as formal operational thought. The purpose of this study is also to determine whether there is a significant difference between males and

females in the extent to which this transition has or has not been achieved.

Hypotheses

On a test of analytical and logical reasoning problems requiring formal operational thinking to answer correctly, fifty percent of the test subjects will answer at eight out of the twelve test problems correctly. The other fifty percent of the test subjects will not answer at least eight out of the twelve test questions correctly. Thus, fifty percent of the test subjects will show that they are functioning at a formal operational level of thought and fifty percent will not. Also, the results of this analytical test will show no significant difference in the scores of male subjects and the scores of female subjects.

Theory

In psychology the concept of development is used in reference to the idea that humans, during the increase of chronological age throughout their life, undergo a series of changes. Development is change of any kind, whether it be forward progress or digression to an inferior state. The important element of the concept is that it is a process. Thus, in terms of psychology, the "concept of development has been used to name those changes in behavior that normally occur with an increase in the chronological age of the child (Fitzgerald, 1970)." Developmental psychologists generally agree that human growth follows a path consistent with a set of regimented developmental laws. Disagreement surrounds the necessity of explaining these developmental laws and the intricacies involved in their resolution. The

cause and effect question of psychological development has in the past been framed within a two sided theoretical controversy and that is, is development formed by heredity or by environment? This controversy has evolved to a point where researchers and theorists don't deny that both heredity and environment play a role in causing developmental patterns. Many even agree that one is no more important than other. The distinction of the controversy appears in the emphasis that a researcher chooses when designing specific research. For instance, a researcher must ask, "Should we first investigate the role of genetic factors in development, can we investigate fruitfully nongenetic factors alone, or must we try to study simultaneously the two sets of factors (Spiker in Fitzgerald, 1970b)?"

The nature-nurture controversy in absolute terms of one being wholly responsible for determining an individual's development is no longer a credible scientific debate. Developmental psychology has reached the consensus that "the proportional contribution of heredity to the variance of a given trait, rather than being a constant, will vary under different environmental conditions. Similarly, under different hereditary conditions, the relative contribution of environment will differ (Anastasi in Fitzgerald, 1990c)."

In light of this reasoning, contemporary research in developmental psychology faces the task of unveiling the multitude of interactions between heredity and environment and asking how these interactions affect the developmental process. It is no longer sufficient or constructive to simply ask how much can the cause be attributed to nature or how much can the cause be attributed to nurture. Ultimately, and no matter what specifics and perspectives are applied to the field, the goal of

developmental psychology is to study the process of change throughout the life span.

Amongst the vast specifics of the developmental process there are some concrete principles. First, motor movement, speech development, and physical and cognitive development generally follow a predictable pattern. This growth process is continuous and directional for most people. Secondly, a maturational process, framed by genetics, determines when a child is able to respond to different levels of learning and environmental stimuli. Another principle states that each individual follows the developmental process in his own unique way due to inherent biological differences or differences in exposure to variables of the environment. Each stage of development exhibits characteristics specific to that particular stage. This is a fourth principle. A fifth principle of developmental psychology is that basic patterns and schemas, developed during infancy and early childhood, determine how the development of that individual will unfold. Finally, it is believed that critical periods exist during development. These are times when "an aspect of growth is most susceptible to damage by abnormal conditions (Kaluger, 1979)" or "when some forms of development can benefit the most from certain types of training (Kruger, 1979b)."

Central to development and the capacity for humans to function at an optimal level of effectiveness and well being are three important processes. These processes are homeostasis, motivation, and learning.

Homeostasis is the term given to the human ability to maintain an equilibrium in which the internal state of the body remains in harmony with exposure to varying external influences of the physical environment. Humans, through this process, ensure that their internal physiological

and psychological states adapt to encounters with the environment in a way that will produce advantageous results. The goals of homeostasis are three-fold and these goals are both innately determined and produce through interaction with the environment. A basic goal is to maintain a physical state of well being necessary to survival. Another is the goal of procreation, ensuring the continuance of the human species. A final goal is that of striving for full potential and self-actualization. When an imbalance occurs in the bodies need to function at a harmonious level stress, tension, and anxiety result. Normally, the body will react by attempting to reduce this stress and restore harmony through homeostasis. The process of motivation is responsible for initiating the balance restoring behavior. "The term motivation is used to refer to the process by which behavior is initiated in response to a need, a deficiency, or a lack in the organism or person (Kaluger, 1979c)." Once the need to restore a homeostatic balance is present and the motivational process inclines the person towards restorative behavior, the learning process becomes important. Through the learning process humans come to know what behavior is needed to restore the body's natural balance. It is the cognitive process of learning that helps the person to maintain an overall well being by ensuring that the person chooses appropriate goal-directed behavior. Without the cognitive learning process the person would not be able to survive, at least not as a self-sustaining, independent individual. Furthermore, the more complicated and developed a society is, the more advanced the cognitive reasoning capacity of the individual has to be in order to successfully adapt and actualize their potential.

Throughout the course of time various views have arisen

concerning the specific ways, within the general developmental process, in which development unfolds. Each view is different primarily through its emphasis on one side or the other of the nature-nurture paradigm.

A maturational view places heavy emphasis on biological determinants for development with not much room for psychonomics. It states that developmental process is innately determined and occurs the same way regardless of varying sociocultural environments. G. Stanley Hall and Arnold Gesell are considered proponents of this view. The genetic-oriented view is similar but even more extreme in its emphasis on the biological element in determining development. All outcomes are a result of genes, predetermined and virtually unchangeable. "The environment is involved, to be sure, but only as it contributes to the genetically determined outcome (Kaluger, 1979d)." Another line of reasoning about the developmental process is the interactionistic approach which states, "At any one moment the level of total development depends upon the maturational level of development plus the experience and materials encountered in the environment (Kaluger, 1979e)." According to this view, there is a certain set of stages or steps involved in development and determined by genetics, but the unfolding of these stages is respondent to the environmental influence. Piaget and Bruner are the most notable advocates of this view. An environment oriented perspective of development suggests that development follows a path based on an individual's interactions with the environment. It is a behavioral-learning model supported by the classical and operant conditioning paradigms set forth by such theorists as Pavlov, Watson, Skinner, and Bandura. Seemingly unscientific and theoretically based on case studies is Freud's view of development. Known as the

psychoanalytic view, it proposes that development patterns result from the internal conflicts of an individual and how these conflicts are resolved or left unresolved. Freud suggested that the primary source of conflict in an individual's life is usually the result of sexual and pleasure-seeking issues. A modification of Freud's theory was advanced by Erikson, who emphasized a social and anthropological element in the developmental process. Rogers and Maslow supported humanistic-existential theories which also deemed conflict issues to be important but framed within a positive orientation that celebrates the human spirit and realizes its capacity for achievement and its ability to reach its full potential. Mead and Benedict propose a view of development which stresses the effect of cultural conditioning on the developing individual. They suggest that how one individual is exposed to the dynamics of their own culture contrasts strongly with an individual raised in a different culture and that this cultural exposure is an overwhelming source of different developmental outcomes. Contemporary trends advocate this view, especially the psychological counseling technique of MCT, or Multicultural Counseling and Therapy. A final perspective of development is the psychosocial view proposed by Havighurst. Central to this view is the idea that developmental outcomes and processes are determined by success or failure at mastering certain developmental tasks during each developmental stage or age level. These developmental tasks are designed by the needs of the individual and the needs of his or her unique society or culture. "In general, Havighurst seeks to combine the age level needs of the individual with the demands of society-or the culture-for that stage of development (Kaluger, 1979f)."

All of these views capitalize on two general categories of factors which influence development. In broad terms, and notwithstanding the enormous amount of possible combinations and interactions between the two, these factors are physiological and psychosocial. Physiological pertains to biological functions and processes of the body while psychosocial encompasses those influences of an individual's psychological make-up combined with exposure to environment throughout the life span. The components of physiology which influence development are the maturation process, the neural system, the glandular system, and genetic background. Maturation process refers to the process by which an individuals physiological growth unfolds according to a pre-ordained sequence. This concept is important to cognitive psychology because it implicates set stages in development when the brain should be ready to perform certain cognitive tasks. Of course, there are individual deviations from the maturation process, and this has broad implications for psychology and education. Variations in the maturation process of any physiological component will have an effect, whether profound or minimal, on the development of an individual. Psychosocial influences are the other set of factors which affects development. Each person has their own unique exposure to the world. Through different socialization patterns, families, cultures, peer groups, climates, and geographic locations, an individual's development evolves and is affected. Psychosocial influences, like physiological ones, can be positive or detrimental to an individual.

The operational framework for this study is Jean Piaget's theory of cognitive development, and more specifically, the period of development concerning the transition to what Piaget defined as formal operational

thought. Piaget's research and study of his theory of formal operational thought as a stage in human cognitive development was extensive. Barbara Inhelder not only assisted Piaget with most of his work but did much on her own to extend the findings of their combined research. "The Growth of Logical Thinking (Inhelder and Piaget, 1959)" is a substantial publication of their research dealing with the development of formal operations.

Since the period of Piaget and Inhelder's initial investigations into formal operations many psychologists and other researchers have attempted to delineate and extend the research on formal operations. One of the strongest factors in question concerns not necessarily the existence of formal operations in cognitive development but the point of development at which it is attained. Research of this question has been done by many, including R.J. Mealings, J.H. Flavell, E.A. Peel, and E.D. Neimark. Attention has also been given to the possibility of gender as a variable in consideration of attainment of formal operations by such people as D.P. Keating and J.S. Hyde.

Definitions

Cognitive development - the development of mental faculties and processes

Cognitive processes - "mental processes concerned with knowing, such as perception, memory, imagery, reasoning, etc. (Beard, 1969)"

Deductive reasoning - the ability to apply knowledge of general rules, principles, and experience to specific situations

Formal operations - the final stage in cognitive development as proposed by Jean Piaget; consists of four aspects:

1. introspection - metacognition, thinking about thought

2. abstract thinking - "going beyond the real to what is possible (Rice, 1990)"

3. logical thinking - "being able to consider all important facts and ideas and to form correct conclusions, such as the ability to determine cause and effect (Rice, 1990b)"

4. hypothetical reasoning - "formulating hypotheses and examining the evidence for them, considering numerous variables (Rice, 1990c)," pragmatic or scientific thinking

Inductive reasoning - the ability to evaluate and process details of a specific situation or experience and use them to form generalizing hypotheses

Psychometrics - "the specialized branch of psychology dealing with mental tests (Chaplin, 1968)"

Psychonomic - "pertaining to factors that influence mental development (Chaplin, 1968)"

Assumptions and Limitations

An assumption of this study, though reinforced by past research, is that a test of analytic problems able to delineate the capacity of the test respondent for formal operational thought. However, this assumption has good face value, for to complete an analytical problem correctly one must utilize the four general aspects of formal operational thought, especially that of hypothetical and logical reasoning, or thinking about all possibilities and determining cause and effect. In order to test the presence or absence of formal operational thought it must also be assumed that Piaget's theory of the existence of formal operational

thinking has considerable reliability. This assumption is strengthened by the multitude of research testing his theory, whether by him or the many researchers after him.

A limitation of this study is inherent in the individual differences that the test subjects will inevitably bring to the testing. That is, there is no knowledge of how the test subjects differ in their prior experiences with tests of analytical problems or how much specific training they have had in this area. Analytical problems are not part of the SAT. Unlike candidates for graduate school who must take the GRE for admission, undergraduate students are not required to display a control of analytic ability in a specific test form. It can not be inferred whether their different performances on the test of analytic problems in this study is a result of differences in the amount of prior training and/or experience or differences in biologically inherent aptitude. It is a descriptive study in that it is describing the status of a certain sample of subjects within a population. It is also an experiment testing potential gender differences in analytic ability, the construct being used to infer the degree of formal operational thought capacity of the male and female test subjects. Randomization is also limited because the test subjects are being selected from a previously defined set of students who live in a particular on-campus student apartment housing facility.

Overview

Chapter two of this study is a review of the literature. There will be an account of Piaget's specific role as a child and adolescent theorist within the purview of developmental psychology. Formal operations will be emphasized within this discussion. A history of Piaget's research,

with the relevance of Inhelder's assistance being noted, will be discussed as it pertains to their work with the formal operations concept. When this is finished a review of other researchers and their work with Piaget's concept of formal operations will commence, with a specific look at the dynamics of transition to formal operations and any gender differences. Chapter two ends with a consideration of research that implicates the role of formal operations in education and the importance it has towards the understanding of human cognition. In chapter three a description of the experiment and how it will be conducted is set forth and the specific hypotheses will be stated. The outcome of the testing and an analysis of these results is presented in Chapter four.

Possible outcomes for this particular study may become evident with a review of the literature. Through a brief description of theory and research in cognition, Piaget's stage theory of cognitive development, and an account of recent studies of formal operations, it will be seen that notwithstanding abundant past efforts, the field requires further investigation.

Chapter 2: Review of the Literature

Of profound importance in human development and psychology in general is the study of human cognition. This area of study has amassed a multitude of information. Especially in these modern times, flooded with technology and computers, studies in cognitive science prove to be both enlightening and advantageous to further technological achievement.

Cognition is the broad term conceptualizing all forms of knowing. Cognitive psychology is a science which examines the processes of cognition and how these mental processes dictate human behavior. Although once considered a purely theoretical psychology, it has evolved to an applied psychology in that its discoveries have been employed towards the advancement of computer technology.

Cognition, as previously stated, involves all forms of knowing, or the processes involved in how an individual comes to know. More specifically, it "refers to all processes by which the sensor input is transformed, reduced, elaborated, stored, recovered, and used (Neisser in Reed, 1992)." These functions which the construct of cognition refers to are problem solving and decision making (thinking), attention, memory, language, and perception. All sensory input is channeled through what are called cognitive modalities. These modalities are visual, auditory, verbal, or sensory-motor in nature.

The process by which sensory input is channeled through the modality(ies) and then transformed, stored, and retrieved has been labeled the information-processing approach. This approach currently receives the strongest support in cognitive psychology and involves a

number of stages. The first stage implicates the existence of a sensory store, in which information is held for about a quarter of a second until its pattern is recognized. If it is not recognized the information is lost. Pattern recognition is the second stage of the model. During this stage the new information is categorized according to a previously stored pattern. The new information can also be classified differently if it does not exactly fit an existing pattern. Between the first two stages a filter controls how much information is delivered to the pattern recognition stage because the information may be coming too quickly or in too much quantity to attempt to recognize it all at once. After the appropriate amount of information is attenuated for pattern recognition it is selected or not selected according to whether or not that information will be entered into memory. The filter and selection elements of the information processing model comprise what is known as attention. The final stage of the model is memory, either short-term (STM) or long-term (LTM). While STM is limited in its capacity for holding information and in the duration for which it can retain that information, LTM is limited in neither of these ways. The entire model is bi-directional, that is, "an earlier stage can be influenced by information in a later stage (Reed, 1992a)." Theories vary as to specifics within the overall information processing framework.

The concept of intelligence is derived from and based on the notion of cognitive ability. It conceptualizes the idea that cognitive ability and the effectiveness of one person's cognition over another's may vary greatly. A measure of intelligence which accurately parallels the information processing model should measure how well a person acquires, stores, retrieves, and uses information. However, the concept

of intelligence has given to a debate about "whether intelligence is better viewed as one or many processes and how cognitive ability should be assessed (Wood, 1983)."

There are a number of views regarding this debate. Spearman's two-factor theory indicates two types of abilities, general and specific, or "g" factor and "s" factor. He posited that some tasks require general ability while others require specific abilities. According to Spearman, measures of intelligence should measure general ability, or the "g" factor. Thurstone believed intelligence to consist of seven primary mental abilities. "Thurstone's seven factors are numerical ability, reasoning, verbal fluency, spatial relations, perception, memory, and verbal comprehension (Wood, 1983b)." Guilford proposed 120 abilities of intelligence. Two general facets of intelligence are central to Cattell's theory. According to Cattell, intelligence entails fluid intelligence and crystal intelligence. Fluid intelligence is the ability to perform tasks that require inductive and deductive reasoning but limited knowledge of culture. "Crystallized intelligence is assessed by tasks that depend heavily on cultural information (for example, vocabulary items, general-information items, verbal comprehension) (Wood, 1983c)." Piaget believed that intelligence, at least in its highest potential, consists in a person's ability for formal operational thought, measured through tasks which target higher level reasoning and abstraction abilities.

Jean Piaget was one of the most influential theorists involved in the study of human development and specifically, patterns of cognitive development. His theories have been instrumental in increasing our understanding of human cognition throughout the life span, but most particularly, during childhood and adolescence.

Due to Piaget's belief that the development of cognition is strongly rooted in hereditary influence, he considered himself a geneticist rather than a psychologist and coined the term genetic epistemology to describe cognitive development and emphasize its genetic core. Piaget was an active participant in the construction of the first intelligence test, which was credited to Alfred Binet and Theophile Simon. His participation entailed the development and refinement of reasoning tasks, which he addressed to children. Upon his discovery that children under the age of twelve were having problems answering questions involving part to whole and cause and effect relationships he was prompted to further his examination regarding the reasoning abilities of children.

Through published works resulting from the findings of his initial experiments, Piaget was recognized by the director of a Genevan institute for the scientific study of children and offered a position there, which he began in 1921. This position served as the catalyst for his life's study of children. Piaget was married during his early years at the institute and they had three children. Although he was criticized later for being unscientific, it was the study of the cognitive development of his own children that was most instrumental in the production of Piaget's findings about the cognition of infants and toddlers. Later, as he broadened his research to include work with older children and adolescents, Piaget coordinated his efforts with Barbel Inhelder, whose assistance was very much a significant element in the creation of the theory.

The importance of Piaget's work lies both in the method and its extent. "His clinical method of investigating children's thinking is

exceptional in that he seeks reasons for children's beliefs and opinion (Beard, 1969)." This characteristic expresses Piaget's interest in the internal processes of the mind that contemporary trends in cognitive psychology emphasize. It is an interest and a method beyond traditional behaviorism, which seeks only a strict stimulus and response investigation, leaving the workings of the internal processes to be described as a black box of irrelevant void. Piaget's method also reflects his emphasis on genetics because he sought hereditary trends and genetic frameworks in cognitive development patterns. He considered cognitive development in all humans to be relatively consistent and following a general path; his theory is a stage theory. Piaget's theory has been criticized on the grounds that although he has outlined general trends of cognitive development he failed to describe exceptions to the process with any substantial statistical backing. He was more concerned with general rules than with outlining possible variances. An example of this criticism is highlighted in the statement, "To teachers it is of some importance not only to know the order of stages in thinking, if there is an invariable order, but also to know what misconceptions to expect among children of different ages and at what age the majority of children in a given environment reach each stage (Beard, 1969b)." Piaget did not substantially refer to the possible effect of interactional variables in producing exceptions to the cognitive development process because he focused on and emphasized genetic trends. Contemporary perspectives on cognitive development realize the importance of environment in affecting genetic predisposition and parallel research efforts with this realization. However, unlike behaviorism, the emphasis recognizes that humans display a freedom of cognitive processes, such that a person

"becomes an actor on, rather than simply a reactor to his environment (Phillips, 1981)."

Piaget's theory of cognitive development begins with the first two years of life, which he broadly categorized as the sensori-motor period and subcategorized into six distinct stages. Piaget implicates the term sensori-motor to emphasize that a language is non-existent. The infant can't utilize symbolic function, "he does not have representations by which he can evoke persons or objects in their absence (Pettijohn, 1994)" and there is no structured thought process. The first stage of this period involves primitive reflexes and "gross, uncoordinated body movements (Pulaski, 1971)." The infant has no awareness of a personal identity and perceives himself to be part of the whole environment without individual reality. This stage comprises the first month of life. For the next three months, in stage two, the infant develops patterns of response by chancely combining reflexes. In stage three, from four to eight months, the baby expresses intentionality by using learned response patterns to ensure that her environment provides interesting changes. During stage four, from eight to 12 months, the infant continues to develop intentionality of performing responses and reflex patterns and coordinates them to achieve desired environmental effects. Perceptual patterns also advance, shown by the infant's search for a missing object. During the age of 12 to 18 months, stage five, the child shows familiarity of learned behaviors and knowingly observes their effects. Finally, in stage six of the sensori-motor period, which lasts from one and a half to two years of age, the child begins to develop internal means of experimenting with response patterns, as opposed to learning completely through "external trial and error (Pulaski, 1971b)." This stage

reflects the beginning of insight and representation of symbols through thought process.

According to Piaget, with the second year of life comes the period which he calls the preoperational period. The main characteristic of this period is egocentrism. The child of this period is able to think using symbolic representation but the world around him is perceived as it relates to him. The preoperational child believes that everything was created for him, he believes that everyone else perceives and understands the world as he perceives and understands it, and he thinks that the world is under his control. Empathy and role-taking are impossible during this period of development because a child's perceptions of the world is limited to how she perceives it from her own standpoint.

Involved in the thought of the preoperational child is what Piaget calls animism, which breaks down into four stages. At its earliest level, animism consists in the child's endowment of life and conscious activity to anything in nature because as yet he is not aware of his own consciousness. Thus, he can't perceive the concept of unconsciousness in inanimate objects. When a transition is made to the second stage of animistic thought a child only believes objects are alive if they move. Next, he only believes they are alive if they move on their own without help. The final transition occurs when a child realizes that only animals and plants are alive, but this transition does not occur until the late concrete operational or early formal operational period of cognitive development. Piaget further classifies the preoperational period into a preconceptual stage and a perceptual or intuitive stage. The preconceptual stage, which frames cognitive development from ages two

to four, outlines the finding that "the ability to represent one thing by another increases speed and range in thinking, particularly as language develops; but because language is acquired slowly and does not immediately take the place of action, thinking remains to a considerable degree tied to the child's actions (Beard, 1969c)." The child is still limited in her ability to develop true concepts. From about four to seven years of age the child, who is now in the intuitive stage, is still unable to make the mental comparisons reflective of the operational periods but begins to form some concepts. The forming of these concepts is done through single actions and immediate perceptions in the environment. The concepts, though framed, are unstable and subject to change because they rely on varying perceptions and here and now experiences.

The child enters Piaget's concrete operational period at about age seven and progresses through this period until about age eleven. In this period children begin to express a level of logical reasoning, though very concrete and linked to what they consider, from their own realities and experiences, to be possible. They develop the ability to understand hierarchical relationships and class inclusion relationships. In other words, categorization becomes possible based on any shared characteristics of objects. "This gives children the ability to understand the relations of the parts to the whole, the whole to the parts, and the parts to the parts (Allyn and Bacon, 1990)." The child understands that, based on certain characteristics, an object can belong to different class ordering at the same time. "The operational child is freed from the pull of immediate perception. He is also able to range forward and backward in space and time on the mental level...In spite of his new freedom, however, he is capable only of thought about concrete, existing objects

and people. The relation of hypothetical thought, dealing with theories and propositions, will not be attainable until his adolescent years (Pulaski, 1971c)."

The formal operational period, according to Piaget, begins at age eleven. He believed that the transition to the formal operational thought status, reflective of this period in cognitive development, is completed by age fifteen. To him, it is the highest level of cognitive development that a person can reach; the qualification of a person's intelligence is accomplished through learning their degree of formal operational thought capabilities.

The dynamics of formal operational thought surround the core principle which maintains that a person thinking in this capacity is capable of high level reasoning, hypothesizing, and logical formations. Specifically, its four primary aspects are introspection, abstract thinking, logical thinking, and hypothetical reasoning. "In other words, formal operations adolescents are able through inductive reasoning, to systemized their ideas and deal critically with their own thinking to be able to construct theories about it. Furthermore, they can test these theories logically and scientifically, considering several variables, and are able to discover truth, scientifically, through deductive reasoning. In this sense, adolescents are able to assume the role of scientists because they have the capacity to construct and test theories (Allyn, 1990b)." Piaget classifies the development of formal operational thought into two substages. First, occurring from ages 11 to 14, the adolescent is in a state of almost full formal function, expressing the capacity to generate hypotheses and assert accurate discoveries but still displaying a lack of scientific completeness. As they reach the second

substage, at about age 15, the adolescent becomes scientifically complete in his thinking by not only making accurate discoveries but generating systematic and scientific proof for their hypotheses and assertions. This, from Piaget's standpoint, is considered full formal function.

Piaget believed that the development of formal operational thought during adolescence parallels the increased social interactions and group peer dynamics indicative of this stage of life. Adolescents evolve to group situations where cooperation is essential for maintaining its cohesion. Cooperation necessitates that adolescents exchange views and discuss each other's situations. They assume the roles of their peers and investigate the elements of given scenarios. This forces them to internalize elements of conversation and reflect abstractly. "As far as intelligence is concerned, co-operation is the first of a series of forms of behavior which are important for the constitution and development of logic (Piaget in Beard, 1969e)." The adolescent begins to construct imaginary worlds resulting in the emphasis of his own world becoming less intrusive and he is able to reason more objectively. He is able to accept hypothetical propositions for the purpose of discussion. He can propose his own hypotheses and tests them systematically. He becomes able to extract general characteristics from reality and formulate general principles about it. Reasoning is not limited to concrete, directly existing properties but gives way to abstraction and the realm of the infinitely possible. Metacognition, in which the person is able to reflect on the dynamics of her own thinking process, becomes a tool through which the adolescent can assess the accuracy of her cognitive decisions. Finally, the adolescent "develops an ability to deal

with a wide variety of complex relations such as proportionality or correlation (Beard, 1969f)." Piaget designed experiments and tasks to test his theory of formal operational thought and compared the results of adolescents to children to show how the concrete operational level differs from the formal operational level. From his research on adolescent task performance Piaget constructed two primary models which reflect the thinking patterns of formal operations. He named them the sixteen binary operations (functions) and the INRC group (identity, negation, reciprocity, and correlativity). The sixteen binary operations of the formal operational thinker are basically the logical relations among task elements that are formulated by the thinker from the results of the task. The INRC group classifies the processes by which the thinker manipulates the logical functions to form proper conclusions about the relationships among them. The INRC group illustrates how the adolescent can perform operations on operations, that is, she is able to transform the sixteen binary operations further to reach conclusions about the relationships among them concerning a certain task.

One of the experiments which led Piaget to conception of the sixteen binary operations and the INRC group is the pendulum problem. In this experiment a basic pendulum was constructed by attaching a weight to the end of a string. The subject was instructed to determine, among four different variables, which variable had the greatest effect on the oscillatory speed of the swinging pendulum. These four variables were length of the string, weight difference, force of push, and height of release. The subjects could manipulate the four variable in any way they chose. Piaget discovered that although the concrete operational child could eventually determine that the length of the string had an effect on

the oscillatory speed of the pendulum, only the formal operational child concluded that the length variable alone determined oscillatory speed. The former is unable to isolate this one factor to alone be the controlling variable while the "child with formal operations can apply combinatorial reasoning and can exclude variables that do not have any effect (Wadsworth, 1971)." They exhibit ability for using scientific process by holding all factors constant with the exception of one variable in order to determine accurate cause and effect.

It is evident that Piaget had strong ideas regarding the existence of formal operational thought, a term he used to describe the cognitive processes involving the ability for abstract and logical thinking, introspection, and hypothetical reasoning. But the fact that even he did not regard this kind of thinking to be absolute in all people old enough to be classified in the formal operations period is an important point to emphasize. As a general rule, Piaget contended that the transition from concrete operations to formal operations is finalized by age fifteen. How general is this principle set forth by his stage theory? How certain can educators be that adolescents and even beyond into young adulthood are making the full transition to formal operational thought? Even if they seem to qualify as exhibiting full formal operational thought, is formal operations really the pinnacle of human intelligence? Are there tasks other than those conceived by Piaget which require more advanced thinking than what Piaget's concept of formal operational thought can generate? How does research beyond Piaget's efforts characterize formal operational thought and the development of its individual elements?

Elkind, in Psychological Science (1996), emphasized that Piaget generally assumed a universality of cognitive development based on the notion that intellectual functioning parallels the socializing process, the movement towards adulthood, and its subsequent process of assuming adult roles. There are too many variables in the socializing process and the transition to adulthood to assume a universality of intellectual development. Taylor shows support for this parallel in Childhood Education (1996). She quotes a constuctivist teacher, Burk, who stated that "children are social beings who do not develop in cognitive isolation from others (Burk in Taylor, 1996)." She emphasizes Piaget's position that understanding and cooperation developed through the construction of friendships and interactions with peers precludes and initiates advancements in cognitive development. Abbot in Educational Leadership (1997), supports Piaget's position that formal thought development is generally universal. He describes the concept of flow, when the brain is challenged to perform multiple operations simultaneously, as a state enabling us "to react to our environment while also thinking about many abstract matters (Abbot, 1997)." Abbot contends that this level of formal operational thought is evolutionarily inherent and developed because of the human need to respond to the social dynamics of civilization. Abbot relates brain flow to the concept of metacognition.

With regards to and in support of Piaget's sixteen binary operations, Van Den Daele proposes that "an additional ten binary nonstandard operations (Van Den Daele, 1996)" develop, preface, and combine with the process of Piaget's binary operations to create full

blown logical reasoning and formal operations. Therefore, Van Den Daele supports Piaget's theory but subjects it to revision.

Though subjects were children ages four through nine and too young to represent formal operational thinkers, an experiment by Bradmetz lends credence to Piaget's stage theory of intelligence development by revealing developmental patterns of "manifest indicators of heterogenous, homogenous, and synergic development of behavior (Bradmetz, 1996)" which represent an early stage and preclusion to formal operational thought.

Manini and Case (1994), tested 80 children ages nine to 19 using a balance beam to uncover their use of mathematical analysis to determine whether development of abstract reasoning occurs at the same rate. Although most subjects did show progression indicative of Piaget's theory of formal operations development, a significant minority showed test results which reflect variances in the theory. Valanides, in School Science and Mathematics (1996), tested 7th, 8th, and 9th grade students for formal operational thought development. "Abilities were measured in five forms of formal logical thought, namely, control of variables, proportional, probabilistic, correlational, and combinatorial reasoning...results showed substantial deficiencies in reasoning ability development (Valanides, 1996)." Comparison of male and female differences produced no significant result. This study debunks Piaget's theory. Subjects in this study were in the age range of twelve to fifteen and, according to Piaget's stage classification concerning cognitive development, should have displayed substantial evidence of formal operational thought development.

A study by Cherry and Stadler (1995): an "analysis of age-linked variations in implicit learning using a modified Nissen SRT task in younger adults and two groups of older adults (Cherry and Stadler, 1995)" led to results which break down evidence of Piaget's stage theory of cognition and universality of formal operations development. Results indicated significant differences in implicit learning abilities which support the argument that variations in formal thought development exist. Since deductive reasoning "has been explained as a result of the formation of mental models that are derived from semantically arranged information...linguistics becomes a basis for inferring logical relationships (Martin-Cordero and Gonzalez-Labra, 1994)." Thus, because different individuals organize and comprehend knowledge according to varying linguistics patterns and abilities formal operations development should not be considered the same and/or absolute for all individuals.

Ackerman (1996) refutes Piaget's claim that adolescence represents the point at which human's reach the cognitive development which reflects the highest form of intelligence, the most complete state of intellectual development to be reached. He theorizes that intelligence continues to develop and transform beyond adolescence. Ackerman claims that "adult intellectual development integrates intelligence-as-process, personality, interests, and intelligence as knowledge (Ackerman, 1996)."

Another example of criticism of Piaget's theory of stage development and the universality of cognitive patterns is a counter proposal which holds that "interpersonal intelligence is isolated from intellect levels and personality (Rosnow et al., 1994)." In addition, Metz,

in Review of Educational Research (1997), debunks the general assumption by Piaget "that the thinking of children develops in line with their age (Metz, 1997)." Metz emphasizes the importance of considering variances in cognitive development.

The dynamics of formal operational thought and its relation to academic success, problem-solving, and gender differences has been reported. Baird et al. (1996) tested the candidates of the Science Olympiad using the Test of Integrated Process Skills and the Group Assessment of Logical Thinking. Results showed that those candidates who revealed more advanced formal reasoning skills were more successful at the Science Olympiad. Vaquera et al. (1996) tested 83 Venezuelan high school freshman using the Group Assessment of Logical Thinking and obtained results positively correlating high scores on these assessments with success in select science classes. Foltz et al. (1995) tested 100 adolescents with a problem-solving proof task and a reasoning competence selection task. Results expressed a positive correlation between formal reasoning competence and a "developmental progression from an inductive to a deductive approach in construction of logical proofs in problem solving (Foltz et al., 1995)."

Trad (1994) indicates an interesting theory which relates development of formal operational thought in adolescents to their tendency to engage in risk-taking, experimental behaviors. Trad claims that this "risk-taking proclivity may arise because the adolescent is just beginning to consolidate the skills of formal operations thought, including abilities to predict behavioral outcomes, weigh options, select alternatives, and adopt the perspectives of others (Trad, 1994)." The undeveloped nature of formal operational thought during adolescence

precludes poor decision making. For example, "the teenager may be susceptible to...pursuing such risk-taking behaviors as the abuse of drugs and unprotected sexual activity (Trad, 1994b)."

A test of formal operations using spatial, numerical, and verbal problems was given to 225 females and 234 males 15 year olds by Lim (1994). Although results did not substantiate a gender difference in ability they did reveal "slight gender-related variations in the methods males and females adopt to solve formal operations...(Lim, 1994)." Within a study analyzing variance among adolescent contraceptive knowledge, attitudes, and behavior and cognitive development, egocentrism, and self-esteem, Holmbeck et al. (1994) utilized an 8-item formal subscale of the "How is Your Logic?" scale to assess formal operational thinking. Results produced significant evidence that males have better mastery of formal operations. The mean score on the subscale for males was 37.07. For females it was 33.34. Molloy et al. (1996) tested formal operations abilities of 35 - 13 year olds using a battery of five tasks including "measures of conservation of number and volume, the additive composition of classes, the pendulum problem, and a test of verbal reasoning...(Molloy et al., 1996)." Test results did not find any significant gender difference in formal operations abilities. Carr and Jessup (1997) conducted a study which examined the strategies that boys and girls use to solve math problems. They discovered that, among the first grade students tested, girls tended to utilize overt strategies such as counting on fingers while boys generally used memory strategies, which is indicative of abstraction and formal operations. Finally, Richardson (1994) examined gender differences concerning mental rotation task abilities and employed level of education as an

independent variable. The study showed men performing better on mental rotation tasks at the introductory undergraduate level but no significant gender differences in ability to succeed at mental rotation tasks at the advanced undergraduate level and the postgraduate level. "...these results confirm that gender differences in at least some aspects of mental rotation may be abolished by educational experience (Richardson, 1994)." Richardson proposes that any gender differences in mental rotation ability to be a result of sociocultural factors rather than biological predisposition.

Through all the theorizing of Piaget and the research which has served to delineate his findings it is clear that formal operational thought is a real and credible facet of human cognition and impertinent to the advancement of human nature. Formal operations give rise to all the innovation and higher level reasoning that sets humans apart from other species. Woods, in the Journal of College Science Teaching (1996), purports that optimal diagnosis in the medical process "involves early hypothetical conception of the patient's condition and the formation of working hypotheses (Woods, 1996)." These qualities are derivatives of formal operational thought. Williams et al. (1995) correlated the study of Newtonian physics and students' reasoning ability to show that "students who were reflective thinkers and could apply logic in a hypothetical situation had greater understanding of physics with minimum misconception than those who memorize without understanding the concept (Williams et al., 1995)." A 1995 Newsweek article highlighted a study that subjected Washington, D.C. high school students to an intensive summer program enforcing abstract learning, thereby increasing their test grades throughout the academic year.

Encouraging formal operational thought in students has its advantages. Ehrlich (1996) believes that hypothetical reasoning can be enforced and posits that "'What if' questions can encourage student participation which can lead to a broader understanding of scientific topics (Ehrlich, 1996)." Huffbenkoski and Greenwood (1995) propose that "analogies are effective in evoking their creative and critical thinking (Huffbenkoski and Greenwood, 1995)." Sigel lends credence to the importance of formal operational thought by proposing that teachers use a level of instruction and questioning with their students that triggers hypothetical reasoning; examples of such questions are those that "challenge students to think in the nonpresent, provides opportunities for alternative actions, challenges students to find alternative solutions for problems they have already solved, and help students understand that every object has more than one property (Ellsworth and Sindt, 1994)." In a final statement concerning formal operational thought and the strong possibility that there are variances in the universal development that Piaget's stage theory suggests, "Teachers should encourage their students to develop problem solving methods that are more suited to their particular cognitive styles (Niaz, 1996)." Sternberg (1994) writes, "Teachers should vary their teaching techniques to cater to a wide range of thinking (Sternberg, 1994)."

It is not self evident that formal operational thought, proposed by Piaget in his theory of cognitive development, is fully developed in all individuals by the age of 15. Discovering the variances and exceptions to his theory is necessary for the advancement of education and the understanding of human cognition. Additionally, it is not clear that Piaget conceptualized every cognitive task when he researched his theory and

subsequently defined the elements of formal operational thought. Today's students may face cognitive challenges which go beyond the dynamics of formal reasoning. Lastly, researching gender difference is always imperative for dissolving stereotypes and misconceptions about the advantages of one gender over another. The truth of a certain line of reasoning can only be substantiated by significant results.

Chapter 3: Design of the Study

Sample

The population from which the sample for this study was derived is college students. This study was basically descriptive in nature and not truly representative of the population. Nor was the sample drawn at random, for the subjects were selected on the basis of their residency in an on-campus apartment facility.

The sample included 34 male and 40 female subjects ranging in age from 17 to 21. Their class ranking ranged from a freshman standing to the senior level. Among the male subjects, 10 were freshman, 14 were sophomores, and 10 were juniors. Among the females, there were 13 freshman, 20 sophomores, 3 juniors, and 4 seniors. No person who varied from these particular age and class ranges were considered for study. The geographic backgrounds of the subjects varied only slightly from the common ground that most came from towns in New Jersey to live at the university. Ethnic backgrounds of the subjects varied considerably, for this sample was drawn from a college population which reflected a diverse student enrollment. This sample was composed of 45 white/Caucasian subjects, 9 Hispanic subjects, 17 African-American subjects, and 3 Japanese subjects.

Measures

The device used to assess the degree of formal operational thinking present among the sample was an analytical section of a practice test designed to prepare students who desire to take the GRE, or Graduate Record Exam. The section assesses analytical ability and also

logical reasoning ability. The analytical segment involved seven questions and the logical reasoning segment included five questions.

Questions one through four in the analytical segment required the test taker to decode and interpret numbered information and answer the questions in a way that fits a certain parameter. It was basically a cryptogram with limited possibilities. For each question, or parameter, five answer choices were provided (labeled A through E). Questions five through seven were constructed around the same premise and assess the same type of cognitive skill but provide a different scenario, or set of parameters. These questions were based on descriptors of a certain instructors six-week course on film genres.

The logical reasoning segment involved five separate questions. Each question was prefaced with a narrative or scenario. To accurately answer the question about the scenario the test taker had to make logical deductions and rule out inconsistencies and invalid hypotheses. Five possible answer choices, labeled A through E, were provided.

The test measures of this study, as mentioned previously, came from a past edition of the Graduate Record Examination (GRE). Prior to October 1992 the GRE was called the "Aptitude Test" and was originally published in 1936. The test taker, when taking the full version of the GRE, is allotted 3 hours and 30 minutes to complete the test. There are 7 equal sections; the test taker is allowed 30 minutes per section. The GRE is considered a general I.Q. and achievement test which measures multiple aptitudes. Aside from the analytical/logical reasoning sections, the complete GRE also includes verbal sections and quantitative sections.

Current mean scores for the GRE are: 481 for Verbal, 557 for quantitative, and 541 for analytical. Standard deviations are: 118 for Verbal ability, 140 for Quantitative, and 129 for Analytical ability. The standard error of measurement (SEM) is 40. The GRE was standardized using a sample which contained 54% women and 45% men and all subjects of the sample had received a Bachelor's Degree. This particular norming was conducted between the dates of October 1991 through October 1994 and involved a pool of 1,210,781 subjects for the verbal section, 1,210,576 subjects for the quantitative section, and 1,209,910 subjects for the analytical section.

Reliability coefficients for the GRE were determined from an internal consistency estimation/inter item consistency or Kuder-Richardson procedure. For the verbal and quantitative sections a reliability coefficient of .92 was found. The reliability coefficient for the analytical sections is .88. The Educational Testing Service states that typical reliability coefficients exceed .90-.93 for the verbal and quantitative sections and .86 for the analytical sections. The ETS also states that the test questions for the GRE are created by "experts." Performance on the GRE over the past 15 to 20 years reflects a relatively long term and stable performance reliability.

Design

Subjects were administered the assessment within their own apartments. Each was presented with a consent form which they were required to sign in order to proceed. The consent form states terms of confidentiality and alludes to the use of their test results. Also as a prologue to the actual test administration was a brief questionnaire to

obtain demographics of age, gender, ethnicity, geographic location, class level, major area of study, G.P.A., and two questions concerning past experience with tests of, or formal class instruction in, analytical and logical reasoning.

Each subject, upon completion of the consent form and brief questionnaire, was handed the test and told they would have 30 minutes to complete the assessment. If the subject did not finish the test in the allotted time, their results were excluded from consideration.

Testable Hypotheses

There were two testable hypotheses in this study. The first serves to examine any gender discrepancy in performance on the dependent variable, or analytical/logical reasoning assessment. The second hypotheses attempted to predict the overall performance results of all subjects combined:

Hypothesis One:

Null hypothesis: There will be a significant difference in the formal operational skills of men and women as measured by a test of analytical and logical reasoning.

Alternate hypothesis: There will be no significant difference in the formal operational skills of men and women as measured by a test of analytical and logical reasoning.

Hypothesis Two:

Null hypothesis: More than 50 percent of the test subjects will answer at least eight out of the twelve test questions correctly.

Alternate hypothesis: Less than 50 percent of the test subjects will answer at least eight out of the twelve test questions correctly.

Analysis

A two-tailed independent t-test was used to analyze the data concerning hypothesis one. It was two-tailed test because the null hypothesis was to be rejected if there was no difference in either direction. Two independent groups, male and female subjects, were being presented with the same condition, warranting an independent t-test. Hypothesis two was not to be subjected to a specific, structured statistical test but results were to be analyzed and presented for their descriptive value and significance concerning their support or non-support of Piaget's theory about formal operations and its specific aspects.

Restatement of Purpose

By analyzing the results of this assessment of formal operational thought it will be shown that Piaget's theory needs further delineation in regards to his statement that formal operations is in general, fully existent in individuals past the age of fifteen. This study also addresses the gender issue concerning this facet of cognitive development. It purports to debunk any past evidence which contends that there is a difference in the formal operational thought ability of men and women.

Chapter 4: Analysis of Results

Restatement of Hypotheses

Testable hypotheses included one which examined gender difference between performance and one which predicted overall performance of subjects, regardless of gender. A two-tailed independent t-test was applied to the data to evaluate the prediction of hypothesis one while a scan of the data and frequency analysis was sufficient to determine the accuracy of hypothesis two.

Hypothesis One:

Null hypothesis: There will be a significant difference in the formal operational skills of men and women as measured by a test of analytical and logical reasoning.

Alternate hypothesis: There will be no significant difference in the formal operational skills of men and women as measured by a test of analytical and logical reasoning.

Hypothesis Two:

Null hypothesis: More than 50 percent of the test subjects will answer at least eight out of the twelve test questions correctly.

Alternate hypothesis: Less than 50 percent of the test subjects will answer at least eight out of the twelve test questions correctly.

Interpretation of Results

Results of the testing of 34 males and 40 females were subjected to a two-tailed independent t-test to determine whether a significant difference existed between male and female performance. The t-test was run at the .05 alpha level. The results were as follows:

t=.369 95% confidence interval of the mean:

df=72

t72=.369, p<.05

Lower= -.6998

Upper= 1.0174

Significance (2-tailed)= .713

The null hypothesis of hypothesis one, which stated that there would be a difference in the formal operational skills of men and women, can be rejected.

A descriptive statistical analysis was used to test hypothesis two. While the null hypothesis predicted that more than 50 percent of the test subjects would answer at least eight out of the twelve test questions correctly the alternate hypothesis stated that less than 50 percent of the test subjects would do so.

The study involved the testing of 74 subjects, comprised of 34 males and 34 females. The best possible score on the test was a twelve, the worst was a zero. All subjects answered at least five questions correctly. Therefore, the range of scores for this study was between five and twelve. The mean score in the overall distribution of scores for the 74 subjects was a nine. The standard deviation was 1.84. Table 4.1 shows the clustering of subject scores in certain score ranges. As can be seen by the table, the highest score clustering occurred in the eight to 10 correct range. Table 4.2 displays the clustering of scores by gender. It is apparent that differences in scores according to gender is visibly, and as

Table 4.1
Clustering of Scores in Certain Score Ranges

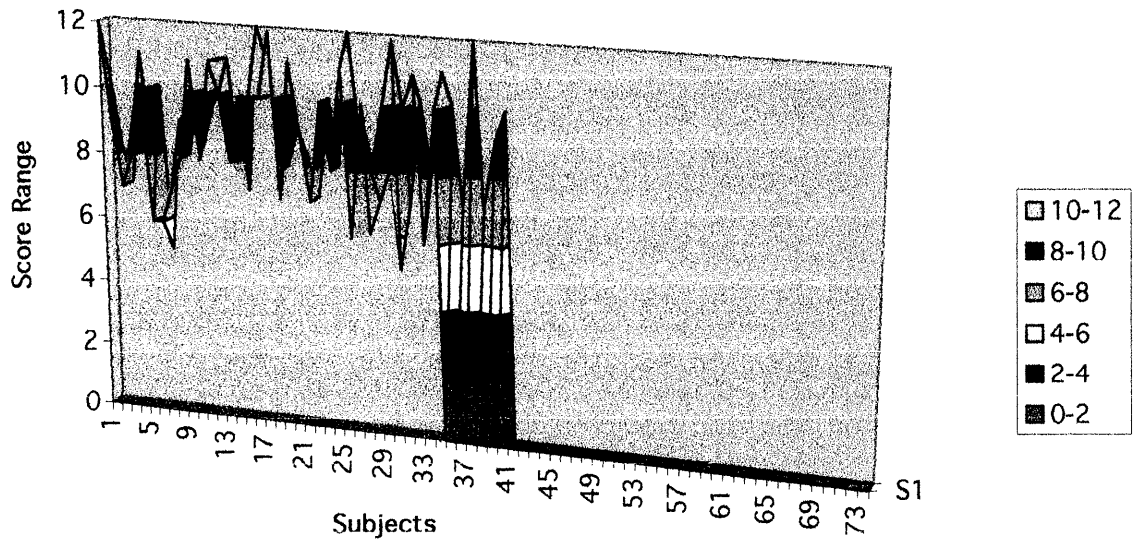
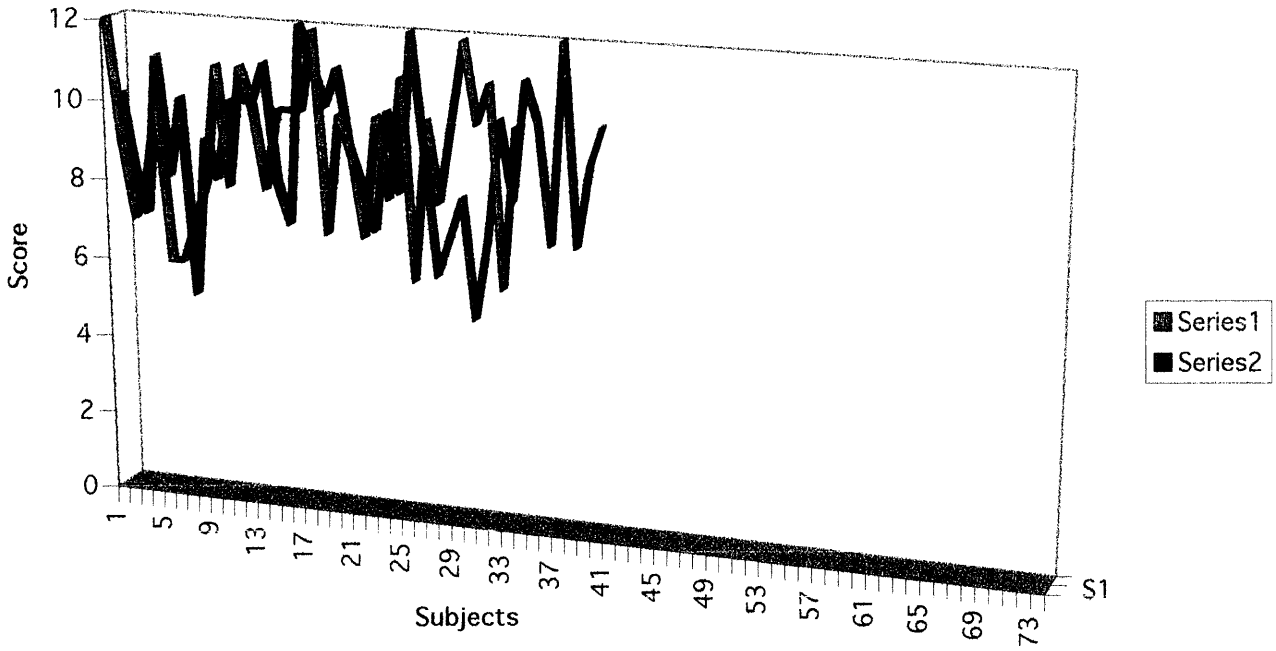


Table 4.2
Clustering of Scores by Gender



the t-test showed, statistically insignificant. Table 4.3 shows the frequencies for subjects and how many answered what amount of questions correctly:

Table 4.3
Frequency of Scores

Frequency(of subjects)	Amt. correct (score)

Thirty-seven subjects made up 50% of the test sample. Since 56 of the test subjects (about 75%) answered at least eight out of the twelve questions correctly, the null hypothesis of hypothesis two cannot be rejected. The alternate hypothesis, which predicted that less than 50% of the test subjects will answer at least eight out of the twelve questions correctly, cannot be accepted.

Summary

Based on statistical analysis of the test results, through the use of a two-tailed independent t-test, the null hypothesis of hypothesis one can

be rejected, confirming the alternate hypothesis which predicted that there would be no difference in the formal operational ability of males and females. According to a descriptive frequency analysis, it appears that the null hypothesis of hypothesis two, which predicted that more than 50% of the test subjects would answer at least eight out of the twelve questions correctly, cannot be rejected. Consequently, the alternate hypothesis of hypothesis two cannot be accepted.

Chapter 5: Summary and Conclusions

Summary

This study was undertaken to measure the formal operational thought capacity of the college student and unveil any gender differences regarding this ability. Formal operational thought is important to the success of every student because it implies the ability of humans to reason scientifically and analytically and to think abstractly. This study also proposed that realizing this ability, and understanding this capacity for formal operational thought in each student, would be a great asset to the educator.

It was understood that theories of development, and more specifically, the developmental process of human cognition, is in need of further research and scrutiny. Although there are many theories regarding this process, no one theory is held as complete or impervious to further investigation. Human cognitive development is a process, but it can take the form of advancement or digression, depending on the individual. The maturational process, determined by genetics, dictates the point at which an individual is "ready" to respond to different levels of learning.

Jean Piaget, one of the most notable theorists to map out the human developmental process, leaned towards the notion that cognitive development is strongly determined by genetics and generally universal, an idea which he called genetic epistemology. The development of

cognition, the processes involved in how an individual comes to know, was outlined by Piaget into four distinct stages, sequential, and as mentioned, universal. They are the sensori-motor period, preoperational period, concrete operational period, and the formal operational period.

The last period, that of formal operations, was the focus of this particular research. Piaget believes these operations include introspection, abstract thinking, logical thinking, and hypothetical or scientific reasoning. Piaget considers the formal operational period to be the highest point of intelligence, or the highest level of cognition obtained by humankind. He also contends that formal operational thought begins to develop by the age of 11 and completes development by 15. This proposition, along with an investigation into possible gender differences among formal operational thought capacity, became the focus for this study. How accurate is the contention that most people develop formal operational thought by the age of 15 and what, if any, are the gender differences concerning this ability?

It was hypothesized in this study that on a test of analytical and logical reasoning problems requiring formal operational thinking to answer correctly, fifty percent of the test subjects would answer at least eight out of the twelve test problems correctly. The other fifty percent of the test subjects would not answer at least eight out of the twelve test questions correctly. Thus, fifty percent of the test subjects would show that they are functioning at a formal operational level of thought and fifty percent would not. It was also hypothesized that the results of this analytical test would not reflect a significant difference in the scores of male subjects and the scores of female subjects.

34 male and 40 female college students were selected from an on-campus apartment facility to be part of the study. The sample ranged in age from 17 to 21 and represented class standings from the freshman to senior level. The subjects included 45 Caucasians, 9 Hispanics, 17 African-Americans, and 3 Japanese.

The measure used to assess the level of formal operational functioning of the sample was an analytical section from a practice form of the GRE, or Graduate Record Examination. The test contained 12 questions. The test was administered to the subjects in their own apartments and they were given 30 minutes to complete the assessment.

Hypothesis one, regarding significant gender difference, was analyzed using a two-tailed independent t-test. Hypothesis two, concerning overall formal operational ability of the sample, was subjected to frequency analysis.

Conclusions

1. There is no significant gender difference between the formal operational ability of college males and the formal operational ability of college females. Reject null hypothesis of hypothesis one.
2. More than 50% of the test subjects answered at least eight out of the 12 test questions correctly. Do not reject null hypothesis of hypothesis two.

Discussion

The results of this study lend credence to Piaget's outline of cognitive development, particularly that segment of his theory which

discusses formal operational thought. This research confirms his position of general universality concerning the development of formal operational thought and the notion that its development occurs largely by the age of fifteen. Though the subjects of this study were at least age 17, two years older than Piaget's proposed ceiling, it appears that his theorizing is fairly accurate. The results of the assessment of this study indicate that 75% of the subjects had a significant mastery of formal operations. Once again, these findings tend to support Piaget's theory. Not only is Piaget's theory of formal operations a very real element of cognitive development, but it is also a facet of cognitive development which one can be fairly certain will develop within the age parameters that Piaget proposes.

Past research concerning gender differences and formal operational thought show various findings. A test of formal operations using spatial, numerical, and verbal problems was given to 225 females and 234 males 15 year olds by Lim (1994). Although results did not substantiate a gender difference in ability they did reveal "slight gender-related variations in the methods males and females adopt to solve formal operations...(Lim, 1994)." This research supports the findings of Lim's study, which did not find a significant difference between the formal operational ability of males and females. Methods used to solve formal operations was not an element of this study and therefore correlation to Lim's findings concerning methods cannot be addressed here.

Within a study analyzing variance among adolescent contraceptive knowledge, attitudes, and behavior and cognitive development, egocentrism, and self-esteem, Holmbeck et al. (1994) utilized an 8-item formal subscale of the "How is Your Logic?" scale to

assess formal operational thinking. Results produced significant evidence that males have better mastery of formal operations. The mean score on the subscale for males was 37.07. For females it was 33.34. This research produced results which contrast the findings of Holmbeck (1994), for no significant gender differences were found.

Molloy et al. (1996) tested formal operations abilities of 35 - 13 year olds using a battery of five tasks including "measures of conservation of number and volume, the additive composition of classes, the pendulum problem, and a test of verbal reasoning...(Molloy et al., 1996)." Test results did not find any significant gender difference in formal operations abilities. Molloy's findings are supported by this study.

Carr and Jessup (1997) conducted a study which examined the strategies that boys and girls use to solve math problems. They discovered that, among the first grade students tested, girls tended to utilize overt strategies such as counting on fingers while boys generally used memory strategies, which is indicative of abstraction and formal operations. Carr and Jessup (1997) deduce that the memory strategies used by the boys in their study indicates more formal operational ability than the girls, who counted on their fingers. Whether or not this deduction is accurate, which seems a premature, unscientific assumption, the results of this research do not support the findings of Carr and Jessup (1997).

Finally, Richardson (1994) examined gender differences concerning mental rotation task abilities and employed level of education as an independent variable. The study showed men performing better on mental rotation tasks at the introductory undergraduate level but no significant gender differences in ability to succeed at mental rotation

tasks at the advanced undergraduate level and the postgraduate level. "...these results confirm that gender differences in at least some aspects of mental rotation may be abolished by educational experience (Richardson, 1994)." Richardson proposes that any gender differences in mental rotation ability to be a result of sociocultural factors rather than biological predisposition. Richardson's study sheds a positive light on the issue of gender difference for it correlates nicely with the feminist perspective which emphasizes the importance of sociocultural factors in the development of men and women. It also correlates well with this study, for it highlights the impact of higher education and the neutralizing effect it can have on gender differences. This research, like Richardson's, dealt with college students, and supports the notion that no gender differences exist between the formal operational thought abilities of men and women.

Implications for Future Research

If an extension of this study were made, to further the research on formal operational thought, one would have to consider sampling a larger pool of subjects for testing. The null hypothesis of hypothesis two, which predicted that 50% of the test subjects would answer at least eight out of the 12 test questions correctly, is, in retrospect, moderately lenient. A more tenuous hypothesis would better suit this investigation and better parallel Piaget's position of genetic epistemology, which itself is strict and very assuming of the universality of formal operational thought development.

However, although the null hypothesis of hypothesis two could not be rejected, the data shows that about 25% of the subjects did not

answer at least eight out of the 12 questions correctly. At face value, it would seem a substantial amount to question Piaget's position at least to some degree, especially since the subjects of this study were at least two years beyond Piaget's proposed age ceiling. Why did this amount of subjects fail to answer eight out of the 12 questions correctly? Further research should investigate this discrepancy. It appears, at least at some level, that Piaget's theory is not as universal as he proposed.

Finally, and as addressed in the literature review, there remains some questions to be answered concerning the possibility of gender differences regarding formal operational thought. At the very least, males and females, notwithstanding an equal capacity for formal operational thought, apparently utilize different strategies and methods when confronting formal operational problems. Further research which investigates these possible differences would further delineate Piaget's theory of cognitive development and be a positive step forward for providing equal education to all individuals, male and female.

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