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Psychological Type and Epistemology in College Freshmen, Elementary Teachers, Preservice Science Teachers and Scientists: Implications for Science Education Reform

Nancy Eaton Chadwell
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To the Graduate Council:

I am submitting herewith a dissertation written by Nancy Eaton Chadwell entitled "Psychological Type and Epistemology in College Freshmen, Elementary Teachers, Preservice Science Teachers and Scientists: Implications for Science Education Reform." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Claudia T. Melear, Major Professor

We have read this dissertation and recommend its acceptance:

Michael L. Bentley, Les Hickok, Mary Ziegler, Charles L. Thompson

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Michael Bentley

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Charles L. Thompson

Accepted for the Council:

Vice Chancellor
and Dean of Graduate Studies

PSYCHOLOGICAL TYPE AND EPISTEMOLOGY IN COLLEGE FRESHMEN, ELEMENTARY TEACHERS, PRESERVICE SCIENCE TEACHERS, AND SCIENTISTS: IMPLICATIONS FOR SCIENCE EDUCATION REFORM

A Dissertation

Presented for the

Doctor of Philosophy

Degree

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Nancy Eaton Chadwell

August, 2004

For
Haley Lynn & Parker Lee

(second things first)

When I looked into your faces
I found a brand new world and the rest of my life

ACKNOWLEGMENTS

I am grateful first and foremost to my mentor, Dr. Claudia Melear, for her insightful and caring guidance and for re-introducing me to Carl Jung, whose work would lead me through a path of discovery that words are not adequate to describe. I wish also to acknowledge the assistance of my Committee: Drs. Michael L. Bentley, Les Hickok, Charles Thompson, and Mary Ziegler, whose input was invaluable to me.

I thank all my teachers in the College of Education, especially Dr. Ralph Brockett, for not giving up on me when I refused to entertain the possibility of other ways of knowing. I had spent the last decade or so re-creating the thrill of discovery in Reproductive Medicine and I was sure my way of looking at the world was superior; I was wrong. I still think we should patent the "E.O. Wilson Litmus Test of Change!"

I have been both blessed and cursed with the desire to understand things in their fundamental form and I could not for the life of me figure out how Jung's *Intuition* got into the brain in the first place. All the books I read only showed information coming in through the external senses (from primary to secondary to tertiary association areas, etc.). I had talked myself into believing that perhaps Jung was wrong and what did it matter anyway? Surely dissertations are written every day without the author understanding every last theoretical detail, though this was an important one to be sure. Just when I thought I had come to terms with the situation, a lecturer appeared at Preston Medical Library where I was hanging out because I could park all day for just one dollar. I had just returned from having the twin's 2-year-old picture made when Martha, one of the most intuitive persons I know, told me I needed go hear a lecture given by some famous

neuroscientist. Since I always do what Martha says; I followed the crowd down the hall to the room reserved for conferences. The famous neuroscientist was Jaak Panksepp, who undoubtedly history will remember as a founding father of *Affective Neuroscience*, which is also the title of his book. Obviously this was not one of the books I had read, which is a good thing because I probably would have been too intimidated to ask questions had I the slightest inclination of the depth and breadth of that man's knowledge. Two things I will always remember. First, the exasperated look he gave his wife when we asked about research she'd heard of on the effects of exposure to testosterone on the girl half of boy/girl twins in utero (her brother still pays for that). Second, when I told him I was using an instrument based on the theory of Carl Jung, he raised one eyebrow and said, "Oh?" with a tone of curiosity and interest. I remember thinking; "a neuroscientist who has heard of Jung, now that IS really odd."

This was the beginning of a series of events that left me awestruck and dumfounded. I could not shake the feeling that these occurrences were just a little *too* coincidental. It was almost as if my dull senses were catching fleeting glimpses of an order much larger than myself connecting the dots. When I told my mentor of this she said, "synchronicity," "synchro-what-ity?" I asked. So of course that sent me off on another adventure (no wonder this dissertation took so long). It seems that something quite "irrational" is needed to shake rigid ideas of reality for those of us "especially steeped in Cartesian philosophy." Nothing budges in nature without necessity; this is a truism.

Thanking all the people who have helped me with this endeavor would be impossible, or at least double the size of my dissertation. I am grateful to my parents,

John and Joan Eaton, as are all children who grow up in an environment that fosters the love of learning. I appreciate the effort and sacrifices of my in-laws, Pauline and Harry Chadwell, whose help with the kids allowed me to get back on track with my dissertation, slowly but surely. Thank you, Rev. Tom and Nathan Schulman, who helped me to find answers to the questions I never could quite formulate. I would like to thank James Newby at the University of Tennessee Medical Center, Department of Continuing Medical Education, for just happening to have the photographs in front of him that I needed for Figure 1. I wish to thank Zen Master Brad Warner and his teacher, Gudo Nishijima Roshi, in Tokyo for finding a way to bring the ancient wisdom to where it is most needed. Brad, so happy you found "Southern" Enlightenment!

Most of all I wish to thank my husband, Michael, for supporting me through this long and tortuous journey. Change is not easy; I could not have done this without you. To our children, Haley and Parker, since no one has yet to show me a day when the world was not new, I hope you will always remember to use your brand new eyes. Every one is special, every moment precious, and if you go to school as long as mommy, daddy says you're on your own.

ABSTRACT

This study examined and compared patterns of perception and judgment measured by the Myers-Briggs Type Indicator (MBTI, Form G) and epistemology in four populations: college freshmen, preservice science teachers, elementary teachers, and scientists. The relationship between dual forms of perception delineated by the MBTI and adherence to the four epistemological dimensions assessed by Schommer's Epistemological Questionnaire (SEQ, 1990) was also investigated

A Chi-Square analysis assessing between-group differences in perception and judgment indicated that scientists were more likely to rely on intuitive perception and thinking judgment compared with college freshmen, preservice science teachers, and elementary teachers.

An ANOVA procedure to test between-group differences in epistemology revealed that college freshmen were more likely to view knowledge as the accumulation of isolated and unrelated facts than were the other groups. Conversely, scientists were significantly more likely to believe that knowledge consists of complex, interrelated concepts and ideas. While college freshmen differed from scientists and preservice science teachers in degree of adherence to a naïve perspective on the QUICK learning dimension (i.e., learning occurs quickly, or not at all), they did not differ significantly from the sample of elementary teachers. Elementary teachers were as likely as college freshmen to view the acquisition of knowledge as an immediate, all-or-none phenomenon, rather than a gradual process requiring sustained effort.

An Independent t-test revealed a significant difference between intuitive and sensory perceptive college students on the SIMPLE dimension of the SEQ. Sensory perceptive students were more likely than their intuitive counterparts to believe that knowledge consists of a collection of concrete, isolated, or unrelated facts. Study findings are interpreted within the context of the effort to reform science education.

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"If I were to wish for anything, I should not wish for wealth and power,
but for the passionate sense of the potential,
for the eye which, ever young and ardent, sees the possible."

Søren Kierkegaard

CHAPTER I

INTRODUCTION

OVERVIEW

Traditional science educational methodology involves the transmission of information by subject-area specialists inside of self-contained classroom settings. Outcome-based educational systems that employ teacher-centered delivery of content appear to promote skills needed to recognize and recall facts upon examination. The efficacy of this practice is being challenged on a number of fronts. Most notably by constructivist learning theory, which asserts that although *information* is easily transferable, *knowledge* cannot be transmitted from the instructor to the student. Rather, a student must develop understanding through an active process of assimilation and accommodation, usually through discourse practices.

Various components of reform efforts in science and math education support a constructivist learning theory framework (American Association for the Advancement of Science [AAAS], 1990, 1993; National Research Council [NRC], 1996; National Council of Teachers of Mathematics [NCTM], 1989; National Science Teachers Association [NSTA], 1995). For example, a central recommendation of current science education reform is for teachers to understand the process of scientific inquiry to the extent that

they can utilize this methodology in their teaching practice. The National Committee on Science Education Standards and Assessment asserts that, "inquiry into authentic questions generated from the students' experiences is a central strategy of teaching science" (1996, p. 21). These measures, that increasingly emphasize the role of the learner as "self-directed, critically reflective and creatively involved in theory building" (Anderson, 1997, p. 68), are an attempt to involve students in the learning process in a way that is qualitatively different from the traditional lecture, test-taking method. Similarly, the American Mathematical Association of Two-Year Colleges (1995) calls for decreased rote application and memorization of formulas and increased active student involvement in open-ended problem solving requiring mathematical reasoning and oral and written communication of mathematics.

Despite national, state, and local recommendations that inquiry-based instruction become an integral component of teaching, science educators are finding that new teachers all too often simply teach the way they themselves were taught (Wells, 1995). A survey conducted by the United States Department of Education (USDE), for example, found that nearly 70% of 12th grade students surveyed had never, or hardly ever, designed and carried out any type of investigation (1999). Lack of progress in the attempt to modify instructional methodology along a constructivist learning framework may stem, in part, from the fact the traditional educational system in the U.S. is based on behaviorist principals of rewarding students for recalling presented information on exams to demonstrate learning. While this methodology is practical from the standpoint of providing documentation, is it the best method we can we envision for educating our youth and inspiring intellectual pursuit to last a lifetime? Findings from comparative

methodological studies tend to support the claim that inquiry-based methods have positive effects on students' science achievement, cognitive development, laboratory skills, and science process skills compared with traditional approaches (Chang & Mao, 1998; Ertepinar & Geban, 1996; Geban, Askar, & Ozkan, 1992; Mattheis & Nakayama, 1988; Padilla, Okey, & Garrand, 1984; Purser & Renner, 1983; Saunders & Shepardson, 1987; Schneider & Renner, 1980; Wollman & Lawson, 1978). This and other evidence suggests that teacher-centered delivery of science content may not be the best instructional strategy for promoting long-term retention and interdisciplinary application of science information, nor is it ideal for engaging and maintaining student interest and enthusiasm for learning science, especially among young learners.

Opposing worldviews and epistemological frameworks may be a limiting factor in attempts to modify science and math educational practice. One manifestation of this problem in science education concerns the two philosophical perspectives generally referred to as *constructivism* and *positivism*. The constructivist view is opposed to the traditional positivistic account in a fundamental way because an internal process cannot be at the same time an object that lies external to the knower. James Wilkinson (1847), a member of the Royal College of Surgeons of London, gave an important lecture entitled, *Science for All*, in which he noted an interesting emergent epistemology among practicing scientists. Wilkinson's valuable insight was that many scientists were beginning to view scientific findings as a private possession, a collection of facts and ideas, meant to be judged for intent, impact, and credulity by a select group of peers (Hurd, 1998). Treating information as a commodity and calling it *knowledge* is problematic for the simple reason that it separates the knower from the process of

discovery. At least it explains how a "scientific literate" individual can be defined as one who "recognizes scientific researchers as *producers* of knowledge and citizens as *users* of science knowledge" (Hurd, 1998, p. 413).

The conflict between the concept of knowledge as a process versus an accumulation of external objects or facts was noted by Carl Jung in *Psychological Type* (1921/1971), which would eventually come to provide the theoretical foundation of the Myers-Briggs Type Indicator (MBTI). Jung proposed that these philosophical differences arise from a fundamental distinction in the way in which internal information (instinct and emotion) is valued and utilized (pp. 310-311). While information-processing pathways involving the incorporation of external sensory stimuli have been well characterized, the study of the representation of internal or somatosensory information by the neurocognitive system remains in its infancy (e.g., Cytowic, 1993; Furman and Gallo, 2000; MacLean, 1990; Panksepp, 1998).

NEED FOR THE STUDY

Little information regarding the nature of the epistemological or worldview differences in the effort to reform science education is currently available. Similarly, the relationship between the perceptual components of psychological typology and the formation of specific beliefs about knowledge and learning has yet to be systematically studied. Although numerous studies attest to the value of the MBTI as an essential research and assessment tool in science education (e.g., Baker, 1982, 1985; Gable, 1986; Lennon and Melear, 1994; McCaulley, 1976, 1977; Melear, 1989, 1990), the MBTI has

not been used to apply Jung's theory of dichotomous mental functioning to specific problems of an epistemological nature within the field.

The need to elucidate the nature of these epistemological or worldview differences is apparent at all levels of the educational system, from primary to post-secondary science education. Schommer (1998) suggests a link between the formation of certain beliefs about the nature of knowledge and teacher-centered, didactic methods that continues through undergraduate science training. Rigden and Tobias (1991) had faculty members and graduate students pose as "real students" and attempt to learn science in the typical undergraduate science classroom. The authors found that examinations stressed the memorization of isolated facts, with a special emphasis on single, right answers. Study participants posing as students were never asked to explain or elaborate on a concept, which may "lead the learner to believe that knowledge is merely a laundry list of facts" (Schommer, 1998, p. 553). The general consensus is that achieving the sort of instruction suggested by the standards for U.S. mathematics and science classrooms "will require reexamining deep-seated beliefs about teaching and learning" (NRC, 1999, p. 6). Many of these deep-seated beliefs are thought to be propagated by the structure of traditional educational practice and include: knowledge consists of isolated and discrete facts; knowledge is absolute or unchanging; the ability to learn is fixed at birth; and learning is quick or not at all (Duell and Schommer, 2001; Dweck and Leggett, 1988; Hofer and Pintrich, 1997; Kitchener and King, 1994; Perry, 1970; Schoenfeld, 1983, 1985; Schommer, 1990, 1992, 1993, 1998; Schommer and Walker, 1995).

Prospective science teachers are likely to experience the consequence of opposing worldviews when they begin undergraduate training as college freshmen (Duggan-Haas,

2000). In their introductory science classes, they sit among others who wish to become doctors, engineers, or scientists. Immediately, the science department or university structure begins to "weed out" large numbers of the scientifically inclined undergraduates and potential teacher candidates. As one engineering student explains,

> "They do the usual speech: 'Look to the right of you; look to the left of you. Forty percent of you won't be here next year.' I think that's the standard speech at every university" (Seymour & Hewitt, 1997, p. 123).

In college science classrooms, it is common place that students are lectured to, competition is fostered and collaboration is discouraged. Little support from faculty is available or encouraged at the initial juncture (Duggan-Haas, 1998, 2000; Seymour & Hewitt, 1997). Students in Seymour & Hewitt's study who planned to teach kept it from their science professors because of widely held beliefs of differential treatment. The competitive nature of science classes and potential outcomes are illuminated in the following quote from a male Hispanic engineering student who eventually transferred to another area:

> "The first two years here, all you think about is hoping you do better than everybody else— actually, you hope that everybody else fails... It's bad. It breeds competitiveness and singles out certain kinds of people to succeed, as opposed to other more gentle types of people—*people* people"
> (Seymour & Hewitt, p. 120).

Unfortunately, the process of weeding out discourages some of the best potential science candidates from becoming educators because an S.M.E. (Science, Mathematics, & Engineering) degree is in many cases required to teach science. In contrast, teacher

education instructors generally attempt to foster a classroom community by requiring collaboration and discouraging competition (Duggan-Haas, 1998, 2000; Salish, 1997). Rarely is the nature of these dual systems articulated and potential science teacher candidates are often left to navigate among the two environments with little social validation of the experience.

For new science teachers who manage to complete their formal training, deeply held beliefs about knowledge and learning may affect both the decision and the ability to use inquiry-based instruction as a teaching strategy in accordance with recommended standards (Bryan and Abell, 1999; Clandidnin and Connelley, 1992; Hofer and Pintrich, 1997). Teachers whose beliefs do not deter adaptation of the science education standards would nonetheless find the task of teaching accordingly daunting. The U.S. national standards in mathematics and science call for an approach to teaching in which students "actively explore mathematical and scientific ideas, ask questions, construct explanations, test those explanations, and communicate their findings to others" (NRC, 1999, p. 6). At the same time, the most sweeping education-reform legislation since 1965 (*No Child Left Behind Act of 2001*) dramatically expands the role of standardized testing in American public education (USDE, 2004). Important pedagogical issues are raised because historically, when standardized testing is mandated, there is a corresponding increase in drilling and test prepping or "teaching to the test" and even "dumbing down the curriculum." Instructional methodology is most likely determined, therefore, by what teachers and administrators believe will best prepare students to obtain high scores on the state exams. Given this climate, it seems unlikely that new secondary science teachers would readily adopt teaching strategies which allow students to actively explore scientific

ideas, construct and test hypotheses, and share their findings with others. In fact, when preservice science teachers were interviewed as to why they did not use inquiry methodology during their internships, the need to prep for the Tennessee Gateway exam was listed as a primary consideration (Brown, Bolton, Chadwell, & Melear, 2002).

Perhaps nowhere are the detrimental effects of the epistemological divide more strongly felt than at the level of primary education, promoting Wallace and Louden (1992) to ask why,

> ... after more than three decades on the reform agenda, elementary science teaching continues to disappoint? Is it because we haven't found the right 'formula,' or could it be that we have an imperfect understanding of the problem and unrealistic expectations for the solution (p. 508)?

Cobern and Loving (2002) argue that for some, "a critical engagement with science simply means studying more science. Their perspective is that science is itself unproblematic. Science is, in other words, a self-evident good" (p. 1017). Cobern and Loving found that while preservice elementary teachers valued the contribution of science to public health and the economy, they differed from a sample of scientists with regard to epistemology. Elementary teachers "clearly do not place science at the top of some epistemological pyramid nor do they consider science more important than religion" (p. 1026). "Resistance to science," the authors conclude, "cannot be reduced to the simplicity of science versus antiscience. There are competing worldviews across which communication remains difficult" (p. 1019).

Characterizing the personal epistemology of elementary teachers is particularly important as over a decade of studies in teacher education have illustrated the influence

of teachers' beliefs about teaching and learning on actual classroom practice (Artilles, 1996; Bowers & Flinders, 1990; Brickhouse, 1990; Briscoe, 1991; Bryan, 1997; Bryan & Abell, 1999; Clark & Peterson, 1986; Nespor, 1987; Pajares, 1992; Tobin & LaMaster, 1995). During the1994-1995 school year 500,000 fourth, eighth, and twelfth grade students from 41 countries took part in the Third International Mathematics and Science Study (TIMSS), making it the largest comparative international study conducted to date. Although most policy makers focused on the poor performance scores of American students, TIMSS-related research provides a wealth of additional information with regard to curricula, teacher practices, attitudes, and beliefs, including videotaped classroom activity for cultural comparisons between the U.S., Germany, and Japan. The in-depth analyses were useful for uncovering an epistemological discrepancy between what American eighth-grade math teachers articulate as being fundamental to the learning process and what they promote in practice. In general,

> Teachers in the United States say that students' success in mathematics is related to their ability to "understand" concepts. However, the typical U.S. lesson is consistent with the belief that school mathematics is a set of skills. In fact, 61 percent of teachers [on the videotaped lessons] said that the main thing they wanted students to learn . . . was how to perform a particular operation or to acquire a particular skill. Apparently, there is a mismatch between what teachers say is most important for students and the goals they set for individual lessons (NRC, 1999, p. 53).

In the U.S., "understanding" may be synonymous with the ability to memorize an equation or fact and subsequently demonstrate that learning has occurred by recalling the

item, or using the equation within a narrow context upon examination. In contrast, TIMSS-related research indicates that Japanese teachers allow students time to struggle with a problem and then participate in a discussion about how to solve it. For Japanese teachers, confusion and frustration are seen as a "natural part of the process and are useful to prepare the students for the information received during the discussion" (NRC, 1999, p. 53). In the U.S. such difficulties are often treated as an indication that preceding material was not mastered, or processed to the extent that it can be recalled on an exam, which usually results in didactic rehearsal of the previous lesson.

PROBLEM

Previous research has implicated epistemological or worldview frameworks as both important determinants of behavior and as possible sources of discordance in almost every sector of the educational system. No studies were found, however, that systematically explored the nature of these differences as a function of the habitual patterns of information processing described by Jung (1921/1971). Similarly, Schommer's Epistemological Questionnaire, which assesses four epistemological dimensions that have been linked to traditional educational methodology,[1] has not been used to characterize the belief systems of groups involved in the teaching-learning process with special relevance to science education reform. In addition, little information

[1] The SEQ assesses adherence to four dimensions of epistemology: 1) SIMPLE —ranging from knowledge is unambiguous, isolated facts to knowledge is highly interrelated ideas and concepts; 2) CERTAIN—ranging from knowledge is absolute and handed down from authority to knowledge is evolving; 3) QUICK—ranging from learning is quick or not-at-all to learning is gradual; 4) FIXED—ranging from the ability to learn is fixed at birth to the ability to learn can be changed.

is currently available describing how MBTI patterns of perception, defined as typical modes of becoming aware of information or experience (Myers, McCaulley, Quenk, and Hammer, 1998), might influence the shaping of epistemological beliefs along a positivistic or constructivistic framework. As characterized in the present study, individuals maintaining a positivistic framework tend to understand knowledge in object form and the acquisition of knowledge as derived from a collection of external facts. An individual structuring reality through a constructivist framework, on the other hand, tends to understand knowledge and the acquisition of knowledge as an internal process of assimilation and accommodation.

PURPOSE

The primary purpose of this investigation was to obtain information regarding epistemological or worldview differences in four populations involved in the transfer of information and the acquisition of knowledge that may serve to restrict the forward progression of educational change towards learner-centered practice. A secondary purpose was to investigate the relationship between the dual forms of acquiring information delineated by the MBTI and the formation of specific epistemological beliefs propagated by the structure of formal educational practice. Areas studied focused on uses of the MBTI in science education and factors affecting type expression, the relationship between patterns of perception/judgment and worldview, and the assessment of epistemology in education.

HYPOTHESES

To achieve the purpose of characterizing components of the epistemological and worldview differences described above, the Myers-Briggs Type Indicator (MBTI) and Schommer's Epistemological Questionnaire (SEQ) were administered to college freshmen, secondary-level preservice science teachers, elementary teachers, and scientists. The following null hypotheses were tested at a significance level of 0.05:

H_1: There are no significant between-group differences in patterns of perception and judgment as measured by the MBTI.

H_2: There are no significant between-group differences in adherence to the four epistemological dimensions assessed by the SEQ.

H_3: There are no significant differences between the two forms of perception distinguished by the S—*i*N scale of the MBTI and adherence to the four epistemological dimensions measured by the SEQ.

ASSUMPTIONS

The following assumptions underlie this study:

1. Individuals responded honestly to statements formulated to assess patterns of perception/judgment and degree of adherence to epistemological beliefs.
2. Individuals are predisposed to prefer and develop one of two forms of perception and judgment that can be identified by the Myers-Briggs Type Indicator.

3. Individuals and groups differ in the degree of adherence to select beliefs about knowledge and learning, which are discernable by Schommer's Epistemological Questionnaire.
4. The Myers-Briggs Type Indicator and Schommer's Epistemological Questionnaire provide valid and reliable measures of patterns of perception and judgment and degree of adherence to select beliefs about knowledge and learning.
5. Cultural norms, conditions, and practices influence both the expression of psychological type and the epistemology of an individual or group.
6. Constructivist learning theory approaches that call for the active rather than passive participation of the learner should be incorporated into the structure of formal educational practice.
7. Epistemological frameworks are important organizing strategies and filtering lenses for the structuring of experience. Development of one organizing framework in the perceptual domain (positivistic or constructivistic) and in the judgment domain (separate or connected) generally precludes development of the complement during initial psychological adaptation defined as the establishment of ego identity.
8. Development beyond ego identity is possible; it requires differentiation of all four functions in Jung's theory (*Sensing*, *Intuition*, *Feeling*, and *Thinking*) and coincides with a transformation of consciousness. This process of becoming represents ultimate psychological adaptation to the external environment.

LIMITATIONS

The following limitations underlie this study:

1. The instruments used to determine preference for patterns of perception and judgment and degree of adherence to epistemological beliefs are self-report, paper and pencil measures. They only evaluate what subjects perceive and are willing to relate about their psychological patterns and degree of adherence to select beliefs about knowledge and learning. Thus responses may differ from actual facts.
2. This study is limited by the reliability and validity of the instruments used to determine patterns of perception and judgment and degree of adherence to select epistemological beliefs.
3. The selection of study participants represents purposeful sampling by convenience thereby limiting the extent to which findings can be generalized.

DELIMITATIONS

The research analysis to test hypothesis three, no difference between patterns of perception and epistemology, was limited to the 60 students who completed demographic information on both instruments.

DEFINITIONS OF TERMS

The following are definitions of terms used in this study:

Active Apperception: A process by which individuals shape experience directly from innate ideational form leading to a subsequent valuation of subjectivity and the internal world (Jung, 1921/1971).

Connected Knowing: An epistemological framework or experience of the self as essentially in relationship or connected to others (Belenky, Clinchy, Goldberger, and Tarule, 1986; Gilligan, 1982; Lyons, 1983). Associated with a global view that includes the subject as part of the big picture in relation to objects and events occurring in the external world.

Constructivistic Framework: A theory, philosophy, or epistemological organizing structure or mechanism characterized by the view that knowledge acquisition is an internal process requiring active assimilation and accommodation of new content.

Cosmic Knowing: A transformation of consciousness beyond ego attachment and the connected knowing epistemological framework. Individuals reaching this stage of development "live on the side of transcendent actuality, universal compassion, and ultimate respect for being, rather than on the side of self-interest, parochial vision, and the measured standards of goodness and morality masking the concern of tribe or species" (Irwin, 2002, p. 190).

Epistemological Beliefs: Individual or shared beliefs concerning the nature of knowledge and its acquisition. Beliefs of this type are "deeply personal, stable, lie beyond individual control or knowledge and are usually unaffected by persuasion. They create an ideal or alternative situation that may differ from reality" (Nespor, 1987).

Feeling (F): The judgment function characterized by a tendency to order choices in terms of feeling values and emotional harmony (Myers, et al., 1998; Jung, 1921/1971). Internal somatosensory sensations linked to predisposed tendencies to act (instinct) and the energy potential of the nervous system.

First-rate Intelligence: "The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind, at the same time, and still retain the ability to function" (F. Scott Fitzgerald).

Intuition (*i*N): The perceiving function that is concerned with meanings, relationships, patterns, and possibilities (Myers, et al., 1998). Perceptions that cannot be traced back directly to immediate external sensory stimuli and that are intimately linked to innate energy potential (Jung, 1921/1971) and the function of the brainstem's *basal ganglia* (Llinás, 2000).

Judgment: A term that refers to the process of interpreting information; making inferences or drawing conclusions based on perceptions (Myers, et al., 1998).

Judgment Functions: *Thinking* (T) and *Feeling* (F). Also referred to as "rational functions." These functions retain the character of being "derived" rather than "given" and involve interpretation of ongoing experience (Jung, 1921/1971).

Myers-Briggs Type Indicator (MBTI): A self-report questionnaire designed to make Jung's theory of psychological types understandable and useful to clinicians and researchers (Myers et al., 1998).

Open Inquiry: An instructional methodology for teaching science where students formulate their own questions, test hypotheses, draw conclusions, and share results.

Passive Apperception: A process by which an individual is guided by the external material containing projected energy/feeling tone leading to a subsequent valuation of objectivity and the external world (Jung, 1921/1971).

Perception: A term that refers to the process of acquiring information or experience (Myers, et al., 1998).

Perceiving Functions: *Sensing* (S) and *Intuition* (*i*N). Perceptive functions are characterized as being "given" rather than "derived" (Jung, 1921/1971), and describe how an individual habitually becomes aware of information, either through the external senses (*Sensing*) or via internally generated somatosensory experience (*Intuition*).

Personality: Jung uses the term to denote the highest stage of psychological development that occurs or can occur only after primary psychological adaptation, which is the establishment of ego-identity. Personality is characterized by the differentiation of all

four mental functions such that the individual is capable of autonomously directing energy toward one or the other as the situation demands. Jung also describes personality as Tao (CW 17; in Storr, 1983, p. 210): "The undiscovered vein within us is a living part of the psyche; classical Chinese philosophy names this interior way 'Tao,' and likens it to a flow of water that moves irresistibly towards it goal."

Positivistic Framework: A theory, philosophy, or epistemological organizing structure or mechanism characterized by an understanding of knowledge in object form and the acquisition of knowledge as accumulated external facts.

Sensing (S): The perceiving function that is concerned with experiences available to the external senses, primarily vision, hearing, and touch (Jung, 1921/1971).

Separate Knowing: An epistemological framework or experience of the self as essentially autonomous or separate from others (Belenky et al., 1986; Gilligan, 1982; Lyons, 1983). Characterized by an "inside looking out" orientation that does not include the subject as part of a global picture.

Sensory Cognitive System: The stream of cognitive activity that emerges from the external senses and that is processed or percolated through the thalamus (Panksepp, 1998). Information processing pathways associated with *Sensing* and *Thinking* (Jung, 1921/1971) that are supported and maintained by the functional integrity of the left cerebral hemisphere (Joseph, 1992).

Somatosensory System: Information processing pathways animating from internal, visceral structures elaborated in the brainstem and hypothalamus (Panksepp, 1998). Pathways associated with *Intuition* and *Feeling* (Jung, 1921/1971) that are supported and maintained by the functional integrity of the right cerebral hemisphere (Joseph, 1992).

Thinking (T): The judgment function by which decisions are made through ordering choices in terms of logical analysis (Myers, et al., 1998).

Worldview: A basic psychological orientation or attitude that includes habitual patterns of perception/judgment and epistemological frameworks.

ORGANIZATION OF THE STUDY

This study is organized into five chapters. Chapter I contains an introduction of the study, a statement of the problem, the purpose and need for the study, assumptions, limitations, delimitations, definition of terms, hypotheses, and organization of the study. Chapter II is a literature review of psychological typology as it relates to the assessment of dual forms of perception and judgment and epistemological research in education. Chapter III contains a discussion of the methodology and study procedures. Chapter IV reports the statistical analyses of the data. Chapter V provides a summary of results and outlines conclusions and recommendations for further study.

CHAPTER II

REVIEW OF THE LITERATURE

INTRODUCTION

The purpose of this study was to investigate epistemological or worldview differences in four populations involved in the transfer of information and the acquisition of knowledge: college freshmen, preservice science teachers, elementary teachers, and scientists. A secondary purpose was to investigate the relationship between the two forms of perception delineated by the Myers-Briggs Type Indicator (MBTI) and the formation of specific epistemological beliefs propagated by the structure of formal educational practice. Patterns of perception and judgment were studied using the MBTI and data assessing epistemological beliefs was obtained through administration of Schommer's Epistemological Questionnaire (SEQ).

This literature review consists of three sections exploring the following topics: a) MBTI research in science education, b) psychological type and worldview, and b) epistemological research in education. The first section describes the perception (S—*i*N) and judgment scales (T—F) of the MBTI, reviews previous research using the MBTI in science education, and explores factors that might serve to shape perception and judgment over time. The second section relates patterns of information processing

described by Jung (1921/1971) to opposing epistemological frameworks and worldview. The third section introduces basic epistemological findings in education, discusses the various means of assessment, and comments on problems associated with the measurement of epistemological beliefs. Particular attention is paid in all three sections to implications for science education reform. A brief introduction to Type Theory (Jung, 1921/1971) is presented below to provide the reader with some background information on the subject.

MBTI RESEARCH IN SCIENCE

The theoretical foundation of the MBTI is based on *Psychological Type* (Jung, 1921/1971), which holds that seemingly random behavior can be attributed to consistent variance of information processing in the perception and judgment domains. According to theory of personality typology developed by Jung and expanded by Isabel Myers and Katherine Briggs-Myers, each person has an inborn preference for one of two forms of perception (*Sensing* or *Intuition*) and judgment (*Thinking* or *Feeling*) established through usage and positive reinforcement during childhood. Jung explains,

> The conscious psyche is an apparatus for adaptation and orientation, and consists of a number of different psychic functions. Among these we can distinguish four basic ones: *sensation*, *thinking*, *feeling*, *intuition*. Under sensation I include all perceptions by means of the sense organs; by thinking I mean the function of intellectual cognition and the forming of logical conclusions; feeling is a function

> of subjective valuation; intuition I take as perception by way of the unconscious, or perception of unconscious content (1921/ 1971, p. 518).

Traits associated with sensory perception include concrete observational skill, attention to detail in the environment, and a tendency to focus on external sensory experience. In contrast, intuition permits perception beyond what is available to the external senses. Individuals oriented towards intuitive perception are described as "imaginative, theoretical, abstract, future oriented, and original or creative" (Myers, et al., 1998, p. 24).

The act of forming a judgment or interpreting perceptions generally becomes habitual in one of two ways, *Thinking* or *Feeling*, and these patterns are also associated with overt characteristics. Individuals who are oriented towards *Thinking* tend to approach and solve problems in an analytic, logical, cause-effect manner; whereas, those oriented towards *Feeling* tend to make decisions and interpret perceptions based on universal values, personal meaning, and emotional harmony. Tendencies associated with *Feeling* include, "concern with the human as opposed to the technical aspects of problems, a desire for affiliation, warmth, and harmony, and a time orientation that includes preservation of enduring values" (Myers, et al., 1998, p. 157).

One of Isabel Myer's major contributions to Jung's theory was to elaborate the nature of the opposition between the primary perceptive functions and the secondary rational functions (J—P scale on the MBTI) at the level of expression. Individuals oriented towards the rational judgment functions (*Thinking* or *Feeling*) tend to utilize their mental capacity to seek closure or form judgments, whereas those oriented towards one or the other primary functions (*Sensing* or *Intuition*) prefer to remain open to perceptions.

Much of the literature relating psychological type to education in science centers on classification of individuals likely to be attracted to specific sub-disciplines. For example, McCaulley (1977) found that *i*NT (*Intuition-Thinking*) type preferences were more numerous in physics and engineering, SF (*Sensing-Feeling*) in nursing and education, and ST in the biological sciences. Melear (1989) surveyed 673 students in an introductory biology course and found the typical non-major's type to be ESFP, quite different from the science majors, typically found to be INTJ. Similarly, Baker (1982,1983) found all science majors expressed, "intuitive, thinking, judging personality found in scientists by the [MBTI]. Non-science majors exhibited the opposite personality type. They were sensing, feeling and perceiving" (1982, p. 14). Baker (1983) confirmed these results in a follow-up study in which she describes the "science-minded" individual as "intuitive, analytical, and logical, with the ability to impose order and come to conclusions from data" (pp. 104-105). Gable (1986) looked at type by occupation and found 77% of research scientists had an *i*NT preference. Similarly, most biologists in Melear's (1989) study were characterized as *i*NT—preferring Intuition and Thinking. In a more recent study comparing community college and university science students, researchers found the dominant type in both populations to be ISTJ (Herbster, Price, and Johnson, 1996).

In addition to the classification studies, researchers have looked at the relationship between perception and judgment type and achievement in science. Even though *Thinking* judgment is most often and consistently associated with the "science-minded" individual, the perceptive function, *Intuition*, is the stronger predictor of science scholastic success (Damico and Dalsheimer, 1974; MacKinnon, 1962; May, 1971;

McCaulley, 1976; McCaulley and Natter, 1974; Myers, 1962; Reynolds and Hope, 1970). MCCaulley (1976) suggests that intuitive types outperform on multiple choice tests and various academic aptitude measures because they typically deal with problems in a "symbolic and abstract way" and "draw out concepts from written material" (p. 6). Myers et al. (1998) refer to sensory perceptive individuals as "knowledge realists" because they tend to be primarily concerned with incorporating and interpreting concrete reality by way of vision, hearing, touch, etc. Intuitively perceptive individuals the authors refer to as "knowledge idealists," meaning that they often see beyond the concrete to make inferences holistically. For example, a *Sensing* student might examine each possible answer on a multiple choice test item as a single entity, whereas a person relying on intuitive perception might surmise the intent of the entire problem while weighing and eliminating choices based on subtle cues in language pattern. According to McCaulley (1976), intuitively perceptive students may also be advantaged for the simple reason that most of the creators of scholastic achievement tests are themselves intuitively perceptive.

Because the MBTI is designed and marketed as an instrument to detect inborn personality traits, few studies have investigated how perception and judgment might be influenced by the norms of the particular social group or subculture. Early work in social psychology, however, reveals "the readiness with which people will adapt to a social situation and mirror its expectations" (Irwin, 2002, p. 68). Irwin writes, "cognition, to the extent that it reveals itself in social behaviors, has been shown to function to reflect group-achievement norms, to be a consensus maker and not a consensus breaker." Irwin describes Asch's experiment in which individual's perceptions of line length, for example, could be made to conform to group norms even when the group perceptions were

purposively inaccurate. Milgram's studies involving obedience to authority, "revealed the extent to which people will inflict pain on others simple because they are told to do so" (Irwin, p. 68). And Zimbardo's prison studies conducted at Stanford University, Irwin writes, "indicated that normal college students, without any apparent psychopathology, can be induced to behave in both passive-dependent or authoritarian-aggressive ways, assuming the roles required by their costumes and their environment, roles dictated by the situation." These findings accord with Jung's contention that the conscious psyche is an apparatus for psychological adaptation, which would include adaptation to one's social environment and cultural conditions.

Support for environmental modification of perception and judgment comes from cross-cultural studies where researchers have found certain cultures and subcultures reporting low preference scores on dimensions related to instinctual/emotional processes and the primary perceptive functions (Battle, 1989, 2001; Ismail, 2000; Jobbagy & Takacs, 1994; Van Rooyen, 1994). While exploring the emerging democracy in South Africa, for example, Van Rooyen (1994) found that only 1% of Black South Africans report a preference for *Intuition* and *Feeling*. Jobbagy and Takacs (1994) surveyed 471 participants in Budapest, Hungry and wondered why males over 35 were showing low scores on the *Feeling* dimension. Ismail also found low preference scores for *Feeling* and *Intuition* in a survey of 1,382 Malaysia managers. In Trinidad and Tobago, Battle (1989) found that 100 percent of Chinese businessmen expressed a preference for the rational judgment functions (J on the J—P scale), and Chinese men and women combined showed no preference for the *Feeling* dimension.

Taken as a whole, these cross-cultural studies indicate a trend away from reliance on indigenous internal informational sources and the primary perceptive functions towards external sensory perception and the rational judgement functions. "If Type presents us with qualitatively distinct inborn preferences," Battle (2001, p. 2) asks, "are we saying that some groups and/or sub-groups do not enjoy some of these preferences?" A more likely explanation might be that individuals and groups tend to modify perception and judgment in order to adapt to changing environmental conditions that increasingly reflect the perceived values and beliefs of Western culture.

What are the perceived values and beliefs of the West? Jungian analyst Marie Louise Von Franz refers to the "active-masculine stance" and "one-sidedly extraverted attitude toward life, with their corresponding values and ideals," which have been dominant in Western society for quite some time" (1980, p. 87). Her colleague, James Hillman, also speaks of the "extraverted and masculine oriented culture with its collective repression of feeling" (Von Franz & Hillman, 1971, p. 147). The "rational-empirical" model of science in the West has been recognized and critiqued by a number of theorists and psychologists (e.g., Herman and Korenich, 1977; Kuhn, 1962; Maslow, 1966; Polanyi, 1946, 1974, 1974). Fudjack and Dinkelaker (1994, p. 3) describe the orientation in terms of psychological typology:

> The present imbalance in our society, manifest in a statistical domination of the ESTJ, has its roots in deeply embedded historical biases in the West. Western society, for quite some time now, has been a predominantly extraverted (object-oriented - i.e., attending to the 'hard' sciences), rational-empirical in approach, with an emphasis on materialism (commonly associated with a predominance of

the 'sensing' function) and pragmatic 'doing' (associated with 'J') as opposed to 'being' (associated with 'P').

Herman and Korenich assert that in our exclusive devotion to the logical and rational we have "cut ourselves off from a great deal by blocking out much of our access to intuition, inspiration and other noncognitive resources in our lives" (1977, p. 220). The case that the authors make is that "much can be gained by learning how to let go of your cognitive, intellectual processes from time to time," a contention long supported by Eastern religions and philosophies (e.g., Zazen and Tao).

In summary, MBTI research studies in science education clearly associate the "science-minded" individual with a preference for the rational judgment functions in general (J), and the *Thinking* (T) preference in particular. Attempts to classify the scientifically inclined individual by perception (*Sensing* versus *Intuition*) have produced mixed results. Myers et al. (1998) refer to sensory perceptive individuals as "knowledge realists" and intuitively perceptive individuals as "knowledge idealists." Knowledge realists tend to be primarily concerned with the facts available to the senses, while knowledge idealist tend to concern themselves with possibilities not available to the senses. No studies were found that specifically link MBTI perception to epistemological frameworks referred to as positivistic and constructivistic in this study. The role that the environment plays in shaping perception and judgment or the expression of psychological type is not clear. The available evidence suggests that modification of both perception and judgment in accordance with the prevalent social order and dominant culture is a likely occurrence.

PSYCHOLOGICAL TYPE AND WORLDVIEW

Activity on the left side represents the transcendental, intuitive, holistic realm of human life; activity on the right side represents the material, rational and analytic realm.

The balanced scale of Libra on the left symbolizes emotional harmony and a scorpion on the right symbolizes the analytic approach to life.[2]

During September of 1913 Jung lectured at the Psychoanalytic Conference in Munich citing examples of the "numerous witnesses in literature to the existence of the two types of mentality," in which he thanked William James for "the best observations in this respect" (1921/1971, 501). James (1911) variably described each temperament type by the terms, *tender-* or *spiritually-* minded and *tough-* or *materially-* minded. The former worldview James characterized as idealistic and devoted to "abstract and eternal principles" with a tendency to start with a holistic construct and attempt to unite experience to fit or fill the abstraction. The tough-minded are the "lover of facts in all their crude variety" who begin with the individual parts and build the pieces into an assemblage (p. 8). As Jung would later explain (1921/1971), James' designation reveals components of both perception and judgment that are opposite or compliment to one another. *Sensing* and *Thinking* are associated with the "tough-" or "materially-" minded delineation, whereas *Intuition* and *Feeling* are aligned with "tender-" or "spiritually-" minded as explained below.

Mention of opposing worldviews similar to what James and Jung describe can be

[2] Anonymous (quoted in Horrobin, 2001). Each hemisphere attends to the contralateral side. In most people, the right hemisphere controls the left hand and attends to the left side of space, whereas the left hemisphere controls the right hand and attends to the right side of space.

traced back at least to the teachings of Gautama Buddha (463-383 B.C.). Gudo Nishijima Roshi (Luetchford, 2000) explains that Buddha taught the existence of four worldviews, two that are unique to Buddhism and two that have become endemic to western civilization. Of the latter,

> one viewpoint is based on thought, and is usually known as idealism. It embraces the subjective view, and most branches of philosophy. The second viewpoint is based on matter, and is usually termed materialism. It includes all the sciences, and is an objective, physical view of the world (p. 8).

The long history attesting to dichotomous mental functioning suggests the possibility that such differences reflect underlying physiological processes or a predisposition inherent to nervous system design and function.

A number of advances in cognitive neuroscience serve to clarify the nature of this dichotomy at the level of physiology. The act of perception is no longer considered the simple encoding of externally derived sensory stimuli on the *tabula rasa* as was once thought. "The critical notion that was missed for some time by many neuroscientists," Furman and Gallo (2000, p. 271) explain, "was the understanding that while the nervous system is sampling the outside world, it is simultaneously sampling the internal world of physiological response via an elaborate network of interoreceptors referred to as the somatosensory system (Damasio, 1994)." Upon sensing a visual object in the external information field, for example, the prefrontal association cortex of the right hemisphere links information about emotional state and body sensations to the image being encoded. When the image is reconstructed internally, or "called up in working memory via the prefrontal cortex," (Furman and Gallo, 2000, p. 264), specialized pyramidal cells index

the reassembled visual image with concurrent somatosensory data about physiological state (Damasio, 1994; Goldman-Rakic, 1987, 1992). This process represents one way meaning is assigned to perceived objects and events stored in memory "so that at a later date we can formulate an adaptive physiological and biochemical response to any similarly perceived event in the information field" (Furman and Gallo, p. 271). The neural circuitry subserving this function is so "elaborate and far reaching that it makes possible higher-order brain processes such as reasoning, decision making, problem solving, future planning, and the encoding of time" (Furman and Gallo, p. 265). Perception, therefore, is an active, dynamic process "as opposed to sensing, which is a more passive process" (Furman and Gallo, 2000, p. 270). The external sensory pathways do not execute sensations, they only serve to inform the internal context about the external world (Llinás, 2001).

Joseph (1992) expanded Jung's theory of complement forms of perception and judgment by linking each half of the perception and judgment dichotomy to lateralized functioning of the left and right cerebral hemispheres. Instinct, emotion, and intuition animate from within and depend on the functional integrity of the dominant *somatosensory* cortex located in the right hemisphere. Conversely, the incorporation of sensory information[3] and internalized language processing (*Thinking* in words) are associated with the dominant sensory cognitive system, supported and maintained by the functional integrity of the left cerebral hemisphere (Joseph, 1992).

[3] Imaging studies show regional blood volume increases in the *left* prefrontal cortex during encoding of externally derived sensory data (Kosslyn, 1994; Posner and Raichle, 1994; Roland, 1993).

Increasing complexity in living organisms is dependent on semi-permeable boundaries or membranes that separate gradients of informed matter (Furman and Gallo, 2000). Hemispheric specialization was the last organizational system to emerge (Ornstein and Thompson, 1984). With lateralized functioning came the ability to process in parallel and both project, the forward extension of events in time, and reflect, the backwards extension of events in time. Throughout the course of evolution duplicate body parts have been exploited to permit the emergence of new modules (Ramachandran, Stone, Rogers-Ramachandran, McKinney, Stalcup, Arcilla, Zweifler, Schatz, and Flippin, 1996). "It would be surprising, therefore, if the redundancy inherent in the two cerebral hemispheres had not been exploited in this manner" (Ramachandran et al., 1996, p. 43). These accomplishments require a spatial (here) and temporal (now) reference point, which may have given rise to the internal marker or amalgam for *self* (Anderson, 1992).

Symbolic skill, creative intelligence, and cultural achievement advanced suddenly approximately 120 to 140 thousand years ago.[4] Combined with hemispheric specialization these changes greatly enhanced computational power and learning, yet added a layer of complexity by creating dual control systems for the management of the innate action-readiness potential of the nervous system. Jung referred to this phenomenon as a splitting of instinct, an inherent consequence of nervous system design that is antagonistic to the completion of psychological adaptation or the development of personality as he defined it. The sensory cognitive and somatosensory control systems

[4] Pre-humans lived in cultural unity with a glacial rate of change in mental functioning for 2 to 4 million years. The exact cause of neurocognitive modification remains a mystery. One theory is that a mutation in the phospholipase A_2 group may have disrupted the generation and recycling of arachidonic acid during phospholipid metabolism altering cell-signaling transmission and loosening neuronal coupling (Horrobin, 2001). Loosening of the neuronal coupling is associated with creativity and novel permutations.

are separated by important physiological and functional differences that restrict psychological unity and render autonomous personal direction of energy/attention difficult. Conscious awareness of duality is limited, and information-processing regularity tends to shape a one-sided internal model of reality as development ensues (Joseph, 1992).

To summarize thus far, instinct, emotion, and intuition animate from within and are related to somatosensory information processing controlled and maintained by the right hemisphere; whereas the incorporation of external sensory information and internalized language processing (thinking in words) are associated with left hemispheric processes and sensory cognitive information processing. Panksepp explains that the major information processing pathways for the incorporation of sensory data and cognition are one and the same, and distinct from hypothalamic-limbic pathways that process internal information, instinct and emotion. "In general," Panksepp writes, "the stream of cognitive activity emerges from the external senses, whence information is conveyed to and processed in the thalamus before being distributed to and reintegrated in the cortex." Emotional activity, in contrast, is "intimately linked to visceral processes," first elaborated in the brain stem and then the hypothalamus (p. 69). A number of differences between sensory cognitive and somatosensory information processing have been described, including the source of pattern propagation (external versus internal) and the mode of pattern transmission. While sensory cognitive information travels in restricted electrochemical form primarily confined to the neural-net or network of nerve cells, somatosensory information travels in diffuse biochemical or hormonal form,

rendering this type of information capable of affecting a number of other systems simultaneously (Furman and Gallo, 2000).

The "science-minded" individual is generally associated with habitual information processing in the sensory cognitive system under left hemispheric control. According to MacLean (1990), the "neocortex subserving 'intellectual functions' appears to be primarily oriented toward the external world" and what can be known about it through sensory perception or some extension thereof (i.e., the microscope, telescope, sonar radar, etc.). "This may help to explain why the sciences from the very beginning have focused on the outside world," MacLean asserts, and perhaps why there has been a lack of interest in "turning the dissecting lamp of the scientific method onto the inner self" (p. 5). Jung believed that science could not concede to internal, instinctual informational sources or subjective processes "as long as it maintains that the only things that really exist are elementary facts perceived by the senses" (1921/1971, p. 310).

Not surprisingly, little is known about the representation of instinct in the neurocognitive system beyond the understanding that it is predominantly a function of right hemispheric information processing. Ramachandran et al. (1996) assert that "during ordinary waking life the left hemisphere engages in 'on-line' processing of sense data, including the temporal ordering of experiences and the imposition of consistency and coherence" (p. 52). Jung recognized that there was something qualitatively different about the on-line processing of sense data compared with the presentation of internal somatosensory experience through his collaboration with theoretical physicist Wolfgang Pauli (Storr, 1983). The principle of complementarity in physics is based on the *Pauli Exclusion Principal*, which states that no pair of identical particles can simultaneously

occupy the same quantum energy state (Furman and Gallo, 2000). Pauli's work contributed to the understanding that the constituents of matter are simultaneously waves and particles, the cornerstone of modern physics. How the observer chooses to observe or measure these constituents determines their essential character. Satinover (2001, p. 124) explains, "Upon detection, these waves assume the form of matter (localized as a particle) so that information comes into existence that previously did not even exist (before detection, the 'particle' had no location)."

Wave-particle duality refers to a synchronistic entity, therefore, whose essential character is both material and non-material in form: when in the material form the location and velocity of elemental particles can be determined, when in the non-material (wave) form, configuration and momentum can be assessed. Even though our sensory systems are not able to detect the conversion from matter to energy and vice versa described by wave-particle duality, that it occurs has been determined by decades of speculation and experimentation. "As Einstein predicted, there are *no* 'fundamental building blocks' to be found, 'matter' itself is energy in different states of motion defined by the famous equation $E = mc^2$" (Furman and Gallo 2000, p. 54). If we could detect the free conversion of matter to energy, which would require temperatures too high to sustain life, rocks and other inanimate objects would explode like hydrogen bombs.

According to both Jung and Pauli, the human psyche, which is a non-linear, self-organizing quantum system, operates on the same principal such that the observer (conscious self) cannot detect the original essential quality of unconscious content without altering its form. As will be explained below, the altered form is the product of temporal coherence, an inherent property of thalamocortical circuitry (Llinás, 2001).

"When an unconscious content passes over into consciousness," Jung wrote, "its synchronistic manifestation ceases; conversely, synchronistic phenomena can be evoked by putting the subject into an unconscious state, or trance" (Storr, 1983, p. 338). Pauli shared Jung's view that scientific laws and theory often derive from innate sources in addition to direct observation of the external world. On the process of discovery Pauli writes, "intuition and the direction of attention play a considerable role in the development of concepts and ideas" (Storr, 1983, p. 334).

In order for conscious awareness to proceed with such clarity and "wholeness" as to enable the detection of cause-effect relationships, "the brain's simultaneous incorporation of billions of pieces of sensory experience must be organized and re-presented in a sequential linear format" (Furman and Gallo, 2000, p. 42). Although the mechanism for parallel-sequential compression is currently not well understood, a promising theory for the binding problem is proposed by electrophysiologist Rodolfo Llinás (Springer and Deutsch, 1998, pp. 531-532). Llinás explains the compression mechanism on the basis of 40 cycle-per-second (Hz) brain wave activity, which reflects the resonant property of the thalamus, the hub-like center of thalamocortical circuitry. Briefly, the wave of nerve impulse samples or polls the cortical mantle once every 0.025 second, and the regions processing sensory input or otherwise actively stimulated are locked into the same rhythm as the scanning wave, and sent back to the thalamus in a precisely timed coherent pattern. Thus, the sensory messages of sight, sound, and subjective reactions to the same events are bound together and re-presented cognitively serving the immensely important function of making the world appear linear, sequential, and coherent. The process of combining "fractured components of external and internal

reality into a single construct" holds special ontological significance; "It binds, therefore I am!" (Llinás, 2001, p.126).

Within the confines of the re-presented material available to us during normal waking consciousness, hemispheric differences in the primary visual cortices have been found with implications for understanding epistemic divisions and possibly the splitting of instinct. James (1911) distinguished two typical organizing strategies: one is to start with a holistic construct and to unite experience to fit or fill the abstraction, and the other is to begin with the individual parts and build the pieces into an assemblage. One side of the brain is more adept at sorting and attending to close at hand visual information, while the other half has become specialized for global vision or the formation of gestalts. This functional distinction is symbolized in the expression that one it is at once impossible to "see the forest for the trees." While the trees represent the singular items or details, the forest is not just the sum of the trees but a gestalt, something more than the sum of parts.

Receptor field physiology (the elaborate tree-like branches on the receiving end of neurons) suggests that each visual cortex has become specialized to handle different types of external information. The receptor fields of the left hemisphere are small and nonoverlapping in comparison to those of the nerve cells in the right visual cortex. As such, incoming sensory stimuli are perceived as two-dimensional containing parts of a whole that move independently. This feature allows the left visual cortex, which controls the right hand and the right side of space, to discern local detail with high resolution. The left hemisphere also encodes color, a function thought to have emerged from the advantage afforded by close examination of food matter, most likely from the ability to

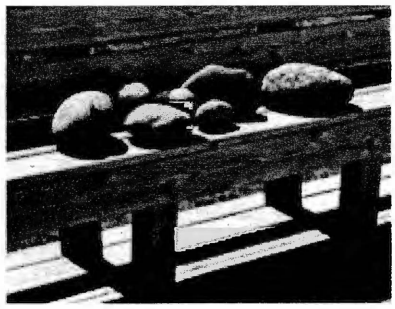
distinguish young reddish color leaves containing higher concentrations of protein (Dominy and Lucus, 2002).

As illustrated in Figure 1, the receptor fields of the right visual cortex are broad and overlapping and therefore more adept at processing visuospatial information, including three-dimensional objects that move in relation to the subject. The replication or calling up of visual imagery into working memory via the prefrontal cortex, is generally a function of right hemispheric processing as fewer neurons are involved and less energy required to complete the assemblage (Furman and Gallo, 2000). The left visual cortex is specialized for near or proximal visual discrimination that does not include the subject as part of the picture, whereas the right cortex is specialized for far or distant sightedness, including the subject in relation to external objects. The representation of instinct in the form of an image most likely occurs in the prefrontal region (behind the forehead) of the dominant right somatosensory cortex. Neuroanatomical and electrophysiological evidence indicates that the hypothalamic visceral (emotional) system has powerful ascending connections to the neocortex and that the *right* prefrontal cortex is differentially served (Davidson and Hugdahl, 1995; Furman and Gallo, 2000; Joseph, 1992; Roland, 1993). Jung writes that instinctual impulses and tendencies "are highly conservative and of extreme antiquity" in regard to both "dynamism and form" (CW 10, par. 547):

> Their form, when represented to the mind, appears as an image, which expresses the nature of the instinctive impulse visually and concretely, like a picture. If we could look into the psyche of the yucca moth, for instance, we would find in it a

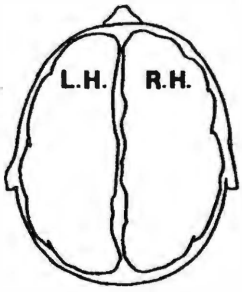
Image projects to RIGHT Cortex

Image projects to LEFT Cortex



Characteristics of the Left Visual Cortex

The LEFT visual cortex evolved special features enabling discernment of local detail and color of objects on the RIGHT side of space: Perception of the "trees."



Characteristics of the Right Visual Cortex

The RIGHT visual cortex receives information from the LEFT side of space and encodes motion as well as provides a global view that includes the subject as part of the picture: The "forest."

Figure 1. Lateralized Functions of the Left and Right Visual Cortex. Adapted from Furman and Gallo, *The Neurophysics of Human Behavior* (2000, p. 247). Photographs courtesy of James Newby, University of Tennessee Medical Center, Department of Continuing Medical Education.

pattern of ideas, . . . which not only compels the moth to carry out its fertilizing activity on the yucca plant but helps it to "recognize" the total situation.

"Instinct is anything but a blind and indefinite impulse," Jung concludes, "since it proves to be attuned and adapted to a definite external situation." Studies conducted by the late Francisco Varela, one of the founding fathers of cognitive science, support Jung's general premise that at least one component of instinct enables comprehension of the "big picture." In one study, for example, efficient nurses in an insect colony were removed to form a sub-colony, with the result that the nurse insects instinctively became foragers. Within the main colony previously low-level nurses increased activity to fit the changing demand. Finally, when efficient nurses (turned forages) were reinstated into the colony, they resumed their former high-level nursing duties (cited in Gray, 2002).

Interestingly, the lopsided appearance of the human cortex also suggests evolutionary pressure along this line. Expansion of the right prefrontal region may result from this structure's important role in coordinating memory with incoming stimuli, as well as for the internal representation of instinctual impulse in the form of imagery. The expansion in the left visual or occipital lobe may reflect the need to accommodate increasingly complex, detailed visual information (Figure 2). The most obvious manifestation of this dichotomy is that the left visual system allows us to see the "trees," whereas the right visual system allows perception of the "forest." Using the analogy of the yucca moth, left hemispheric processes enable daily proximal activity and attention to detail, while right hemispheric processes enable recognition of the total situation, including one's place in the ongoing flux of external events.

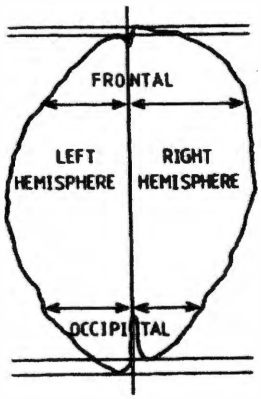


Figure 2. Asymmetrical Morphology or the Human Cortex. Adapted from *Human Cerebral Asymmetry*, Bradshaw & Nettleton, 1983.

Jung argued that instinct begins to loose clarity and distinction when the learning capacity increases to the level of the great apes and above. This implies an antagonistic relationship between the evolutionarily newer sensory cognitive system characterized by parallel sequential compression and the evolutionarily older instinctual systems. To be aware of the parallel aspects of information processing are actually quite common for humans during periods of "dreaming, therapeutic trance, and meditation" when the "brain undergoes a transition from a more ordered state (sequential, cause-effect) to a less ordered state" (Furman and Gallo, 2000, p. 42). During a waking state phase transition (therapeutic trance), dominant activity switches from the left to right cerebral hemisphere. The electrochemical activity of the brainstem during REM sleep is the "mirror image of waking" (Panksepp, 1998, p. 128), meaning neurochemicals that activate during waking, produce inhibitory effects during REM. The location and estimated age of the arousal system for dream sleep and other findings have led Panksepp

to speculate that REM may have been the original form of waking consciousness that had to be "actively suppressed in order for higher brain evolution to proceed efficiently" (p. 128). If waking consciousness is characterized by the on-line processing of sense data (proximal activity and detail), one manifestation of the splitting of instinct Jung refers to might be that the pattern of ideas that help us to recognize the larger picture occurs primarily during REM information processing.

If so, the fact that we can remember so little of dream content at the moment of waking may explain one aspect of the complicated internal conditions that prevent complete psychological adaptation in Jung's theory. With all the information processing during REM sleep, it is remarkable that humans can recall so little of it. "It is almost as if humans experience an amnesic syndrome similar to that which follows hippocampal damage" (Panksepp, p. 142). The hippocampus has long been associated with memory consolidation and is the structure often damaged in Alzheimer patients who forget significant life events because they cannot consolidate and store the memory. For example, they might continually ask where their spouse is, despite the fact that the loved is deceased. MacLean's extensive work with psychomotor epilepsy shows that during normal waking, the hippocampus acts as clasp for the integration of internally and externally derived experience. The processing of sense data is off-line during REM, however the electrical activity of the brain exceeds that of the waking state. Panksepp (1998) speculates that perhaps memory consolidation of a subtler type is occurring during REM. In the final analysis, REM "may help construct the many emotional myths and beliefs around which our individual lives revolve" (p. 140).

The disunity created by hemispheric specialization and the splitting of instinct between sensory cognitive processing during waking and somatosensory during sleep may be components of the complicated internal conditions noted by Jung as detrimental to complete psychological adaptation. In addition, Jung delineated an energic process in 1913 at the Psychoanalytic Conference in Munich that may have some bearing on the epistemic divide in science. He identified active and passive apperception, which approximate the epistemological differences between the constructivistic and positivistic frameworks outlined in the preceding chapter. A constructivistic framework follows from the understanding that knowledge acquisition is primarily an internal, subjective process, whereas a positivistic framework is characterized by the view that knowledge lies external to the knower and is capable of direct transmission. According to Jung the opposing temperaments identified by James "clearly show a different localization of libido[5]...which, depending on the individual, is directed sometimes to our inner life, sometimes to the objective world" (p. 503). The centrifugal (outwardly directed) tendency is to exalt the object in an effort to understand and dominate it, whereas the centripetal (inwardly directed) tendency is to empower the subject at the interface between the subject and objects and events occurring in the external world. [6]

Jung noted that the tendency to attribute or project feeling tone to external objects, people, and events is quite common in humans. As William James points out, we readily assume that the "man is really hateful; the action really mean; the situation really tragic—all in themselves and quite apart from our opinion" (1905, quoted in

[5] Whereas Freud used the term *libido* to refer to sexual energy exclusively, Jung used it to refer to the general energy/attention of the nervous system.
[6] Jung also used the terms *extraverted* and *introverted* to describe directed energy/attention.

Panksepp, 1998, p. 49). Individuals who habitually rely on either passive or active apperception are "opposed in a remarkable way," Jung writes,

> The one shapes the material out of his own unconscious idea and thus comes to experience [active apperception]; the other lets himself be guided by the material which contains his unconscious projection and thus comes to the idea [passive apperception].

The projection of feeling tone or energy externally leads to a valuation of the external world and a devaluation of the internal world, whereas the opposite occurs with active apperception, interest in external detail pales by comparison to the rich inner life of subjective experience. According to Jung, passive apperception is "oriented by sense impressions. As the result, the object is always emphasized; 'it' is the agent prompting him to insights and complicated ratiocinations" (p. 310). When thinking is oriented by active apperception, on the other hand, internally derived information "acquires the value of basic functions, or faculties or activities operating from within, because for him the accent of value lies on the concept and not on the elementary processes" (p. 310). Jung found the conflict created by these two orientating tendencies somewhat irritating, and at times responsible for the "most heated and futile scientific discussions" (p. 311).

Although it might be tempting to associate *Feeling* judgment with somatosensory, limbic, or visceral information processing exclusively, Jung clearly identified this function as *rational.* Previously proven adaptive functions are generally not discarded through the process of evolution, but rather new modules are added on to pre-existing ones thereby altering the function of both (e.g., Cytowic, 1993, Jung, 1921/1971; MacLean, 1990; Panksepp, 1998). All mammals have basic sensory input and instinctual

output systems; however, the capacity for rational thought (reasoning, rationalizing) is for the most part, uniquely human. Jung writes that the evolutionarily older primary input systems in humans, "are by their very nature opposed to the rational functions,"

> When we think, it is in order to judge or to reach a conclusion, and when we feel it is in order to attach a proper value to something. Sensation and intuition, on the other hand, are perceptive functions — they make us aware of what is happening, but do not interpret or evaluate it. They do not proceed selectively, according to principles, but are simply receptive to what happens. But "what happens" is essentially irrational (p. 539).

The ability to autonomously direct energy/attention and willfully exclude interfering or extraneous mental activity from conscious awareness is a function of rationality associated with the frontal lobes, particularly the prefrontal cortices located directly behind the forehead. These areas have been linked to personality ever since Phineas Gage survived a freak railroad construction accident that destroyed most of his frontal lobes (Harlow, 1945, cited in Heilman, 2002). Damage to the *left* prefrontal cortex appears to disrupt the forward directional component of energy/attention so that planning and the monitoring of ongoing activity to achieve future goals is impaired, while *right* prefrontal lobe damage is associated with changes best described as emotional indifference or apathy (Heilman, 2002).

The epistemic division at this juncture may be expressed as the difference between *separate* and *connected* knowing (Belenky, Clinchy, Goldberger, and Tarule, 1986). Table 1 provides a summary of information processing patterns as they relate to

Table 1. Information Processing Dichotomies and Worldview

	I	II
Pathways:	Sensory Cognitive	Somatosensory
Informational Source:	External	Internal
Perception & Judgment Type:	*Sensing* *Thinking*	*Intuition* *Feeling*
Visual Field Perception:	Proximal Subject "in-side looking out"	Global/Gestalt Subject part of larger picture
Apperceptive Type:	Passive Apperception	Active Apperception
Valuation Tendency:	External objects & events—Objectivity	Internal processes—Subjectivity
Epistemological Frameworks:	Positivistic Separate Knowing	Constructivistic Connected Knowing

epistemological and worldview differences. Gilligan (1982) and Lyons (1983) first used the terms separate and connected knowing to describe two experiences of the self, as essentially autonomous (separate from others, "inside looking out"), or as essentially in relationship (connected to others). A number of references connect separate knowing to science. In words reminiscent of those used by William James, Belenky et al. refer to separate knowers as "tough-minded (1986, p. 104):"

> When presented with a proposition, separate knowers immediately look for something wrong—a loophole, a factual error, a logical contradiction, the omission of contrary evidence. ... Separate knowers ... are especially suspicious of ideas that feel right; they feel a special obligation to examine such ideas critically (Francis Bacon advised men to avoid 'whatever the mind seizes and dwells upon with peculiar satisfaction').

Bacon should have heeded his own advice or perhaps this is an example of a self-regulatory mechanism between rational and irrational processes frequently noted by Jung. In either case, Bacon's "death in the early spring of 1626 was symbolically condign," Wilson (1998) writes, "the result of an impromptu experiment to test one of his favorite ideas" (p. 25). The role of skepticism in science is spelled out in the *National Science Education Standards* (NRC, 1996), which claim "science distinguishes itself from other ways of knowing and from other bodies of knowledge through use of empirical standards, logical arguments, and *skepticism*" (p. 201, italics added). With regard to objectivity, "separate knowers try to 'weed out the self' so that the flowers of pure reason may flourish" (Belenky, et al., 1986, pp. 109-110). "Disinterested reason is, of course, one of the highest of human achievements," the authors note, "and separate knowers appreciate

it. ...They believe they can see more and see more clearly than they could when blinded by their own passions and opinions."

In connected knowing there is an understanding that the "most trustworthy knowledge" comes from inner experience rather than from outside sources (Belenky, et al., p. 112). The authors assert that connected knowers develop means of gaining access to the knowledge of others through their capacity for empathy. Connected knowers begin with the premise of connection, which sometimes requires a letting go of attempts to control. As Noddings (1984) observes, "this sort of passivity...is not a mindless, vegetablelike passivity. It is a controlled state that abstains from controlling the situation" (p. 163). Although the term empathy is sometimes used to denote the projection of energy/attention towards the object in order to imbue it with emotional values, in the context of connected knowing it expresses the opposite. Connected knowing is not about *projection*, Nodding asserts, but rather about *reception*: "I receive the other into myself, and I see and feel with the other" (p. 40).

Connected knowing at higher levels of development includes a transcendence of attachments to the ego, the ultimate psychological barrier to experiencing the unity of all existence. "Cosmic knowing" (Irwin, 2002) involves a transcendence or transformation of consciousness beyond rational, self-direction and ego identity. The unity experienced is "richly plural and highly variegated, a celebration of the diversity and complexity of creation" (Fowler, 1995, p.205). Individuals at this stage of development "shatter our notions of normalcy," Irwin writes,

> They live on the side of transcendent actuality, universal compassion, and ultimate respect for being, rather than on the side of self-interest, parochial vision,

and the measured standards of goodness and morality masking the concern of tribe or species (p. 190).

Irwin suggests, however, it may be best to exercise caution when interpreting the generality of Fowler's highest stage, given that his account is based on "only one subject (unless we include Fowler himself in this stage!)" and extrapolation taken from literary sources. Although Jung also theorizes development of consciousness beyond initial psychological adaptation, the Myers-Briggs Type Indicator (MBTI) is capable of pointing directionally towards a preference (either *Thinking* or *Feeling*) only and not capable of detecting development within or across functions.

"As we age," Joseph writes, "the frontal lobes not only control or direct information processing within the brain but increasingly exert inhibitory influences on our emotional states as well" (1992, p. 115). This finding has important implications for understanding the nature of the opposition noted previously between the evolutionarily older input systems and the newer rational, interpretive judgment functions. Although Western science has been slow to recognize the "*duality* of our source of information—namely, one source of signals is from the world within, the other from the world without" (MacLean, 1990, p. 575), other civilizations and cultures have long embraced such notions. For example, shortly after the ancient Egyptian culture rose to prominence, the people of the Indus valley of India used the term *Brahma* to describe the principal life force animating from within. Joseph explains,

> Brahma was described as an all-pervasive, sustaining, and creative force that exists in oneself as the most essential aspect of ones being, one's soul. In addition to this all-encompassing god within, these people also postulated the existence of

> a surface layer of the self that engages in the seeking of knowledge, referred to as the *atman*. It was this psychic cleavage and thus the duality of the mind and spirit (atman and Brahman) which *prevented as well as made possible* the seeking of one's hidden self and essential being, and thus the attainment of unity and enlightenment (1992, p. 12, italics added).

Within the context of the present discussion, the "surface layer of the self that engages in the seeking of knowledge" is akin to what others have referred to as ego or ego identity and related to habitual information processing associated with the sensory cognitive system. "Despite all the fuss over it," Cytowic points out, "the actual ribbon of cortex is just 1 millimeter thick on average, a fraction of the brain's total bulk" (1993, p. 23). Development in the frontal portion on this cortical shell, which continues at least until the mid-twenties (Stuss, 1992), appears to be both a necessary and prohibitory component of ultimate psychological adaptation. A fundamental tenet of Jung's theory of adult development is that one perceptive and one judgment function always develops at the expense of the complement. For example, Jung writes,

> I must carefully exclude feeling if I am to satisfy the logical laws of thinking ... In this case I withdraw as much libido[7] from the feeling process, with the result that this function becomes relatively unconscious. Experience shows again, that the orientation is largely habitual; accordingly the unsuitable functions, so far as they are incompatible with the prevailing attitude, are relatively unconscious, untrained, undifferentiated (CW 8, 1928, par. 64).

[7] Whereas Freud used the term "libido" to signify sexual energy exclusively, Jung uses the word to describe the general energy/attention of the nervous system.

"And yet," he asserts, "it is necessary for the development of character that we should allow the other side, the inferior function, to find expression" (CW 7, 1926, par. 32). Since we cannot "develop backwards into animal unconsciousness, there remains only the more strenuous way forwards into higher consciousness" (par. 33).

Cobern and Loving (2002, p. 1018) contrast the following passages from Walt Whitman (1959) and the biography of Charles Darwin (1888) to provide a sense for how worldview differences present themselves in science education.

Whitman: When I heard the learn'd astronomer,
When the proofs, the figures, were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer
Where he lectured with much applause in the lecture room,
How soon unaccountable I became tired and sick,
Till rising and gliding out I wandered off by myself,
In the mystical moist night-air, and from time to time,
Look'd up in perfect silence at the stars.

Darwin: I have said that in one respect my mind has changed during the last twenty or thirty years. Up to the age of thirty, or beyond it, poetry of many kinds…gave me great pleasure, and even as a school boy I took intense delight in Shakespeare…. I have also said that formerly pictures gave me considerable, and music very great, delight. But now for many years I

> cannot endure to read a line of poetry: I have tried to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music.... I retain some taste for fine scenery, but it does not cause me the exquisite delight which it formerly did.... My mind seems to have become a kind of machine for grinding general laws out of a large collection of facts...

Libido or that "magical power in the depth of our being" (Jung, 1921/1971, p. 503) seems to require replenishing or perhaps what is required is receptiveness, a letting go of the urge to exert the will and an opening up to direct experience. Cytowic (1993) explains,

> The cognitive mind is the one that speaks out loud to others and silently to ourselves in the form of internal dialogues. The cognitive mind must have reasons; the emotional mind is attracted to experience. The cognitive mind is interested in analyzing and explaining because it thinks it can control what it understands. ...The emotional mind, on the other hand, lets objects and situations present themselves as they are (p. 222).

Although it is a truism science tells us how the physical universe "really is" Cytowic claims, "its rejection of direct experience leads to a distorted view of it" p. 227). "We cannot discard our objectifying impulse, but we must insist that it learn to live alongside the inner perspectives that can neither be denied nor objectified" (p. 227). "We have only to decide, whether we are going to stay closed or open up, accept experience as it is or rationalize it to death" (p. 224). Similarly, Joseph Campbell (1988) asserts,

> People say that what we're all seeking is a meaning for life. I don't think that's what we're really seeking. I think that what we're seeking is an experience of being alive, so that our life experiences on the purely physical plane will have resonances within our own innermost being and reality, so that we actually feel the rapture of being alive. That's what it's all finally about, and that's what these clues [mythology] help us to find within ourselves (p. 5).

As the people of ancient India alluded to long ago, the duality of the cognitive mind and its emotional core (atman and Brahman) must first be recognized and understood or sensed, before the spiritual potentialities of the human life are realized.

In summary, opposing worldviews drawn along the line of the dichotomous information processing patterns proposed by Jung have long been noted, raising the possibility that such differences might reflect underlying physiological processes inherent to nervous system design and function. A review of the literature suggests that information-processing regularity associated with either the sensory cognitive or somatosensory system might serve to orient the individual either externally or internally towards the source of pattern propagation. Western scientific thinking is most often associated with an external orientation and a subsequent valuation of the external world and what can be learned about it through the external senses or some technological extension thereof.

This review yielded a number of epistemological frameworks that might develop as the result of the internal-external orientation dichotomy and the functional nervous system divisions in general. From Jung's opposing patterns of perception (*Intuition* and *Sensing*), information processing regularity and associated pattern of apperception (active

or passive, respectively) could help establish a positivistic or constructivistic lens for understanding knowledge acquisition as either external or internal to the knower. With regard to the epistemic division in judgment, the literature reviewed in this section suggests a link to a type of epistemology or experience of the self defined as separate or connected knowing. Finally, although the MBTI cannot assess transformation of consciousness or differentiation of all mental functions, Jung and others postulate potential development beyond initial psychological adaptation and the establishment of ego identity. The available evidence suggests that higher development along this line may be both dependent upon and prohibited by the evolutionarily newer sensory cognitive system, specifically in the frontal cortical areas which are the last brain structures to fully mature.

EPISTEMOLOGICAL RESEARCH IN EDUCATION

William Perry pioneered epistemic research in education in the 1950s and 1960s. Perry found that Harvard undergraduates often manifest what he referred to as *epistemological dualism*, meaning a felt sense of Authority that resides external to the knower (1970). With development in college, Students' perception of the role that authorities play in determining truth and knowledge undergoes profound qualitative changes, presumably from exposure to diverse, competing claims and perspectives. Perry (1970) and Schommer (1994) suggest that because post-secondary students are "faced with theories that contradict each other or are shown revolutions of thought over time, the evolving nature of knowledge is made apparent" (Schommer, 1998, p. 588).

Irwin (2002) consolidates Perry's nine developmental stages into four: *dualism*, *multiplism*, *relativism*, and *commitment*. The first stage, *dualism*, is an epistemological position where the individual sees truth as residing with authorities. Learning, therefore, is conceived of as adopting the views of authorities and positions are dichotomized into categories such as; Right versus Wrong, Good versus Bad, and We versus Them. During the second epistemological phase, *multiplism*, students begin to see knowledge domains as problematic and uncertain. When faced with uncertainty, students may rely on intuition or subjective feelings to decide the matter, but often view any one position as equally valid or "just as good" as any other. *Relativism* is characterized by an understanding that opinions can be compared and contrasted rationally. This stage requires an understanding that knowledge is relative to a frame of reference and that knowing involves an interpretive act by the subject. The final stage, *Commitment*, involves the construction of "lifelong orientations, values, or choices that are guided by rational truth claims, but which are nonetheless informed and permeated by points of view or frames of reference that have nonrational components" (Irwin, 2002, p.139).

Perry's theory has been studied extensively, most rigorously by Kitchener and King (1994) and colleagues, who describe epistemological growth as eventuating in the realization of the constructed and social nature of reality descriptions. This position entails some understanding that humans carry with them as part of their psychological make-up an internal model of how the world works largely shaped by linguistic structures and categories common to the environment in which they are reared. Belenky et al. (1986) refer to a similar level of epistemic development as "constructed knowing." In general, these theories suggest that college students evolve form adherents to "copy

theory," where knowledge is thought to involve the direct transmission and encoding of outside stimuli onto the *tabula rasa*, to an understanding that knowledge is constructed or integrated internally by the effort of the subject. Learning is no longer conceived of "merely passively reflecting what exists in the real world and in the minds of authorities, but as subjectively "arrived at by forms of rational inquiry, inquiry carried out in social contexts by means of discourse practices" (Irwin, 2002, p. 141).

Rather than understanding epistemic development as a progression through various stages, Schommer stressed the contextual nature of belief formation, arguing that personal epistemology represents a series of more or less independent beliefs that may not follow a prescribed pattern of linear development. Schommer's Epistemological Questionnaire (SEQ, 1990), which is one of the instruments used in the present study, assesses the degree of adherence to beliefs along four dimensions: 1) SIMPLE —ranging from knowledge consists of unambiguous, isolated facts to knowledge consists of highly interrelated concepts and ideas; 2) CERTAIN—ranging from knowledge is absolute and handed down from authority to knowledge is evolving; 3) QUICK—ranging from learning is quick or not-at-all to learning is gradual; 4) FIXED—ranging from the ability to learn is fixed at birth to the ability to learn can be changed.

These beliefs are thought to be promoted by outcome-based educational systems and teacher-centered instructional methodology (Dweck and Leggett, 1988; Hofer and Pintrich, 1997; Kitchener and King, 1994; Perry, 1970; Schoenfeld, 1983, 1985; Schommer, 1990, 1992, 1993, 1998; Schommer and Walker, 1995). Schommer (1998) suggests a link between the formation of beliefs about the nature of knowledge (SIMPLE & CERTAIN) and teacher-centered, didactic methodology, which also represents the

predominant mode of instruction in post-secondary science education. As mentioned in Chapter I, Rigden and Tobias (1991) found that most science examinations at the undergraduate level stressed the memorization of isolated facts, which may lead the learner to view knowledge as merely a "laundry list of facts" (Schommer, 1998, p. 553).

Beliefs concerning the nature of learning (QUICK & FIXED) might also be shaped by traditional educational practices. A belief in QUICK learning, for example, may arise from the setting of specific time limitations for test taking and various other classroom activities. Schoenfeld (1983, 1985) showed that children who believe solutions to math problems should be immediate will often cease to persist trying to solve difficult problems, even though continued effort would likely have led to success. TIMSS-related research also shows that Japanese teachers are more likely than their American counterparts to allow students time and opportunity to struggle with difficult problems. From this perspective, confusion and frustration are seen as necessary conditions for integrating presented material with preexisting schemata. The practice of testing young children for intelligence (IQ) may in some cases promote a belief that intelligence is predetermined (FIXED), and that the ability to learn cannot be modified. Dweck and Leggett (1988) have shown that while some children believe intelligence to be a fixed entity, others think intelligence can be improved with effort. The researchers found that both groups of students performed about the same on easy tasks; however, children who believed that intelligence was malleable outperformed the other group when faced with difficult tasks. Those children who held a belief in incremental intelligence tended to vary their problem solving strategies and persist in their efforts, while those that

believed in fixed intelligence often continued using the same unsuccessful strategy or gave up trying altogether.

In 1998 Schommer extended Perry's work with college students to include older adults in the general population. Schommer surveyed 418 adults using stratified random sampling to ensure a fairly even distribution of educational experiences into three categories: those with high school, college, and graduate education. Results indicate that education predicted two epistemological factors, SIMPLE knowledge ($p < .001$) and CERTAIN knowledge ($p < .001$). That is, "the more education adults obtain the more likely they are to believe that knowledge is highly complex and constantly evolving (Schommer, 1998, p. 557). Conversely, older adults with only secondary or high school training, are more likely to retain the beliefs in SIMPLE & CERTAIN knowledge thought to be propagated through formal educational practices. "Although belief in an evolving nature of knowledge does not eliminate the notion of timeless truths," Schommer writes, it many "predispose students to question facts and to anticipate change in the future."

These results tend to support a contextual theory of belief formation, rather than a linear stage model of epistemological development common to most people within a specified age category. Academic scientists actively involved in independent inquiry and exposed to competing theory, therefore, may hold different epistemological beliefs than elementary teachers entrenched in the daily business of making sure no child is left behind. Of the few studies investigating epistemological beliefs of scientists most have found a commitment to empirical standards and logical argument. Pomeroy (1993) found that scientists were significantly more likely to adhere to logicoempiricist views of the nature of science than secondary science and elementary teachers. Scientists in

Pomeroy's study also tended to subscribe to traditional, nonconstructivist views of teaching, which included a rationale for teaching the way that many scientists were themselves taught, often by didactic, teacher-centered instructional methods. Glasson and Bentley (2000) observed and later interviewed scientists presenting cutting edge research as part of 2-day professional development conference for teachers. Interviews revealed a "commitment to empiricism and experimental design, found particularly among scientists from traditional disciplines" such as chemistry, biology, and botany (p. 480). Glasson and Bentley also found that "implicit in the data was a commitment to objectivity and the tacit assumption that science may be free of values and ethical assumptions" (p. 469). According to some, the fact that the scientists are even paying attention to the phenomenon they choose to study is a value judgment of a subtle type (i.e. "the object of inquiry is worthy of investigation"). Zinman (1991) offers a detailed explanation of the implicit assumptions scientists often hold. He describes normative science as ethical (scientists use morally and technically efficient methods): universal (science has an impersonal and objective approach); communal (scientific knowledge is public, available to everyone), disinterested (scientific work has no special motives) and possessing organized skepticism (scientific work takes nothing for granted). Many of these assumptions are characteristics of positivistic and separate knowing frameworks described in the last section.

The way that science is communicated, whether in scientific journals, at scientific meetings, in the classroom, or at professional development seminars, tends to perpetuate characteristics of positivistic and separate knowing epistemological frameworks. These include a valuation of one form of reasoning and judgement (devoid of subjective

elements); an understanding that knowledge is singular in voice or singularly universal; and a deference to authority as the ultimate source of knowledge (Bentley & Garrison, 1991; Guba, 1990; Southerland & Gess-Newsome, 1999). Cobern and Loving (2002) showed that while elementary teachers valued the contributions of science to economic growth, healthcare, and such; they did not hold the epistemological assumptions of scientists in the same regard. Perhaps it is because elementary teachers see these assumptions through the lens of their own epistemological frameworks and thus question the extent to which science is free of value and judgment, impersonal, and "communal" or available to everyone. Unfortunately, many Western scientists are in the habit of excluding somatosensory experience and in some cases disavowing its existence all together, rendering recognition of complement frameworks impossible or difficult at best. Glasson and Bentley recommend attempting to open the doors of communication between the scientific community, science educators, and historians/philosophers of science. Ideally, those employed to present science and model its methods would be a little part of each: teacher, scientist, historian, and philosopher.

Of the four epistemological dimensions assessed by the SEQ, the SIMPLE dimension appears to be most relevant to distinguishing between the two epistemological frameworks referred to in this study as positivistic and constructivistic. Whether or not one believes that knowledge is handed down intact by authority, is secondary to whether or not one believes that knowledge originates inside or outside of the knower. If one believes knowledge lies outside the knower as a collection of facts or external entities, then one is likely to believe that objective reality is accessible and obtaining objective truth becomes possible. If one believes that the source of knowledge resides internally,

then the individual becomes the active constructor of meaning derived from personal perceptions, making obtainment of objective, external truth less plausible. According to Jung's theory of *Psychological Types* (1921/1971), patterns of perception and apperception are linked to habitual reliance on one or the other informational sources (internal or external), which in turn leads to a structuring of experience either through a positivistic or constructivistic framework.

Support that the SIMPLE dimension might be related to a tendency to rely on either internal or external informational sources comes from a study by Paulsen and Feldman (1999). In theory, a belief in SIMPLE knowledge might be associated with a positivistic framework characterizing knowledge as an object that lies external to the knower and the acquisition of knowledge as the accumulation of external facts. These researchers found that students adhering to a naïve belief in SIMPLE knowledge were less likely to have an intrinsic goal orientation, to appreciate the value of learning tasks, to perceive an internal control over learning, and to feel efficacious about their capacity to learn. On the other hand, such students were more likely to have extrinsic goal orientations and to experience higher levels of test anxiety than were students who adhered to more sophisticated belief on the SIMPLE dimension. Similar relationships between intrinsic motivation and locus of control were found on the QUICK and FIXED dimension. One possible explanation for these findings might be that a student viewing knowledge as external facts and learning as the accumulation of facts becomes a passive recipient of the discoveries of others, rather than playing an active role in the discovery process itself. It follows that an active constructor of knowledge might experience a

sense of ownership and control that in turn empowers the student with regard to future learning endeavors.

Other evidence supporting a possible relationship between reliance on internal versus external informational sources and epistemological frameworks comes from a study utilizing a Chinese version of Pomeroy's (1993) questionnaire. Tsai (1998) assessed the degree of adherence to either positivistic[8] or constructivistic ideology in Taiwanese eighth-graders, and then conducted a series of in-depth interviews to assess the type of learning strategies employed by each group. A positivistic framework with regard to science tends to support that scientific knowledge is unproblematic and provides right answers; scientific knowledge is discovered by the objective data gathered from observing and experimenting or from a universal scientific method; scientific knowledge is additive and bottom-up; and evidence accumulated carefully will result in infallible knowledge. In contrast, the constructivistic views assert that scientific knowledge is constructed (or invented) by scientists, its status is tentative, and its development experiences a series of revolutions or paradigm shifts (Tsai, 1996).

A qualitative analysis of in-depth interview data revealed that those students classified as positivistic tended to emphasize external informational sources and employ more rote-like strategies to enhance understanding, whereas constructivistic students tended to emphasize internal informational sources and employ a wide variety of techniques to promote their own learning. According to Tsai, positivistic students

[8] Tsai (1998) uses the terms, "empiricist" and "empiricism" synonymously with "positivistic" and "positivism." The term "positivistic" was substituted for the term "empiricist" in this study for clarity and consistency.

> stressed the important role of (precise) experimental evidence in science. On the other hand, constructivistic students viewed the dynamic nature of scientific knowledge as among its main characteristics. Later, when asked the sources of scientists' ideas, constructivists tended to believe that scientists' ideas came from their intuitions or flashes of insight, the theories proposed by earlier scientists, and even ancient folklore, but none of them mentioned anything about observations. ... [Most of the positivistic students] viewed careful observations as the main sources of scientists' ideas (Tsai, 1998, p. 478).

Constructivistic students "believed that the power or potential and the acceptance of a new theory caused theory changes in science," whereas positivistic students focused on the evidence and the "correctness" of theory as leading to change. Although the positivistic students showed convictions for the tentative nature of science, they believed that this "tentativeness came from the limitations of technology and sensory limits. Thus, when advanced technology was available, one could approach the truth . . ." (p. 479).

Knowledge constructivists were mainly motivated by "their interest and curiosity about science, whereas [positivistic] subjects were mainly motivated by performance on examinations" (p. 473). As the instructional methodology employed at the time of the study was primarily textbook and teacher driven, one constructivistic student remarked,

> Right now, I am not very motivated to learn science since our science classes mainly focus on practicing a lot of tutorial problems. Science is nothing more than solving a set of problems in the classes. If we can have more time to explore some interesting science ideas, I definitely would have much higher motivation to learn science (p. 483).

When asked to describe an ideal environment for learning science constructivist students tended to "emphasize the opportunities to discuss with others, to solve real-life problems and control their own learning activities" (p. 480). Tsai speculates that because positivistic students believe science is a collection of correct facts, it was "plausible for them to think that they could learn best when teachers could clearly present their ideas." They tended to show more anxiety about making mistakes, possibly because facts are construed as either right or wrong, and to rely on the role played by the teacher for their learning as mentioned above. Constructivistic subjects believed that they could "learn best by discussing with others and, to a certain extent, constructing their own knowledge, possibly because they believed that science was constructed by people's negotiation and human decision making." Tsai concludes that from an positivistic viewpoint, science is interpreted as "static information already existing there for them to learn; hence, it is not necessary for them to try to construct their ideas right in class." Rather they can wait until later and "transfer these facts from outside into their mind" (p. 485). This evidence supports the notion that students may habitually rely on one or the other informational source (external or internal) as Jung's theory suggests, and also shows how such orientations might be reflected in the establishment of epistemological frameworks that subsequently modify learning behavior and motivation.

Although Schommer's instrument has made the quantification of epistemological beliefs possible and less time consuming for researchers compared to the exhaustive interviews conducted by Perry with Harvard undergraduates, for example, some have argued the merit of assessing complicated psychological beliefs based on the level of agreement to simple written statements. The criticism of the SEQ falls into two general

categories: the ambiguity of some items, such as "Nothing is certain, but death and taxes" and "I don't like movies that don't have an ending" (Appendix B), and whether or not the four epistemological factors are domain specific or independent. The former criticism is centered primarily on the assessment of CERTAIN knowledge. The "I don't like movies that don't have an ending" item is supposed to measure a tolerance for ambiguity (the more tolerant the less likely the respondent is to believe knowledge is absolute and handed down by authority). At least for the purposes of the present study, whether or not one believes that knowledge is handed down by authority (and thus is absolute or certain) is secondary to whether or not one believes that knowledge originates inside or outside of the knower. The SIMPLE dimension appears to be a more stable predictor of knowledge viewed as an external entity compared with the other three dimensions. Stated from the naïve perspective, the SIMPLE dimension assesses the belief that knowledge consists of bits of unrelated facts and knowledge acquisition is defined as the accumulation of these transmittable external facts.

The second major criticism of the SEQ concerns whether or not the instrument is subject area specific, or is equally applicable to all disciplines. Hammer and Elby (2001) question whether a student's reaction to the "death and taxes" item gives an accurate insight into a view of scientific knowledge and whether students even have stable beliefs or theories about certainty—beliefs that apply just as well to science as they do to everyday events. Hofer and Pintrich (1997) assert that students thinking about chemistry, for example, might view knowledge as more certain than students thinking about psychology do. Again, the major focus of the criticism appears to be connected with the measurement of CERTAIN knowledge. In response to a previously implicit assumption

that epistemological beliefs were independent of specific domain, Schommer and Walker (1995) conducted a within-subject analysis of undergraduates' beliefs relative to mathematics and social studies. Each student completed two modified versions of the SEQ, one pertaining to mathematics and one to pertaining to social science. Analysis of responses yielded no significant difference between students' beliefs about the two areas of study, leading the authors to conclude that epistemological beliefs are moderately domain-independent.

Review of the epistemological literature in this section suggests that positivistic and constructivistic frameworks are associated with a tendency to rely on external or internal information sources, though this finding was limited to just one study. Students who held a belief in SIMPLE knowledge presumably take a less active role in the learning process. These students tend to be less oriented towards intrinsic goals, less likely to appreciate the value of learning tasks, less likely to perceive an internal control over learning, and less likely to feel efficacious about their capacity to learn compared with students with a more sophisticated perspective.

No studies were found specifically using the SEQ to clarify and compare beliefs of populations involved in the transfer of information with special relevance to science education reform. Similarly, no studies were found assessing the formation of epistemological beliefs measured by the SEQ as a function of patterns of perception delineated by the MBTI.

SUMMARY

The literature pertaining to MBTI-related research in science education, the relationship between Psychological Type (Jung, 1921/1971) and worldview, and epistemological research in education was reviewed. Information related to the target populations and to the hypotheses of the study was sought. Although MBTI-related research in science education clearly associates *Thinking* judgment with the "science-minded" individual, attempts at classification by perceptive type have produced mixed results. No studies were found that investigated the relationship between specific patterns of perception and epistemological beliefs or frameworks. Research from the psychological and brain-based sciences confirms Jung's earlier hypothesis that humans are privy to two sources of information, one arriving through the external senses that is processed through the sensory cognitive system (*Sensing*) and one animating from within and processed through hypothalamic-limbic circuitry of the somatosensory system (*Intuition*). In theory, habitual attention towards the external world and information arriving through the senses might serve to orient the individual towards the source of pattern propagation and shape epistemological frameworks accordingly. Conversely, habitual reliance on intuition or direct apperception might lead to a valuation of internal processes, including the process of meaning making or knowledge construction.

Other literature reviewed linked patterns of information processing delineated by Jung to worldview differences described by William James as tender- or spiritually minded and tough- or materially minded. As rational functions, *Thinking* and *Feeling* are both associated with the evolutionarily newer sensory cognitive system, however the

source of pattern in the *Feeling* domain is more likely derived from internal or visceral processes rather than external sensory perception alone. The epistemological difference at this level is described by two orientations of the self, one as essentially separate (separate knowing) and the other as essentially connected or "in relationship" (connected knowing). Higher levels of connected knowing are not measured by the MBTI, but are suggested by William James in the distinction between materially- and spiritually-minded individuals. Such development is postulated to include differentiation of both *Thinking* and *Feeling* in Jung's theory and a transcendence of ego attachments. In general, perceptions of the "scientific worldview" include an external orientation and valuation of sensory perception, as well as separate knowing which seeks to detach subjectivity from the analytic process. One-sided development can occur, according to Jung, because the secondary rational functions are innately opposed to the primary perceptive functions.

No studies were found in the epistemological research reviewed that assessed the four epistemological dimensions measured by the SEQ in the target populations. One study was found linking reliance on internal versus external informational sources with constructivistic and positivistic epistemological frameworks based on in-depth interviews with middle school students. A belief in SIMPLE knowledge (knowledge consists of isolated, unrelated facts and learning is the accumulation of these facts) has been linked to a number of adverse effects related to approach, motivation, and attitude towards learning. If knowledge is viewed as external facts and learning as the accumulation of facts, the student then becomes a passive recipient of the discoveries of others, rather than an active participant or constructor of knowledge.

CHAPTER III

METHODOLOGY

INTRODUCTION

To achieve the purpose of delineating epistemological and worldview differences in populations involved in teaching-learning process, information was sought concerning patterns of information processing and epistemological beliefs through the administration of the Myers-Briggs Type Indicator (MBTI) and Schommer's Epistemological Questionnaire (SEQ). This study is important because it systematically examines differences that may serve as barriers to successful implementation of science education reform efforts, as well as the relationship between perception and the formation of specific epistemological beliefs thought to be propagated by the structure of formal educational practice. Using a quasi-experimental design, the following null hypotheses were tested for significance at the 0.05 level:

H_1: There are no significant between-group differences in patterns of perception and judgment as measured by the MBTI.

H_2: There are no significant between-group differences in adherence to the four epistemological dimensions assessed by the SEQ.

H_3: There are no significant differences between the two forms of perception distinguished by the S—*i*N scale of the MBTI and adherence to the four epistemological dimensions measured by the SEQ.

This chapter describes the experimental design of the study including hypoteses statement, study participants, recruitment and testing, instrumentation, and data analyses.

PARTICIPANTS IN THE STUDY

Participants in this study were divided into four populations comprising the following groups: 1) College Freshmen, 2) Elementary Teachers, 3) Preservice Science Teachers, and 4) Scientists. Age and gender ratios are presented in Table 2.

Table 2. Population Demographics

Classification	n	Female (%)	Male (%)	Average Age	Range
Freshmen	211	147 (70%)	64 (30%)	19	17 - 27
Elem.Teach.	37	33 (89%)	4 (11%)	44	25 - 60
Preservice	41	24 (59%)	17 (41%)	27	21 - 45
Scientists	24	4 (17%)	20 (83%)	53	33 - 74

Summary of gender ratios and approximate age at survey

RECRUITMENT AND TESTING

College Freshmen

College freshmen were recruited from two large introductory psychology courses taught at the University of Tennessee during Fall Semester, 2002. Students received extra course credit for their participation as part of an ongoing agendum designed to facilitate recruitment of human subjects for graduate research. Following review and approval by program coordinator, notices were placed on the designated bulletin board and announcements sent to the undergraduate psychology's web-site. Four sessions were prearranged and a room reserved to comfortably accommodate 60 students per session. Test material, answer sheets, consent forms, extra credit vouchers, and number two pencils were placed at each workstation prior to scheduled test administration. Verbal instructions were given for completing the instruments and forms. Students retained a copy of the extra credit voucher with contact information should questions regarding their participation arise. The original copy was forwarded to supporting staff who arranged for course credit to be given at the end of the term.

Elementary Teachers

Elementary teachers were recruited from a pool of participants attending a workshop offered at the University of Tennessee and supported by a Title X grant from Tennessee's Department of Education during the summer of 2002. Workshop attendees were all experienced educators drawn from diverse locations across East Tennessee. The

purpose of the workshop was to provide veteran elementary teachers with hands-on experience and to furnish them with resources and instructional material to bring back into their own science classrooms. The present study was introduced to teachers on the second day of the 14-day workshop, which the researcher also attended as a participant. Teachers who were interested in participating were given packets containing instructions, instruments, and consent forms to take home and return prior to the end of the workshop.

Preservice Science Teachers

Participants in the preservice science teacher group were all enrolled at the time of survey in accredited teacher training programs at major state institutions. One cohort of students was enrolled in an experimental course at the University of Tennessee designed to model independent-inquiry methodology (Melear, Goodlaxson, Warne, and Hickok, 2000). Students taking the course partake in all phases of scientific inquiry, including the development of researchable questions, articulation of theories, experimental design, data collection, evidence evaluation, and the defense of findings (Hickok, Warne, Baxter, and Melear, 1998).

The present study was explained to preservice science teachers on the first day of the course during Spring Semester, 2002. Students were informed that their participation was voluntary and that a decision not to participate would not affect their course grade or treatment in the course. The same information was restated on the consent form that students received prior to making the decision of whether or not to participate in the study. Instruments were explained and administered in class. Each student participant

received a copy of the consent form containing contact information for the researcher and various supporting agencies in compliance with the Office of Human Subject Research at the University of Tennessee (Appendix A). These procedures were undertaken at the beginning of the semester to avoid the possibility that the unique format of the course might influence results of the study.

In addition, science educators from four other large public universities were asked to distribute the instruments to preservice science teachers who volunteered to participate. Packets were prepared containing the instruments, consent forms, and instructions. Students at off-site locations were allowed to take the instruments home to avoid using excessive instructional time. Self-addressed return envelopes were given to course instructors so that completed forms and test materials could be returned to the researcher.

Scientists

Faculty members of the University of Tennessee's Biology Division were sent electronic notices describing the study and inviting interested faculty to reply. Packets containing test material, information, and consent forms, along with a self-addressed, stamped envelope for returning completed material, were delivered to the academic offices of faculty members agreeing to participate. A cover sheet included in the packet asked participants to check whether they would like to receive information regarding their MBTI results and/or results of the study.

INSTRUMENTATION

Myers Briggs Type Indicator (MBTI)

Isabel Myers spent over six decades studying the works of Jung and developed the MBTI as a tool for the practical application of his theories. An important objective of MBTI test developers is to assure that "Jungian theory is taken into account in every question and in every step of development of the MBTI instrument" (Myers et. al., 1998, p. 21). The commitment to connect the instrument to Jung's original theory has continued since Isabel Briggs Myers death in 1980, as evidenced by frequent references to Jung's work throughout the recent edition of the *MBTI Manual* (Myers et al., 1998).

Form G was developed in the late 1970s and contains a total of 126 questions or word pairs in three parts with multiple choice answers. Parts I and III consist of 26 and 55 questions, respectively, with the respondent marking the answer that corresponds to how he or she *usually* feels or acts. A sample of the type of question asked in parts I and III are presented below.

25. In doing something that many other people do, does it appeal to you more to

    (A) do it in the accepted way, or

    (B) invent a way of your own?

83. Is it higher praise to say someone has

    (A) vision, or

    (B) common sense?

Part II consists of 45 questions asking about the respondent's preference in forced choice format. Examples of the word pairs presented in part II are shown below.

"Which word pair appeals to you more?"

32. (A) convincing touching (B)

61. (A) build invent (B)

The MBTI is made up of four dichotomous scales, two measuring general orientations or attitudes, and two corresponding to dual forms of perception (*Sensing* and *Intuition*) and judgment (*Thinking* and *Feeling*). Data pertaining only to the four basic human mental functions measured on the perception and judgment scales will be used to determine statistically significant differences, if any, between the study populations.

Internal reliability is a measure of how consistently respondents answer the items on a given scale. One method of determining the internal reliability of a scale is to split the item pool into two halves (X and Y), compute the internal consistency of each half, and correct for length of scale. Internal Consistencies for Form G were calculated from the databank at Center for Application of Psychological Type (CAPT) on a sample size of 32,671 and are reported as .84 and .83 for the perception and judgement scales respectively (Myers et. al., 1998).

Test-retest reliability is an estimate of how stable the test is over time. The longest time interval that information is available for Form G is a two-and one-half year period. Test-retest scores on the perception and judgment scales respectively for males are .85 and .57 and for females .80 and .70 (Myers et. al., 1998).

Confirmatory Factor Analysis provides a test for the plausibility of a hypothesized factor structure. The MBTI is a four-factor model (corresponding to the four scales) and several studies indicate clear support for the predicted structure of the instrument (Harvey, 1996; Harvey, Murry, & Stamoulis, 1995; Johnson and Saunders, 1990;

Thompson and Borrello, 1989). The MBTI also correlates with many other personality tests indicating support for the constructs and its consistency with Jungian theory. For an extensive review of the validity and reliability of the MBTI, the reader is referred to the *MBTI Manual* (Myers et. al., 1998).

Schommer's Epistemological Questionnaire

In 1990, Schommer proposed a multi-dimensional model of personal epistemology based on the theory that different aspects of personal epistemology possibly develop at different rates. At that time she also published a Likert scale questionnaire that measured four factors or beliefs about knowledge and learning (Appendix B). The four factors stated from a naïve perspective are as follows: 1) SIMPLE: knowledge consists of a collection of isolated facts; 2) CERTAIN: knowledge is absolute or unchanging; 3) QUICK: learning is quick or not at all, and 4) FIXED: the ability to learn is fixed at birth.

The 63 item questionnaire asks participants to respond to statements such as, "If you are ever going to be able to understand something, it will make sense the first time you hear it" (learning is QUICK), and "The best thing about science courses is that most problems have only one right answer" (knowledge is SIMPLE). Subjects are instructed to rate the degree to which they agree or disagree with the statement by recording a number ranging from 1 (strongly disagree) to 5 (strongly agree) for each test item. Using exploratory factor analysis and mean scores from the subsets of items, four constructs have been generated (Schommer, 1990). The four-factor structure has been

replicated in a number of studies with college students (Dunkle, Schraw, & Bendixen, 1993; Jehng, Johnson, & Anderson, 1993; Schommer, 1993; Schommer et al., 1992) and older adults (Schommer, 1998). For college students, test-retest validity is .74 and inter-item correlation for items within each belief factor ranges from .63 to .85 (Duell and Schommer, 2001).

DATA ANALYSIS

All respondents were asked to complete the demographic information section on the MBTI answer sheet, which was then photo copied in order to calculate gender ratios and participant age at the time of the survey. Completed MBTI forms will be computer-scored at the Center for Application of Psychological Type in Gainesville, Florida. Between-group differences in perception and judgment will be assessed using the SPSS statistical software package and Pearson Chi-Square analysis.

Schommer's Epistemological Questionnaire requires hand scoring and some manipulation of the raw Likert score as each item is worded such that a respondent answering from a naïve perspective would sometimes agree with the statement and sometimes disagree. The two items listed on the preceding page, for example, have a positive valence, meaning a respondent answering from a naïve perspective would likely agree with the statement. If the statement is stated with a negative valence, the Likert score must be reversed so that a low score corresponds to a more sophisticated epistemological position and a high score to a more naïve perspective. The instrument's author provided valences for each item and a list of items that correspond to the four factors or beliefs about the nature of knowledge and learning (SIMPLE, CERTAIN,

QUICK, FIXED). A parametric analysis of variance (ANOVA) with the Tukey post hoc test applied was used to determine between-group differences in degree of adherence to each of the epistemological dimensions.

The relationship between perception and epistemology was analyzed using Levene's test for equality of variance and the independent t-test.

SUMMARY

Chapter III presents the methodology of the study. Included in this chapter is a description of study participants, method of recruitment and testing, and descriptions of the two instruments, including reliability and validity measures. Also included in this chapter is a description of data treatment and statistical procedures proposed to reject or accept the research hypotheses. The next chapter presents the results of the study.

CHAPTER IV

RESULTS

INTRODUCTION

The purpose of this study was to obtain information regarding epistemological and worldview differences and to examine the relationship between patterns of perception and epistemology. To collect data, college freshmen, preservice science teachers, elementary teachers, and scientists were administered the Myers-Briggs Type Indicator (MBTI) and Schommer's Epistemological Questionnaire (SEQ).

Three null hypotheses concerning patterns of perception and judgment, adherence to select epistemological beliefs, and the relationship between patterns of perception and epistemology were formulated and tested at the 0.05 level of significance using SPSS software. Hypothesis 1, pertaining to between-group differences in perception and judgment, was analyzed by Chi-Square analysis. Hypothesis 2, which assessed between-group differences in degree of adherence to four epistemological dimensions, was analyzed by parametric analysis of variance (ANOVA) with the Tukey post hoc test applied. Hypothesis 3, pertaining to the relationship between patterns of perception and epistemology, was analyzed using Levene's test for equality of variance and the independent t-test.

HYPOTHESIS 1

H_1: There are no significant between-group differences in patterns of perception and judgment as measured by the MBTI.

Data Analysis

A total of 313 students and educators participated in the study comprising the following groups: 211 college freshmen, 37 elementary teachers, 41 preservice science teachers, and 24 scientists. Results are presented in Tables 3 and 4.

Table 3. Between Group Differences in Perception

			Perception		
			Sensing	Intuition	Total
Classification	College Freshmen	Count	132	79	211
		% within Classification	62.6%	37.4%	100.0%
	Elementary Teachers	Count	24	13	37
		% within Classification	64.9%	35.1%	100.0%
	Preservice Science Teachers	Count	26	15	41
		% within Classification	63.4%	36.6%	100.0%
	Scientists	Count	7	17	24
		% within Classification	*29.2%	*70.8%	100.0%

*Pearson Chi-Square = 10.662, df=3, $p<.05$.

Table 4. Between Group Differences in Judgment

			Judgment		
			Thinking	Feeling	Total
Classification	College Freshmen	Count	80	131	211
		% within Classification	37.9%	62.1%	100.0%
	Elementary Teachers	Count	14	23	37
		% within Classification	37.8%	62.2%	100.0%
	Preservice Science Teachers	Count	23	18	41
		% within Classification	56.1%	43.9%	100.0%
	Scientists	Count	20	4	24
		% within Classification	*83.3%	*16.7%	100.0%

*Chi-Square 21.263, df=3, p<.001.

Hypothesis 1 Conclusion

Hypothesis 1 is rejected based on the findings of a significant difference between scientists and the other three groups in the perception and judgment domains. Scientists were significantly more likely to rely on intuitive perception (70.8% *i*N, $p < .05$) and thinking judgment (83.3% T, $p < .001$) compared with college freshmen (37.4% *i*N and 37.9% T), preservice science teachers (36.6% *i*N and 56.1% T), and elementary teachers (35.1% *i*N and 37.8% T).

HYPOTHESIS 2

H_2: There are no significant between-group differences in adherence to the four epistemological dimensions assessed by the SEQ.

Data Analysis

Data from seven participants who did not complete Schommer's Epistemological Questionnaire were excluded from this analysis resulting in the following group ratios: 209 college freshmen, 37 elementary teachers, 37 preservice science teachers, and 23 scientists. ANOVA data are presented in Table 5.

The Tukey post hoc test was applied to determine how the groups differed from one another on the SIMPLE and QUICK based on the ANOVA procedure. A multiple comparison Tukey HSD with the SIMPLE dimension as the dependent variable (Table 6) indicates that college freshmen are more likely to adhere to a naïve epistemological perspective that the other three groups. Restated, college freshmen are significantly more likely to view knowledge as the accumulation of isolated and unrelated facts that preservice science teachers, elementary teachers, and scientists. Conversely, the scientists surveyed in the study tended to adhere to a more sophisticated perspective (i.e., knowledge is complex and consists of interrelated concepts and ideas) than the other three groups. Preservice science teachers and elementary teachers did not differ from one another on the SIMPLE dimension and held an intermediate position between college freshmen and scientists.

Table 5. ANOVA of Between-Group Differences in Epistemology

		Sum of Squares	Df	Mean Square	F	Sig.
Simple	Between Groups	172.945	3	57.648	37.693	.000 *
	Within Groups	461.885	302	1.529		
	Total	634.830	305			
Certain	Between Groups	1.040	3	.347	1.000	.393
	Within Groups	104.759	302	.347		
	Total	105.799	305			
Quick	Between Groups	13.848	3	4.616	7.269	.000 *
	Within Groups	191.783	302	.635		
	Total	205.632	305			
Fixed	Between Groups	17.626	3	5.875	2.429	.065
	Within Groups	730.431	302	2.419		
	Total	748.057	305			

* Statistical Significance

Table 6. Tukey HSD Multiple Comparisons on the SIMPLE Dimension

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
College Freshmen	College Freshmen			
	Elementary Teachers	.7578(*)	.22058	.004
	Preservice Science Teachers	1.1340(*)	.22058	.000
	Scientists	2.6366(*)	.27169	.000
Elementary Teachers	College Freshmen	-.7578(*)	.22058	.004
	Elementary Teachers			
	Preservice Science Teachers	.3762	.28753	.558
	Scientists	1.8788(*)	.32838	.000
Preservice Science Teachers	College Freshmen	-1.1340(*)	.22058	.000
	Elementary Teachers	-.3762	.28753	.558
	Preservice Science Teachers			
	Scientists	1.5026(*)	.32838	.000
Scientists	College Freshmen	-2.6366(*)	.27169	.000
	Elementary Teachers	-1.8788(*)	.32838	.000
	Preservice Science Teachers	-1.5026(*)	.32838	.000
	Scientists			

* The mean difference is significant at the .05 level.

A multiple comparison Tukey HSD with the QUICK dimension as the dependent variable is displayed in Table 7. While college freshmen tended to adhere to a more naïve perspective on this dimension compared with scientists and preservice science teachers, they did not differ significantly from elementary teachers. That is, elementary teachers are as likely as college freshmen to adhere to a belief that learning occurs quickly or not at all as opposed to a belief that knowledge acquisition involves a gradual process of sustained or continued effort.

Hypothesis 2 Conclusion

Hypothesis 2 was rejected based on the findings of significant between-group differences on the SIMPLE and QUICK dimensions of the SEQ. College freshmen were significantly more likely than preservice science teachers, elementary teachers, and scientists to view knowledge as the accumulation of isolated and unrelated facts ($p < .01$). Scientists were significantly more likely to believe that knowledge consists of complex, interrelated concepts and ideas compared with the other three groups ($p < .001$). While college freshmen differed from scientists and preservice science teachers in degree of adherence to a naïve perspective on the QUICK learning dimension ($p < .01$), they did not differ significantly from the sample of elementary teachers.

Table 7. Tukey HSD Multiple Comparisons on the QUICK Dimension

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
College Freshmen	College Freshmen			
	Elementary Teachers	.1682	.14213	.638
	Preservice Science Teachers	.4701(*)	.14213	.006
	Scientists	.6304(*)	.17507	.002
Elementary Teachers	College Freshmen	-.1682	.14213	.638
	Elementary Teachers			
	Preservice Science Teachers	.3019	.18527	.364
	Scientists	.4721	.21160	.117
Preservice Science Teachers	College Freshmen	- .4701(*)	.14213	.006
	Elementary Teachers	-.3019	.18527	.364
	Preservice Science Teachers			
	Scientists	.1702	.21160	.852
Scientists	College Freshmen	- .6304(*)	.17507	.002
	Elementary Teachers	- .4721(*)	.21160	.117
	Preservice Science Teachers	- .1702	.21160	.852
	Scientists			

* The mean difference is significant at the .05 level.

HYPOTHESIS 3

H_3: There are no significant differences between the two forms of perception distinguished by the S—*i*N scale of the MBTI and adherence to the four epistemological dimensions measured by the SEQ.

Data Analysis

The analysis to test hypothesis 3 was limited to the 60 students, 46 college freshmen and 14 preservice science teachers, who completed demographic information on both instruments. The relationship between perception and epistemology was analyzed using Levene's test for equality of variance and the independent t-test. The mean score for each of the four epistemological dimensions as a function of sensing or intuitive perception are displayed in Table 8.

A significant difference between intuitive and sensory perceptive college students was found on the SIMPLE dimension of the SEQ. Sensory perceptive students (S) were more likely than intuitive (*i*N) students to believe that knowledge consists of a collection of isolated and unrelated facts rather than complex, interrelated concepts and ideas. Results of the independent t-test of statistical difference between means for each epistemological dimension are presented in Table 9.

Hypothesis 3 Conclusion

Hypothesis 3 was rejected based on the findings of a significant difference between perceptive type, *Sensing* versus *Intuition*, on the SIMPLE dimension of the SEQ.

Table 8. Means for each Dimension as a Function of Perceptive Type

	Sensing and Intuition	N	Mean	Std. Deviation	Std. Error Mean
Simple Knowledge	Sensing	37	10.1935	1.07352	.17649
	Intuition	23	9.0322	1.37243	.28617
Certain Knowledge	Sensing	37	2.8557	.48616	.07992
	Intuition	23	2.6796	.58789	.12258
Quick Learning	Sensing	37	4.5700	.74508	.12249
	Intuition	23	4.3661	.88625	.18480
Fixed Learning	Sensing	37	9.2595	1.57306	.25861
	Intuition	23	8.7013	1.74375	.36360

*Higher means are associated with a more naïve epistemology

Table 9. Differences in Epistemology as a Function of Perceptive Type

Dimension	t	df	Sig.
Simple Knowledge	3.658	58	.001*
Certain Knowledge	1.258	58	.213
Quick Learning	.958	58	.342
Fixed Learning	1.282	58	.205

*Statistical Significance. Sensory perceptive students are more likely to hold a naïve belief in SIMPLE knowledge than are intuitively perceptive students.

Sensing students were more likely than their intuitive counterparts to believe that knowledge consists of isolated and unrelated facts rather than complex, interrelated concepts ($p<.001$).

SUMMARY

Between-group differences in patterns of perception and judgment and adherence to four epistemological beliefs were analyzed, and the relationship between perception and epistemology was investigated. The populations studied were college freshmen, preservice science teachers, elementary teachers, and scientists. Patterns of perception and judgment were assessed on the Myers-Briggs Type Indicator (MBTI), while adherence to select epistemological beliefs was measured by Schommer's Epistemological Questionnaire (SEQ).

Three hypotheses were researched and tested in the study. Hypothesis 1, stating there are no significant between-group differences in patterns of perception and judgment between college freshmen, preservice science teachers, elementary teachers, and scientists, was rejected. A Chi-Square analysis revealed that scientists are more likely to rely on *Intuition* (70.8% *i*N, $p < .05$) and *Thinking* judgment (83.3% T, $p < .001$) compared with college freshmen (37.4% *i*N and 37.9% T), preservice science teachers (36.6% *i*N and 56.1% T), and elementary teachers (35.1% *i*N and 37.8% T).

Hypothesis 2, stating there are no significant differences in adherence to the four epistemological dimensions measured by the SEQ, was rejected. College freshmen were significantly more likely than preservice science teachers, elementary teachers, and

scientists to view knowledge as the accumulation of isolated and unrelated facts (SIMPLE knowledge, $p < .01$). On the other hand, scientists were significantly more likely to believe that knowledge consists of complex, interrelated concepts and ideas compared with the other three groups ($p < .001$). While college freshmen differed from scientists and preservice science teachers in degree of adherence to a naïve perspective on the QUICK learning dimension (i.e., learning occurs quickly, or not at all, $p < .01$), they did not differ significantly from the sample of elementary teachers. Elementary teachers were as likely as college freshmen to view the acquisition of knowledge as an immediate, all-or-none phenomenon, rather than a gradual process requiring sustained effort.

Hypothesis 3, stating there is no relationship between patterns of perception and adherence to the four epistemological dimensions, was rejected. A significant difference between intuitive and sensory perceptive college students was found on the SIMPLE dimension of the SEQ. Sensory perceptive students (S) were more likely than intuitive (*i*N) students to believe that knowledge consists of a collection of concrete, isolated, or unrelated facts ($p < .001$).

The next chapter, Chapter V, summarizes the results of this study, along with conclusions and recommendations for future research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

INTRODUCTION

The primary problem in this study was to investigate epistemological and worldview differences in four populations involved in the teaching-learning process with special relevance to science education. The secondary problem was to examine the relationship between patterns of information processing in the perceptual domain and adherence to select epistemological beliefs thought to be propagated by the structure of formal, didactic teaching methods. The purpose of the study was to obtain information that would clarify epistemological and worldview differences plaguing education reform efforts in general, and science education in particular. A secondary purpose was to gather data for educators regarding the role perceptive type preferences might play in the likelihood that certain beliefs about the nature of knowledge and learning become incorporated. To achieve these objectives a quasi-experimental design was employed. Patterns of perception and judgment and epistemology were assessed and compared in college freshmen, preservice science teachers, elementary teachers, and scientist from data collected through the administration of the Myers-Briggs Type Indicator (MBTI)

and Schommer's Epistemological Questionnaire (SEQ). A summary of the results of this study, along with conclusions and recommendations, are presented in the sections that follow.

SUMMARY

College freshmen, preservice science teachers, elementary teachers, and scientists were invited to participate in the study. Participants were asked to complete the two self-report instruments and provide demographic information. A total of 313 students and educators participated in the study comprising the following group ratios: 211 college freshmen, 37 elementary teachers, 41 preservice science teachers, and 24 scientists. Data from seven participants who did not complete Schommer's Epistemological Questionnaire were excluded from the data analysis of hypotheses 2. Data analysis assessing the relationship between perceptive type and epistemology was limited to the 60 students who completed the demographic information on both instruments.

To accomplish the purpose of the study, three null hypotheses were formulated. Hypothesis 1 claimed there would be no significant between-group differences in patterns of perception and judgment as measured by the MBTI. Hypothesis 2 claimed there would be no significant between-group differences in adherence to the four epistemological dimensions measured by the SEQ. Hypothesis 3 claimed there would be no relationship between MBTI patterns of perception and adherence to the four epistemological beliefs assessed by the SEQ.

Statistical Package for Social Sciences (SPSS) software was used for data analyses. A 0.05 level of significance was used in all tests. Hypothesis 1, no between-group differences in patterns of perception and judgment, was studied with Pearson Chi-Square analysis. Hypothesis 2, no between-group differences in adherence to the four epistemological dimensions measured by the SEQ, was studied using parametric analysis of variance (ANOVA) with the Tukey post hoc test applied. Hypothesis 3, no relationship between patterns of perception and epistemology, was analyzed using Levene's test for equality of variance and the independent t-test. The findings are provided in the following section.

SUMMARY OF FINDINGS

1. Scientists were more likely to rely on *Intuition* (70.8%) and *Thinking* judgment (83.3% T) compared with college freshmen (37.4% *i*N and 37.9% T), preservice science teachers (36.6% *i*N and 56.1% T), and elementary teachers (35.1% *i*N and 37.8% T). Hypothesis 1 was rejected.

2. Although the majority of preservice science teachers indicated a preference for *Thinking* judgment (56.1%), this difference was not significant compared with college freshmen (37.9%) and elementary teachers (37.8%).

3. College freshmen were significantly more likely than preservice science teachers, elementary teachers, and scientists to view knowledge as the

accumulation of isolated and unrelated facts and knowledge acquisition as the accumulation of these facts (SIMPLE knowledge). Hypothesis 2 was rejected.

4. Scientists were significantly more likely to believe that knowledge is complex and consists of interrelated concepts and ideas compared with the college freshmen, preservice science teachers, and elementary teachers.

5. College freshmen were more likely than scientists and preservice science teachers to believe that learning occurs quickly or not at all (QUICK learning).

6. Elementary teachers were as likely as college freshmen to view the acquisition of knowledge as an immediate, all-or-none phenomenon, rather than a gradual, sustained process.

7. Sensory perceptive students (S) were more likely than intuitive (*i*N) students to believe that knowledge consists of a collection of concrete, isolated, or unrelated facts and knowledge acquisition as the accumulation of these facts (SIMPLE knowledge). Hypothesis 3 was rejected.

8. No significant differences in pattern of perception and the degree of adherence to the CERTAIN, QUICK, and FIXED epistemological dimensions measured by the SEQ were found.

CONCLUSIONS

The following conclusions were reached as a result of the findings presented in this study:

1. Significant differences were found on measures used to clarify the nature of worldview differences between scientists and elementary teachers in the perception and judgment domains. The majority of scientists relied on *Intuition* (70.8 %) and *Thinking* (83.3%) judgment, while only 35.1% and 37.8% of elementary teachers indicated a preference for *Intuition* and *Thinking*, respectively. With regard to epistemology, significant differences between scientists and elementary teachers were found on two of the four dimensions, SIMPLE knowledge and QUICK learning.

2. *Sensing* and *Thinking* in Jung's theory are linked through associated information processing pathways, which was thought to orient scientists towards the external world and the source of pattern propagation. The majority of scientists in this study, however, did not rely on concrete observation of external objects and events, but rather on the more

imaginative form of perception that is derived or animates from within. Academic scientists were also the only group studied actively involved in intellectual pursuits in their area of interest or expertise similar to the type of instruction one arm of current science education reform seeks to emulate (i.e., open inquiry).

3. College freshmen were more likely to hold a naïve epistemological perspective on the SIMPLE dimension (knowledge consists of the accumulation of isolated facts) compared with the other three groups, including preservice science teachers nearing the end of formal training.

4. College freshmen were also more likely to hold a naïve perspective on the QUICK dimension of the SEQ (i.e., learning occurs quickly or not at all) compared with perservice science teachers and scientists. However, they did not differ significantly from elementary teachers. Both college freshmen and elementary teachers tended to adhere to the belief that learning is an all-or-none phenomenon that will occur quickly if it is to occur at all.

5. Sensory perceptive college students were more likely to adhere to a belief in SIMPLE knowledge (i.e., knowledge consists of a collection of isolated, unrelated facts) than were college students with a preference for *Intuition*.

DISCUSSION

Worldview as defined in the present study includes patterns of information processing in the perception and judgment domains as well as epistemological frameworks. The scientists and elementary teachers surveyed in this study differed from one another on all three measurements. Scientists were more likely than elementary teachers to rely on an internal informational source in the perceptual domain, but less likely to draw upon internal somatosensory experience in the decision-making process. Findings from the epistemological indicator showed elementary teachers were more likely to view knowledge as a collection of isolated facts and to believe that learning occurs quickly, or not at all, compared with scientists.

One interpretation of these findings might be that elementary teachers' habitual reliance on external sensory perception may render this group more susceptible to the development of an epistemology that understands knowledge as external to the knower. In contrast, scientists who habitually rely on internal informational sources might be less inclined to understand knowledge as an accumulation of external facts. This explanation is supported by the present finding that sensory perceptive college students in this study were more likely to adhere to a belief in SIMPLE knowledge (i.e., knowledge consists of a collection of isolated facts) than were intuitive college students.

Consistent with theory that associates science with an experience of the self or way of knowing that is essentially separate (separate knowing), scientists in this study were more likely to rely on *Thinking* judgment as a basis for decision-making than were any of the other three groups. This finding might reflect habitual response patterns that

result from the need to carefully exclude somatosensory experience to maintain the objective distance needed for logical analysis. These results support previous researchers' findings that the dominant type among scientists is *i*NT (Baker, 1982, 1983; Gable, 1986; Melear, 1989).

The finding that elementary teachers were as likely as college freshmen to maintain a belief in QUICK learning is consistent with TIMSS-related research indicating Japanese are more likely than U.S. teachers to allow students time to struggle with difficult problems and engage in discussions about how to solve them. Confusion and frustration are seen as a "natural part of the process and are useful to prepare the students for the information received during the discussion" (NRC, 1999, p. 53). If teachers held a belief that learning should be relatively passive and understanding quick, strategies employed by teachers in other cultures might seem like a waste of valuable and limited instructional time. A belief in immediate or QUICK learning may be more contextual, whereas a belief in SIMPLE knowledge more developmental in the sense that individuals may be predisposed to develop a positivistic or constructivistic orientation based on perceptive type. The structure of formal educational practice at the primary level that increasingly includes demands for time-limited standardized testing to document student learning may reinforce a belief in QUICK learning in the minds of primary level educators as well as in the student.

College freshmen were more likely than the other three groups, including preservice science teachers, to hold a naïve belief on the SIMPLE dimension (knowledge consists of the accumulation of isolated facts). This finding is consistent with other research that indicates college students' epistemology evolves from a conception that

knowledge lies external to the knower (in authority) to one that conceptualizes knowledge acquisition as inherently complex and socially constructed. What is not clear, however, is the extent to which the epistemic development that occurs during college represents, in part, an undoing of social conditioning from long exposure to teacher-centered educational practices that relegate the role of the student to passive observer.

As mentioned above, the finding that sensory perceptive college students were more likely than intuitive college students to believe knowledge consists of a collection of isolated facts suggests the possibility that individuals may be predisposed to develop an epistemological framework as a function of the type of perception habitually employed. This finding is consistent with the characterization of sensory perceptive individuals as "knowledge realists" and intuitively perceptive individuals as "knowledge idealists." Sensory perceptive individuals are concerned with the details available to the senses rather than the imagination of possibilities. Essentially, the details provided inside a traditional, didactic classroom are bits of unrelated facts to be memorized, which would tend to reinforce a predisposed tendency to view learning as an accumulation of external facts (positivistic epistemological framework).

This interpretation is supported by the work of Tsai (1998) who showed that by the time students reach middle school epistemological frameworks are in place that can alter learning behavior and attitudes. A qualitative analysis of in-depth interview data revealed that those students classified as positivistic tended to emphasize external informational sources and employ more rote-like strategies to enhance understanding, whereas constructivistic students tended to emphasize internal informational sources and employ a wide variety of techniques to facilitate learning. While most positivistic

students in believed careful observation as the source of scientists' ideas, constructivistic students tended to believe that scientists' ideas came from "their intuitions or flashes of insights, the theories posed by earlier scientists, and even ancient folklore, but none of them mentioned anything about observation" (p.478). Although the positivistic students showed convictions for the tentative nature of science, they believed that this "tentativeness came from the limitations of technology and sensory limits. Thus, when advanced technology was available, one could approach the truth . . ." (p. 479).

Paulsen and Feldman (1999) found that students believing knowledge consists of accumulated external facts (SIMPLE knowledge) were less likely to be motivated by intrinsic factors or to perceive an internal control over learning compared to students who believed otherwise. Similarly, knowledge constructivists in Tsai's study were mainly motivated by "their interest and curiosity about science, whereas [positivistic] subjects were mainly motivated by performance on examinations" (p. 473). Tsai concludes that from an positivistic framework, science is interpreted as "static information already existing there for them to learn; hence, it is not necessary for them to try to construct their ideas right in class." Rather they can wait until later and "transfer these facts from outside into their mind" (p. 485).

RECOMMENDATIONS

Based on the results of the study, recommendations and suggestions regarding epistemological issues and worldveiw differences in science are provided.

1. The relationship between patterns of perception, *Intuition* and *Sensing*, and positivistic versus contstructivistic epistemologies should be investigated directly, either through qualitative interview or by the use of an instrument such as Pomeroy's questionnaire (1993), designed to specifically detect differences along this line.

2. The relationship between the tendency to base decisions on logical analysis (*Thinking*) versus somatosensory experience (*Feeling*) and the epistemological frameworks labeled separate and connected knowing should also be systematically studied. Currently, in-depth qualitative interviews have been employed to discern this epistemic division. If possible, development of an instrument to facilitate assessment would be beneficial.

3. More research is needed to clarify development associated with Jung's second phase of psychological adaptation that is characterized by differentiation of all four mental functions (1921/1971). Particularly helpful is this regard would be cross-cultural studies aimed at uncovering psychological and environmental factors prohibiting transformation and higher levels of development beyond the establishment of the autonomous, self-directed agent or ego identity.

In a classic paper entitled, "Development as the Aim of Education" Kohlberg and Mayer argued that the purpose of education was to assist children move towards more mature intellectual, epistemological and ethical development. This was not indoctrination, the authors claimed, because it merely guided children in the "natural directions" of development (1972, p.475). Belenky et al.

(1986) suggest that the "natural directions" in which all human beings supposedly head toward, in actuality promote an "epistemology based on standard (and separate) 'principles of scientific method'" and rational reflection (p. 228). Opposing worldviews in science education need not present an insurmountable impasse when considered form the perspective that neither separate knowing nor connected knowing in and of themselves are the endpoint of development.

4. An important question is whether or not exposure to the structure of traditional, didactic teacher-centered practice shapes or predisposes students through habitual usage a reliance on *Sensing* perception and the "knowledge realist" orientation. Why is it that scientists actively involved in intellectual pursuits of their own interest and choosing (personally relevant) show such a high preference for intuitive perception compared with other groups involved in the teaching-learning process? A longitudinal study comparing type of perception as a function of exposure to distinct instructional methodology (Montessori versus traditional public schooling, for example) would be particularly informative. In addition, studies using instructional methodology as the independent variable and development of a positivistic or constructivistic framework as the dependent variable would help clarify the relationship between instructional methods and epistemology.

5. Gender issues related to the connected versus separate knowing categories need to be addressed in conjunction with the *Thinking* and *Feeling* patterns of information processing. Belenky et al. (1986) claim, "separate and connected are not gender-

specific," however, "the two modes may be gender-related" (p. 102). Females may be more likely to base decisions on internal somatosensory or hypothalamic-limbic information (*Feeling*) and demonstrate a preference for connected knowing because females have a "hypothalamus with a more rich and complex pattern and with more intricate interconnections between nerve cell" than males (Joseph, 1992, p. 111). Presumably the hypothalamus is more complex in females because of the complexities involved in the reproduction and nurturance of infants.

6. Educators, particularly educators of future teachers, should make the epistemological beliefs of their students explicit. However, according to Nespor (1987) such beliefs are "deeply personal, stable, lie beyond individual control or knowledge and are usually unaffected by persuasion." Freire's (1973) "problem-posing" method might be a suitable strategy for this task. In this method both teacher and student engage in the process of thinking about a particular problem (an epistemological dilemma, for example), and as they talk out what they are thinking, their roles begin to merge. "Through dialogue, the teacher-of-the-students and the students-of-the-teacher cease to exist" (Freire, p. 67). Freire's method is an example of a connected knowing teaching strategy where the student is an active participant in the learning process, which ultimately is the goal of most educational reform efforts. Rather than having the knowledge located externally (in the teacher), it becomes a shared potentiality of both parties. If epistemological frameworks could be brought to the surface and recognized as

organizing strategies that serve a purpose, the possibility of modification increases.

7. The way that science is communicated in public forums, especially those involving the professional development of teachers, may serve to perpetuate the positivistic and separate knowing epistemological frameworks associated with science that derail attempts to move toward learner-centered educational practice. Scientists may not be able to discuss the nature of their research from an epistemological perspective, recognize that science is value-laden, or understand the existence of other organizing strategies for experience that are equally valid. Exposure to the history and philosophy of science and a deeper understanding of fundamental differences in information processing pathways is needed within the communities of science and education for personal as well as professional growth.

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APPENDICES

APPENDIX A

INFORMED CONSENT

Consent Form

You are invited to participate in a research study. The purpose of the study is to assess patterns of information processing and adherence to select epistemological beliefs that may or may not influence new science teachers ability to teach using inquiry-based instructional methodology. This project originated as a pilot study of the Salish II research consortium designed to research and implement programs that adequately prepare science teachers for the new standards of teaching, which require student-centered inquiry as the basis of instruction. The Salish II consortium currently consists of university/college faculty in science and science education from over 46 institutions in 24 states. The Consortium focuses on the preparation of science teachers as defined by the emerging U.S. National Education Standards and Assessment.

Your participation in this study may include the following:

- Providing demographic information.
- Answering questions assessing how you normally act or feel towards everyday situations and events on the Myers-Briggs Type Indicator (MBTI, Form G).
- Completing a 63-item survey designed to assess beliefs about the nature of knowledge and learning. These items are presented as statements and a 5-point Likert scale is used to determine degree of agreement or disagreement with the statement.

Risk of Particpation

There are no known risks associated with participation in this study

Benefits

This study may provide important information for preparing new teachers to use the instructional strategies recommended by the U.S. National Education Standards.

Confidentiality

The information in the study records will remain confidential. All data will be stored securely and will be made available to persons conducting the study unless you specifically give permission in writing to do otherwise. No direct reference will be made in oral or written reports which could link you to the study. Results of the MBTI will become part of the Center for the Application of Psychological Type's (CAPT) database. Confidentiality of information contained in the database is mandated by licensing agency.

Contact

If you have questions at any time about the study or the procedures, you may contact Dr. Claudia Melear at the University of Tennessee, (865) 974-5394. If you have questions about your rights as a participant, you may contact the Compliance Section of the Office of Research, (865) 974-3466. If you have questions regarding the MBTI instrument, scoring procedure, or database maintenance, you may contact CAPT, Gainesville, Florida, (800) 777-2278.

Participation

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw form the study at anytime without penalty or loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed upon your request.

I have read and understand the above information. I have received a copy of this form. I agree to participate in this study.

Participant's Signature _____ Date _____

Investigator's Signature_____ Date _____

Last four digits of your social security number _____

APPENDIX B

SCHOMMER EPISTEMOLOGICAL QUESTIONNAIRE

Directions: There are no right or wrong answers for the following questions. We want to know what you really believe. After each statement write the number (1-5) that corresponds with the degree to which you agree or disagree.

Strongly Disagree				Strongly Agree
1	2	3	4	5

1. If you are ever going to be able to understand something, it will make sense to you the first time you hear it.
2. The only thing that is certain is uncertainty itself.
3. For success in school, it's best not to ask too many questions.
4. A course in study skills would probably be valuable.
5. How much a person gets out of school mostly depends on the quality of the teacher.
6. You can believe almost everything you read.
7. I often wonder how much my teachers really know.
8. The ability to learn is innate.
9. It is annoying to listen to a lecturer who cannot seem to make up his mind as to what he really believes.
10. Successful students understand things quickly.
11. A good teacher's job is to keep his students from wandering from the right track.
12. If scientists try hard enough, the can find the truth to almost anything.
13. People who challenge authority are over-confident.
14. I try my best to combine information across chapters or even across classes.
15. The most successful people have discovered how to improve their ability to learn.
16. Things are simpler than most professors would have you believe.

Strongly Disagree Strongly Agree
1 2 3 4 5

17. The most important aspect of scientific work is precise measurement and careful work.

18. To me studying means getting the big ideas from the text, rather than details.

19. Educators should know by now which is the best method, lectures or small group discussions.

20. Going over and over a difficult textbook usually won't help you understand it.

21. Scientists can ultimately get at the truth.

22. You never know what a book means unless you know the intent of the author.

23. The most important part of scientific work is original thinking.

24. If I find the time to re-read a textbook chapter, I get a lot more out of it the second time.

25. Students have a lot of control over how much they can get out of a textbook.

26. Genius is 10% ability and 90% hard work.

27. I find it refreshing to thing about issues authorities can't agree on.

28. Everyone needs to learn how to learn.

29. When you first encounter a difficult concept in a textbook, it's best to work it out on your own.

30. A sentence has little meaning unless you know the situation in which it is spoken.

31. Being a good student generally involves memorizing facts.

32. Wisdom is not knowing the answers, but knowing how to find the answers.

33. Most words have one clear meaning.

34. Truth is unchanging.

Strongly Disagree Strongly Agree
1 2 3 4 5

35. If a person forgot details, and yet was able to come up with new ideas from a text, I would think they were bright.

36. Whenever I encounter a difficult problem in my life, I consult my parents.

37. Learning definitions word-for-word is often necessary to do well on tests.

38. When I study, I look for specific facts.

39. If a person can't understand something within a short amount of time, they should keep on trying.

40. Sometimes you just have to accept answers from a teacher even though you don't understand them.

41. If professors would stick more to the facts and do less theorizing, one could get more out of college.

42. I don't like movies that don't have an ending.

43. Getting ahead takes a lot of work.

44. It's a waste of time to work on problems which have no possibility of coming out with a clear-cut and unambiguous answer.

45. You should evaluate the accuracy of information in a textbook, if you are familiar with the topic.

46. Often, even advice form experts should be questioned.

47. Some people are born good learners, others are just stuck with limited ability.

48. Nothing is certain, but death and taxes.

49. The really smart students don't have to work hard to do well in school.

50. Working hard on a difficult problem for an extended period of time only pays off for really smart students.

Strongly Disagree Strongly Agree
1 2 3 4 5

51. If a person tries too hard to understand a problem, they will most likely just end up being confused.

52. Almost all the information you can learn from a textbook you will get during the first reading.

53. Usually you can figure out difficult concepts if you eliminate all outside distractions and really concentrate.

54. A really good way to understand a textbook is to re-organize the information according to you own personal scheme.

55. Students who are "average" in school will remain "average" for the rest of their lives.

56. A tidy mind is an empty mind.

57. An expert is someone who has a special gift in some area.

58. I really appreciate instructors who organize their lectures meticulously and then stick to their plan.

59. The best thing about science courses is that most problems have only one right answer.

60. Learning is a slow process of building up knowledge.

61. Today's facts may be tomorrow's fiction.

62. Self-help books are not much help.

63. You will just get confused if you try to integrate new ideas in a textbook with knowledge you already have about a topic.

APPENDIX C

RECRUITMENT OF SUBJECTS: CORRESPONDENCE

ELECTRONIC TRANSMITTAL

Dear Biology Faculty,

I am a doctoral candidate in the College of Education conducting a study to examine and compare worldview and epistemological differences that may be a factor in the interpretation and implementation of current science education standards that call for the use of scientific inquiry methodology in science teaching. This project is an extension of efforts by Drs. Claudia Melear (UTK-TPTE) and Les Hickok (UTK-Botany) to improve training for secondary preservice science teachers seeking certification in Biology. As most of the preservice science teachers are preparing to teach in the biological and life sciences we are recruiting practicing research scientists from the Biology Division for statistical comparison.

Your participation in the study would take approximately 45-50 minutes. It involves completing two self-report survey instruments, the Myers-Briggs Type Indicator (MBTI, Form G) and an epistemological belief questionnaire. Research results and individual MBTI profiles will be made available and interpreted to you as part of your participation. All information in the study records will remain confidential and will only be made available to the persons conducting the study. No direct references will be made that could link you to the study in accordance with the Compliance Section of the Office of Research at the University of Tennessee. If you are willing to participate in this study aimed at improving biology teacher preparation, please reply to this e-mail and arrangements will be made to get the test materials to you. Thank you for your time.

COVER LETTER TO SCIENTISTS

Dear Scientist,

Thank you for agreeing to participate in this study. Please find enclosed the following material to be completed and returned in the stamped, self-addressed envelope provided:

1). Two copies of the Consent Form with contact information (sign and return one form and keep the other for your record)

2). The Myers-Briggs Type Indicator test booklet and answer sheet (please follow instructions for completing the instrument and providing demographic information, the section marked "optional" can be omitted).

3). A four page, 63-item Epistemological Questionnaire (please rate the degree to which you disagree or agree with each item and record the number after the statement).

4). A #2 pencil

Information regarding the results of the study and your MBTI profile will be made available to you upon request. Please indicate your preference(s) below and be sure to return this form with your test material.

_____ Summary of Study Findings

_____ MBTI Results

COVER LETTER TO OFF-SITE SCIENCE EDUCATORS

Dear Science Educator,

Thank you for agreeing to assist me with recruitment of preservice science teachers for my study. Please find enclosed the following items for distribution to your students who have agreed to participate:

1). Two copies of the Consent Form with contact information (one copy must be signed and returned, the student may keep the other)

2). The Myers-Briggs Type Indicator test booklet and answer sheet (please have students follow the instructions for completing the instrument and providing demographic information, the section marked "optional" can be omitted).

3). A four page, 63-item Epistemological Questionnaire (please have students rate the degree to which they agree or disagree with each item and record the number after the statement).

4). A #2 pencil

Students may take the packets home and return the completed forms so that you do not have to use class time. I've enclosed two large self-addressed stamped envelopes for returning completed test material. Please contact me if you have and questions. I appreciate your assistance.

Nancy Chadwell
Doctoral Candidate
Department of Educational Psychology
University of Tennessee

RECRUITMENT OF COLLEGE FRESHMEN

Psychology Department
Psychology Students Subject Pool Guide for Users
Revised Fall 1999

Students enrolled in Psychology 110 are permitted to participate in research studies for points toward their final grade. The amount of credit will be determined by the instructor, based upon the amount of time spent in the environment. Please remember - you are not allowed to go into the 110 class to make announcements or conduct experiments.

RESEARCHERS

You must follow the standard procedures, or you will lose the privilege of using Psych 110 students. For classes other than Psych 110, check with the faculty member in charge of the course to determine whether students in the course can earn extra credit and how procedures are handled.

1. Prepare a one-page description of the study for Dr. Saudargas

2. Provide an approved (Must have signatures) Form A or B. Students cannot be used as subjects without an approved form.

3. Prepare a sign-up sheet for posting. This should include a brief description of the project, and names and phone numbers of the researchers. Provide a copy for Dr. Saudargas

4. Provide the UG Office with copies of ALL sign-up sheets and or appointment lists before they are posted.

5. Get Student Extra Credit Voucher forms from Sandy Thomas in advance.

6. After the experiment, turn the white copies in to Sandy. Give the yellow copy to the student.

Sign-up sheets can be posted as soon as steps 1-5 have been completed. Any sign-up sheets which are not approved, or which the UG office does not have a copy of will be removed from the board.

Student Extra Credit Voucher:

ENTERED ON COMPUTER _____

PSYCHOLOGY 110 EXTRA CREDIT FORM
PLEASE PRINT ALL INFORMATION

CLASS TIME _____ SECTION # (if known) _____

TEACHER'S NAME _____

STUDENT'S NAME _____

SOCIAL SECURITY NUMBER _____

HAS PARTICIPATED IN AN EXPERIMENT OF___ HOUR(S) _____ MINUTES

DATE GIVEN _____

EXPERIMENTER NAME _____ PHONE # _____

_____
(MUST BE SIGNED BY EXPERIMENTER)

THIS EXTRA CREDIT FOORM IS TO BE FILLED OUT AND INDIVIDUALLY SIGNED BY THE EXPERIMENTER. IT IS THE RESPONSIBILITY OF THE EXPERIMENTER TO TURN THE FORMS INTO THE PSYCH 110 OFFICE. THE STUDENT IS TO KEEP THEIR RECEIPT FOR THEIR RECORD.

WHITE COPY- PSYCHOLOGY DEPARTMENT OFFICE
YELLOW COPY- STUDENT RECEIPT

APPENDIX D

TYPE DISTRIBUTION TABLES

COLLEGE FRESHMEN

N = 211

ISTJ N = 17 (8.1%)	**ISFJ** N = 19 (9.0%)	**INFJ** N = 4 (1.9%)	**INTJ** N = 4 (1.9%)
ISTP N = 9 (4.3%)	**ISFP** N = 7 (3.32%)	**INFP** N = 15 (7.1%)	**INTP** N = 5 (2.4%)
ESTP N = 15 (7.1%)	**ESFP** N = 11 (5.2%)	**ENFP** N = 28 (13.3%)	**ENTP** N = 8 (3.79%)
ESTJ N = 16 (7.6%)	**ESFJ** N = 38 (18.0%)	**ENFJ** N = 9 (4.3%)	**ENTJ** N = 6 (2.8%)

ELEMENTARY TEACHERS

N = 37

ISTJ N = 4 (10.8%)	**ISFJ** N = 10 (27%)	**INFJ** N = 1 (2.1%)	**INTJ** N = 5 (13.5%)
ISTP N = 0 (0.0%)	**ISFP** N = 1 (2.7%)	**INFP** N = 3 (8.1%)	**INTP** N = 1 (2.7%)
ESTP N = 0 (0.0%)	**ESFP** N = 1 (2.7%)	**ENFP** N = 5 (5.4%)	**ENTP** N = 0 (0.0%)
ESTJ N = 4 (10.8%)	**ESFJ** N = 4 (10.8%)	**ENFJ** N = 1 (2.7%)	**ENTJ** N = 0 (0.0%)

PRESERVICE SCIENCE TEACHERS

N = 41

ISTJ N = 6 (14.6%)	**ISFJ** N = 5 (12.2%)	**INFJ** N = 1 (2.4%)	**INTJ** N = 4 (9.8%)
ISTP N = 0 (0.0%)	**ISFP** N = 2 (4.9%)	**INFP** N = 1 (2.4%)	**INTP** N = 2 (4.9%)
ESTP N = 2 (4.9%)	**ESFP** N = 2 (4.9%)	**ENFP** N = 1 (2.2%)	**ENTP** N = 0 (0.0%)
ESTJ N = 5 (12.2%)	**ESFJ** N = 4 (9.8%)	**ENFJ** N = 2 (4.9%)	**ENTJ** N = 4 (9.8%)

SCIENTISTS

N = 24

ISTJ N = 2 (8.3%)	**ISFJ** N = 1 (4.2%)	**INFJ** N = 0 (0.0%)	**INTJ** N = 6 (25%)
ISTP N = 0 (0.0%)	**ISFP** N = 0 (0.0%)	**INFP** N = 2 (8.3%)	**INTP** N = 4 (16.7%)
ESTP N = 0 (0.0%)	**ESFP** N = 0 (0.0%)	**ENFP** N = 0 (0.0%)	**ENTP** N = 1 (4.17%)
ESTJ N = 4 (16.7%)	**ESFJ** N = 0 (0.0%)	**ENFJ** N = 1 (4.17%)	**ENTJ** N = 3 (12.5%)

VITA

The author received a B.A. degree from Kalamazoo College in Michigan in 1981 and worked in the field of reproductive technology at Baylor College of Medicine in Houston, Texas prior to transferring to the University of Tennessee Medical Center in 1987. She was a supervisor in the Department of Obstetrics and Gynecology at UTMCK before entering the doctoral program in the College of Education, Department of Educational Psychology, on a two-year fellowship from the Graduate School of Medicine. She resides in Knoxville with her husband, Michael Chadwell, and their twin 4-year-olds, Parker and Haley.