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A CONCEPTUAL INTEGRATION ANALYSIS OF
MULTIPLE INSTRUCTIONAL METAPHORS

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

Robert Johnson

College of Education and Behavioral Sciences
School of Psychological Sciences
Educational Psychology

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This Dissertation by: Robert Johnson

Entitled: *A Conceptual Integration Analysis of Multiple Instructional Metaphors*

Has been approved as meeting the requirement for the degree of Doctor of Philosophy in the College of Education and Behavioral Sciences in the School of Psychological Sciences, Program of Educational Psychology

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ABSTRACT

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The present study was conducted to investigate some of the practical implications of conceptual integration theory for educators. This research was a mixed-methods study exploring how improvements in understanding—learning—(as measured by a selected-response assessment) are reflected in changes in learner language (described in terms of conceptual integration patterns). After a pretest with open-response and selected-response prompts, two groups of young adult participants viewed different videos of a slightly different review lesson in genes, genetics, and heredity, the difference lying in two different metaphor conditions: the experimental group was shown a more "metaphor-rich" version of the lesson using two classic metaphors about the topic. Both groups then took somewhat elaborated posttests to provide data as to what kinds of conceptual integration processes may have been in use by the participants as they processed, learned, and communicated their understanding of the instructional content.

Results were compared to determine if the instructional metaphors bore on patterns of learning and understanding as described by the conceptual integration model. The different metaphor conditions were not shown to have been significantly different in their respective effects on participant learning; however, the broad gains across all pre-post quantitative results suggested real learning among the participants. This learning—or

at least the participants' communication about the content domain—was indeed reflected in changes identified by a conceptual integration analysis of the qualitative data.

The researcher concluded not only that the conceptual integration model could be used as a guide to improve teaching practices; if the conceptual integration model could account more robustly or subtly for cognitive elements of teaching and learning, it also could be used to refine the language used in the creation and interpretation of assessments, leading to improved validity and reliability at any level of assessment, from teacher-developed classroom assessments to large-scale standardized assessments.

ACKNOWLEDGEMENTS

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Their many excellent qualities, so generously shared, are reflected throughout this work; any errors herein, on the other hand, are mine alone.

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CHAPTER I

INTRODUCTION

Theoretical Context and Background

In pursuit of my doctoral program in educational psychology at UNC, I have tried

to keep in mind the three topics of foremost interest to me throughout my 30-year

teaching career: language, learning, and psychology. A deceptively simple core issue in

educational psychology has proven to be frustratingly difficult for generations of

researchers, i.e., just what happens psychologically when students learn something new

from classroom instruction? In this research, I addressed that question about the

psychology of learning through the perspective of language.

Though there have been many advancements in the assessment of student learning

since the foundations of educational psychology were being established about 100 years

ago, theoretical solutions to that question—What happens psychologically when students

learn something new from classroom instruction?—remain elusive. Studies of the

phenomena of consciousness, memory, neurology, linguistics, social psychology,

communication, and pedagogy have enriched the ongoing discussion with increasing

subtlety and explanatory power. However, until recently, there was little common

intellectual ground among these various fields. Although each separate field yielded

valuable understanding, educators seeking wide-ranging practical applications have been

stymied by the piecemeal nature of the different disciplines' findings.

Previous "transmission" models (Mayer, 1999) of learning have been woefully inadequate in explanatory power, especially in light of recent advances in cognitive psychology and cognitive linguistics. In the present study, I addressed the psychology of teaching and learning through the application of principles from the newly emerging cognitive model of conceptual integration (Coulson & Van Petten, 2002; Evans & Green, 2006; Fauconnier & Turner, 2002; Turner & Fauconnier, 1995; Underhill, 2002), also known in the literature as conceptual blending. Because of its unified and holistic, rather than fragmented, nature, the conceptual integration model has the potential to offer a number of useful insights and tools to the field of educational psychology. The research reported here uses a conceptual integration approach in a mixed-method analysis of the relative effects of two instructional metaphor conditions by quantitative and qualitative measures of change in student understanding.

In brief, conceptual integration theory offers a model of how people think (Coulson & Van Petten, 2002; Evans & Green, 2006; Fauconnier & Turner, 2002; Turner & Fauconnier, 1995; Underhill, 2002). To the extent it is valid, the model could account for much of what happens psychologically when people teach and learn. Likewise, the model could account for many occasions of informal, ad hoc teaching and learning as well; however, the educational focus of the present study is designed to provide an application of the conceptual integration model to the analysis of formal instruction and assessment. Although other types of thought are included in the conceptual integration model, language is the most common medium of human interaction. As such, it is recognized as a prime example of at least certain kinds of thought. Because of this, most of the examples provided in this research are language-based. The more specific focus of

this research is that very powerful feature of language and instruction--the intentional use of metaphor as a teaching strategy. Unless otherwise cited, the examples are mine.

In this chapter, I examine and develop the general theoretical and historical bases of the areas of research for this study. To facilitate the reader's understanding of the areas of psychology and linguistics to be addressed, I include a set of terms and definitions specific to cognitive linguistics (and an even more specific set of terms and definitions in the field of conceptual integration in the second chapter). Having by then established a general framework of inquiry, I close this section with an overview of some of the potential applications of these concepts to educational psychology and an overview of the present research involving an analysis of the use of metaphor in both instruction and learning.

Proponents of the conceptual integration model (e.g., Coulson & Van Petten, 2002; Fauconnier & Turner, 2002) argue that it implies a vast range of educational applications; this research was just such an application. The purpose of this mixed–methods research was to apply the conceptual integration model to the analysis of metaphors used by both teachers and students in a realistic teaching and learning situation. Although this research was limited to a small sample size, a single pair of experimental conditions, and a single suite of assessments, the relatively natural setting and highly focused prompts and responses provided enough quantitative and qualitative data to begin to address the idea that the conceptual integration model could be used to measure or otherwise analyze learning.

I have long been fascinated by the ideas that there are underlying genetic and linguistic universals shared by all humans and it seems the evidence keeps pointing in

that direction (Pinker, 2002; Wells, 2006). Piecing together evidence from different disciplines has yielded a high level of plausibility for scenarios that account for much of what we see in the fields of linguistics, sociology, psychology, and genetics today in terms of our most widely distributed and universally held human characteristics. But regardless of the exact sequence of events then, we are now faced with the fact that as a species, we are surely the only species capable of intentional choices and activities which affect the entire human population and indeed the entire world. Wells' (1922) famous maxim that history, and we may presume also the future, "is a race between education and catastrophe," seems increasingly true as the years go by. In spite of truly marvelous abilities and potential, humans also continue to face dire consequences of overpopulation, poverty, war, disease, permanent loss of habitats and other resources, etc. For those of us who think education is better strategy than for solving such widespread and deeply rooted problems than complacency or ignorance, the urgency of discovering more effective classroom practices is self-evident. My work as an educator is informed and driven by this very sense of the value and urgency of what we do.

After establishing a general background, theoretical context, and relevant terminology in this introductory chapter, I will move to a level of much greater specificity in Chapter II--Review of Literature. This review provides a framework of inquiry as well as a more detailed terminology based in research and theory, primarily from the fields of cognitive linguistics and conceptual integration. At the end of Chapter II, having established the validity of investigating and testing the conceptual integration approach to learning theory, I posed the primary research questions for this study. From these questions, I formulated hypotheses regarding evidence of learning measured by

changes in patterns of conceptual integration as evidenced by changes in students' use of

metaphors. In Chapter III, I describe the design, materials, methods, and procedures used

in conducting this research.

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Evolutionary Psychology and
Conceptual Integration

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In making a case for how the conceptual integration model could be supported by

what scientists are continuing to learn about the workings of the brain, I now turn to the

evidence related to our understanding of how humans could have evolved such a useful,

dynamic, and creative capacity, that is, the capacity to support conceptual integration.

If, as Pinker (1997) suggests, "the mind is what the brain does" (p. 21), we must

take into account the structure, internal processes, external influences on, and the

products of the brain. The primary focus of this research is specifically related to

language and learning, though the conceptual integration model goes much beyond these

in scope. In order to establish an understanding of the possible mental networks of

conceptual integration, I explore some of the current theory about the evolution of neural

systems and work toward an understanding of how these systems could support the kind

of brain activities implied by a conceptual integration perspective. As will be shown, the

amazingly complex, fast, and recursive nature of brain activity seems to fit well with the

tenets of conceptual integration. Although the specific physical details of all possible

mental networks are not accessible in a practical way, what we are learning about the

brain continues to support, rather than refute, the theories of the conceptual integration

model.

First, then, I consider some of the theories for the biological evolution of the

human brain. Because of the scant physical evidence of human life before about 100,000

years ago, much of the conjecture regarding specific factors in the emergence, and even the definition of "modern humans," remains moot. But there is at least some level of consensus (Blackmore, 1999; Calvin, 2004; Wells, 2006) that somewhere around that time, give or take about 50,000 years, what we today would recognize as cognitively modern humans appeared. Our deeply shared DNA suggests a common family group as does our "Universal Grammar" (Marcus, 2004; Pinker, 1994; Wilson & Keil, 1999). Also sometimes called "Generative Grammar" (Pinker; Wilson & Keil), this is considered by its proponents to be a genetically determined mental proclivity in humans to work in certain ways with language. Those ways are called "grammars," or rule sets, and they are considered a more or less "given" part of our psychological genetic endowment as humans. I go into more detail about this concept in the following terminology section of this paper. Just as the superficial differences in human physiology have now recently been explicated by a much more complete picture of our underlying genetic unity (Wells), the "Tower of Babel" illusion of huge differences in human languages has been dispelled by a new and deeper understanding of commonality in language structures and processes shared by all people (Deutscher, 2005; Pinker).

Some evolutionary scientists regard the turning point between pre-modern and modern humans as the emergence of specifically human physical skills and abilities. For example, Calvin (2004) asserts that the development of the ability to throw objects, such as rocks, then spears, allowed early humans to survive what would otherwise have been fatal encounters, thereby giving them the opportunity to establish human colonies with specific, transferable, and evolving survival skills. The roots of early *homo-habilus* (the "tool-maker") go back to the earliest evidence of simple tool-making (roughly on a par

with simple tools we see in other species, particularly some primates and birds, for example), some two or three million years (Calvin). But the surge in the variety and sophistication of tools of the much more recent *homo-sapiens* (the "wise") is qualitatively quite different from any previous tool-making.

Calvin also brings up a more current example he calls the "curb-cut" phenomenon (2004, p. 97). Today's urban dwellers have seen many different uses of curb cuts beyond the original function of allowing greater access for wheelchair-bound people; cyclists, skateboarders, pedestrians, cart-pushers, carriage pushers, etc., to use the same structure, though such use was not the original intent. Indeed, most of the traffic through a curb cut is *not* the kind of traffic for which it was intended. The point here is that language may well have been a happy by-product of other structures and functions of the evolving human brain, most of which seem to play multiple roles (Marcus, 2004; Ridley, 2003). Taken in combination with the inevitable interaction of these various neural structures and functions, we may move toward a plausible explanation of the evolution of our complex (specifically, our "computational" and "combinatorial"—each explained in detail below) language capacities. Briefly put, this view explains the evolution of language as a more or less inevitable by-product of having all or most of the modern brain's structures and functions already in place. Calvin (2004) cites Chomsky, Hauser, and Fitch:

> The human faculty of language appears to be organized like the genetic code—hierarchical, generative, recursive, and virtually limitless with respect to its scope of expression…Most current commentators agree that, although bees dance, birds sing, and chimpanzees grunt, these systems of communication differ qualitatively from human language. In particular, animal communication systems lack the rich expressive and open-ended power of human language (based on humans' capacity for recursion). (p. 86)

Artifacts from early—so far, dating back to about 75,000 years ago (*World's oldest jewelry found in cave*, 2005) — *homo-sapiens* include something entirely new as well: art, and lots of it. Bead-making, stone- and bone- carving, basket-making, and cave paintings attest to utility and ritual at a completely unprecedented level (Ahuja, 1998; Mayell, 2004). Clearly, the latter part of the middle Stone Age represents a reasonable time frame (roughly 200,000-100,000 years ago) for the advent of at least anatomically modern humans. Though the rise of agriculture is a much more recent phenomenon, from probably near the end of the last ice age--some 10,000-12,000 years ago, tribal cultures based on traditional hunter-gatherer roles must have flourished for tens of thousands of years before, developing language, art, rituals, and world views. Thus, we may be fairly sure of the arrival (with *homo-sapiens*) of a new, thoroughly modern mental capacity: complex, symbolic thought (Ahuja; Calvin, 2004; Mayell).

In contrast to emphasizing a set of particular physical skills or individual mental characteristics, other evolutionary scientists point to the development of culture, language, and art as the hallmarks of the new species (Heminway, 2001; Pinker, 1994). Though some of these thinkers (Blackmore, 1999; Forceville, 2001) posit that primitive cultural advances paved the way for increased cognitive capacities, others (Ahuja, 1998; Donald, 1991; Gardner, 1997; Winerman, 2005) argue that increased mental or emotional capacities were necessary preconditions for societies to emerge. For example, Blackmore uses the concept of memes—as in "mimetic: imitative" (Dawkins, 1976, p. 206; *Oxford Encyclopedic English Dictionary*, 1991, p. 922) —to argue that it may have been the rise of culture and, specifically, the cognitive ability to copy and adapt behavior that impelled our brains to evolve further. Marcus (2004) also suggests that part of what we are "born

to learn" is culture, including language, specifically by imitation. "The very ability to acquire culture is, I would suggest, one of the mind's most powerful built-in learning mechanisms" (p. 27). Likewise, Azar (2005) advances the case that the evolutionary emergence of mirror neurons—a recently discovered type of neuron which activates a sense of experiencing a physical activity merely by watching others participate in the activity— allowed culture to form. These are fascinating "chicken-or-egg" debates; though definitive answers continue to be elusive, the pieces of the intellectual puzzles of how evolution shaped our human capacities are beginning to fall into place. Ornstein (1991) sums it up thusly:

> So, although blind evolution may well have originally selected for adaptability, resistance to heat and the like, it all comes together in the complex of factors that lead to us: bipedal, capable of graceful movements, needing a large brain to control them as well as speech. And…this can well be grasped… by the processes Darwin described. His contribution to the evolution of our understanding of ourselves is much greater than we'd realized. (p. 78)

In other words, although Darwin was focused on the grand picture of how all different species could have developed, one of those species was *homo-sapiens.* And in focusing on how our own species could have evolved not only physically but also mentally and culturally, evolutionary psychologists are continuing to add to our understanding of who we are, and how we may come to grips with our dilemmas and our promise.

Greenspan and Shanker (2004) hold that response to sensory input is the wellspring of emotions and memory, and is thus the deepest "ancestor" and most essential formative element of our modern social and cognitive abilities. The authors especially note the ongoing reciprocity of responses in interactive parent-child behaviors

as evidence. Like the other researchers and theorists cited above, their claims are

plausible and provide valuable insights about the nature of human cognition. But taken

separately, the various explanations fall short of providing a complete picture of how we

think and learn. The story of the blind men and the elephant (Kuo & Kuo, 1976) seems to

be in force here with a need for some kind of unifying perspective. With this in mind, I

turn now from the past to the present.

<div align="center">Neuroscience and Conceptual Integration</div>

Whatever the original impetus, the human brain's amazingly complex

connectivity and specialized functions which have evolved are continuing to be

understood more completely, occasionally yielding to ever more subtle means of

scientific research. With estimates of neuron counts ranging from 20 billion (Marcus,

2004) to 100 billion (Pinker, 1997), and total connections at up to 100 trillion (Pinker),

the brain is the most subtle and complex system known to exist. Among those billions of

cells, there are an estimated 100,000 different types of neurons with specialized functions

(Marcus). Yet having evolved to address certain kinds of needs in our ancestors' lives,

our brains are not necessarily equipped to address the needs of our modern lives, an issue

evolutionary psychologists continue to explore (Pinker, 2002). The exploration of the

present research, however, requires our path to diverge away from evolutionary

psychology and on toward what neuroscience has to offer in describing the brain and its

functions.

Marcus (2004) suggests that there are at least hundreds or even thousands of areas

of specialized brain functions that appear to have basic "locales." However, between

different individuals, the exact shape, location, and connectivity patterns of these

"modules," as they are called (Gardner, 1997), may vary widely. Issues of localized function have only recently become amenable to empirical evidence; early psychologists were taught that the brain operated as a whole during cognition (Posner & DiGirolamo, 2000). But recent advances in neuroscience (particularly neuroimaging techniques such as Positron Emission Tomography [PET] scans and functional Magnetic Resonance Imaging [MRI] scans for localization of activity) ostensibly allow researchers to study brain activity "in progress" and therefore much more directly.

Moreover, the computational metaphor used to describe brain functions has also been evolving from earlier "serial processing" models to "distributed parallel processing" models (Levitin, 2002). The serial processing model traces evidence of brain activity as a single chain of related neural events; however, parallel processing implies many events at once, reflecting many complex neural pathways and many concurrent activities in the brain.

The neural architecture and functions required for the conceptual integration model depend crucially on the orchestration and recursion provided by parallel activation processes, "recruiting" information from several sources at once (Evans & Green, 2006; Fauconnier & Turner, 2002; Turner & Fauconnier, 1995; Underhill, 2002) such as external/verbal cues in addition to internal memory cues, and in-progress meaning construction. "During diverse cognitive tasks, neural areas work in concert to form a neural circuit with particular areas active at particular times to perform the necessary cognitive computations in the appropriate order of the task demands" (Posner & DiGirolamo, 2000, p. 880). In addition to "modules" of specific functions, some hemispheric-specific capabilities may be in service when understanding language as

well; for example, right hemisphere activation of *possibilities* may dovetail with left hemisphere activation of logical *probabilities*, allowing for the in-progress understanding (meaning construction) of novel discourse and information as it becomes available (Shuren & Grafman, 2002).

Basic pathways, sites, systems, and structures have been mapped out (Carter, 1999) such as the visual system, the limbic system, and the language areas (Marcus, 2004; Pinker, 1994; Wilson & Keil, 1999). There also seem to be astonishing levels and ranges of plasticity and redundancy in neural development, giving rise to the idea that experiential and/or social factors—in addition to genetic factors—may literally help shape many of the brain's specific structures and functions (Pinker, 2002). The long period of human infants' post-natal dependence on caregivers attests to the idea that the well-documented development of the nervous system before birth is in itself incomplete, impressive though it may be. The high levels of neural development achieved in childhood are part of what shapes and structures our distinctly human cognitive capacities (Ridley, 2003).

Additionally, many of the brain's activities have been timed. Studies of Event-Related Potentials (ERPs) –specifically, the N400 component, so-called because this negative brain wave occurs very predictably at 400 millisecond intervals after words are heard or read— are commonly used to determine recognition and processing speeds in language use. The N400 component is impacted (as evidenced by different amplitudes or height of the wave/signal) by various linguistic factors such as predictability, incongruity, and lexicality (Andrews, 1991).

ERP studies (Weber-Fox, Davis, & Cuadrado, 2003) have been used in both impaired and normal populations to determine some elements of locale, direction, and speed of mental processing activities during language comprehension. Weber-Fox et al. demonstrated differences in ERP results which suggested not only different processing speeds for adults with different levels of language proficiency but also a reduced dependence on context in individuals with more advanced language proficiency, both of which may bear on patterns of conceptual integration.

In particularly relevant work, Coulson and Van Petten (2002) have used ERP studies to explore conceptual integration in relation to metaphor; for example, "Consistent with conceptual blending theory, the results suggest that the demands of conceptual integration affect the difficulty of both literal and metaphorical language" (p. 958). The Coulson and Van Petten study is subtle and powerful, but its focus on comprehension speeds does not specifically address nor produce evidence regarding *change* in subjects' understanding as a result of prompts. Comprehension of metaphors is not the same as *production* of metaphors. Would evidence of learning be as likely to be found in changes of metaphor production as it is in metaphor comprehension? Beyond metaphor production per se, are other usages or patterns of language likely to change as a result of learning? The present study employs and applies conceptual integration theory to investigate evidence of such change.

Change, in the form of natural expressive language reflecting emergent meaning, is taken in this study to be indicative of *learning*. I developed assessment questions eliciting participants' written responses before and after instruction. I then used conceptual integration concepts to analyze and measure changes in language patterns in

general and specifically, the comprehension and production of metaphors. For example,

to the extent that responses reflect any internalized instructional metaphor, we may

suspect that Vygotskyan scaffolding has taken place, perhaps via interactive and/or

mimetic processing at the very least (Azar, 2005; Dingfelder, 2005; Greenspan &

Shanker, 2004; Marcus, 2004; Vygotsky, 1934/1987; Winerman, 2005).

LeDoux (2002) provides a current example of how neurologists continue to

explore, discover, and understand quite complex brain processes—including certain types

of positive ("amplifying") and negative ("regulating") feedback loops—operating at

incredibly minute scales, even within individual neurons. The location, direction,

intensity, and timing of the flow of neural activity are being mapped "on-line" in recent

MRI work. The global patterns of brain activity neuroscientists are able to observe with

this technique take place in an amazing exchange of lightning-fast electro-chemical

signals across millions of microscopic synapses. Additionally, other, non-neuronal

activities are becoming more well understood, not only as local and directional processes,

but also as global (that is, mentally global) phenomena. For example, glia, which are 10

times more numerous than neurons, are now seen to modulate neural activity in ways

unimagined just a few years ago and may be instrumental in allowing groups of neurons

to function collectively (Fields, 2006).

<div align="center">

Limitations of Reductionist
Approaches to Cognition

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Still, no matter how finely tuned our observational abilities may be, it has now

become apparent that descriptions of atomic level processes do not explain well what we

call understanding or learning. Understanding how ionic charges and neurotransmitters

work are wonderful extensions of the reductionist (Wilson & Keil, 1999) view that we

can explain more of any phenomenon if we can analyze the components finely enough. But the mechanics of synaptic levels of brain functions do not explain human meanings, motives, or emotions. An individual's bio-electro-chemical brain functions with a personal history and in a socio-cultural context; the psychology of any person cannot be fully described by a list of the person's physical brain parts and processes. For example, a brain researcher could examine the parts of a person's brain in the most fine-grained detail without finding evidence in the cells about whether the person who contributed the brain spoke Hindi, liked lilacs, or cared for her dog. The whole mind is indeed more than the sum of its brain's parts, all 100 billion of them.

To paraphrase an example made famous by Vygotsky (1934/1987), it would be impossible to understand the properties and qualities of water merely by analyzing hydrogen and oxygen, even though they are the constituent elements of the liquid. There is nothing inherent in hydrogen and oxygen when considered separately—even at the atomic or subatomic level—which would hint at what their combination in a two-to-one ratio could produce or do, e.g., become the essential medium of life on earth, or float its solid form on top of its liquid form, or expand its solid volume by 10% over the same amount of liquid, etc.

In sum, instructive though it may be, an atomistic dissection of a physical brain could at best lead to only a partial understanding of psychology. Likewise, a similarly reductionistic approach to language leads to formal linguistics, a vast and highly sophisticated field in its own right. But psychology is more than neurology alone, or language alone, or culture alone. Recognition of the need for an integrative, holistic approach to psychology has led to the so-called cognitive revolution of the last 30 years

(Wilson & Keil, 1999). And there has been no richer sub-field of cognitive psychology than cognitive linguistics (Evans & Green, 2006), the theoretical background of the present study. And, as will soon become evident, conceptual integration may be considered one of the most robust current theoretical models in cognitive psychology and cognitive linguistics.

Thus, in cognitive psychology, the work of Vygotsky is being regarded with a new respect in light of recent advances in neurology--the computational and combinatorial nature of language and thought are now seen to have a viable neurological basis (Frawley, 1997). To Frawley, language is the exact nexus of the "social and computational mind" as indicated by the subtitle of his work. The new perspective of the "computational mind" (Gladwell, 2005; Narayan, 1997; Pinker, 1994, 1997; Wilson & Keil, 1999) does not refute Vygotsky's contentions about socio-cultural shaping of mental processes; on the contrary, it provides a mechanism for understanding these processes more fully.

Likewise, Piaget's emphasis on the internal, "natural" instincts for acquiring knowledge, including language acquisition, is not contradicted by an increased understanding of cultural and environmental forces at work in an individual's psychology; these instincts are understood to be most amenable to social influence (Ridley, 2003). The "wild child" phenomena which have been documented over the years attest to the essential role of a nurturing environment for even the slightest hope of successful, "normal" development (LaPointe, 2005). The "debate" between nature and nurture is past. Both innate readiness and experiential aptness are *sine qua non* for humans to learn and grow psychologically (Pinker, 2002).

Theories of Chaos, Complexity, and
Dynamic Systems in Relation to
Conceptual Integration

Theories in the fields of chaos, complexity, and dynamic systems (Briggs & Peat, 1989; Gleick, 1987; Waldrop, 1992) support the types of understanding we are beginning to have about neural systems, modularity, and probabilistic decision-making (Gladwell, 2000, 2005). As these fields have developed, it has become more and more evident that they can provide valuable insights into scientific understanding, not only in physics, but in biological and neurological processes as well. Next, I briefly review some of the relevant specifics from these theorists and their fields.

In *Chaos*, an early classic in the field, Gleick (1987) describes the evolution of thought among biologists as they found case after case of fractal branching to be the rule, rather than the exception, in how biological structures of all scales are formed--mighty oaks to lungs, arteries, and, yes, neural networks. Although

> DNA surely cannot specify the vast number of bronchi, bronchioles, and alveoli or the particular spatial structure of the resulting tree… it can specify a repeating process of bifurcation and development. Such processes suit nature's purposes…And theoretical biologists began to speculate that fractal scaling was not just common but universal in morphogenesis. (p.110)

Where each part (or cell) encodes the entirety of an organism, we see the function of DNA applied in the form of a fractal: iteration/repetition of a basic structure *on many scales*, exhibiting apparently diverse manifestations, but which ultimately derive from a common self-organizing form (DuPlantier, 2003). Crucially, this applies not only to the genetic "code" but also to neurological structures as well. Moving between different scales is a defining feature of true systems and a very real part of human consciousness/cognition. Surely it is plausible that the awesome connective structure of the brain is

capable of allowing cascades of information to move through any number of neuronal/ synaptic thresholds, effortlessly flowing from one level of activation to another. As will become evident, conceptual integration would require this kind of connectivity; nowhere is such connectivity possible except in the human brain. Furthermore, moving between different scales is specifically one of the most important and universal features of conceptual integration (Fauconnier & Turner, 2002), lending still more weight to the argument that human neurological infrastructure supports the kind of mental activities described by conceptual integration theory.

Briggs and Peat (1989) explain positive and negative feedback loops as naturally occurring phenomena "everywhere: at all levels of living systems, in the evolution of the ecology, in the moment by moment psychology of our social interaction…" (p. 26). Recall from LeDoux (2002) that the systems at work in our brains have the physical capacity and particular function of regulating (i.e., via negative feedback loops) or amplifying (i.e., via positive feedback loops) electro-chemical signals both within and among individual neurons and neural clusters. Indeed, Bak, cited in DuPlantier (2003), calls for a new metaphor for the mind, beyond the information-processing metaphor, which has a rich history of valuable use but which, as is necessarily true of any metaphor, cannot entirely illustrate—even if it could remain "novel" forever, an impossibility in itself—what we are continuing to learn about the workings of the brain/mind.

Specifically, Bak (cited in DuPlantier, 2003) proposes a fractal model--a "brain as rhizome" metaphor. A rhizome is by definition "rootlike" (*Oxford Encyclopedic English Dictionary,* 1991*),* meaning here a network with many branches and levels. The organic/self-organizing, dynamic, complex, chaotic nature of the brain's structure and the

mind's inductive and deductive workings are surely more accurately described in these terms than in those of a mechanistic, linear model. This goes even beyond the parallel/distributed processing model currently in use. The rhizomic metaphor is much more in keeping with the multiple-level, three-dimensional, fractal nature of the processing activities of the brain than the "brain as computer" metaphor.

Here is a warning, then: the reader must be aware that the term "computational" is not the same as the "brain as computer." Yes, the idea of "processing information" is still important and viable in understanding brain function but this will allow us to use the term "computational" in a much more valid, mathematically understood way. At this point, it is appropriate to elaborate the idea of brain functions, especially in the use of language, as both *computational* and *combinatorial*. Understanding these terms in a more technical way will allow the reader to conceptualize the precepts of conceptual integration more readily.

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Combinatorial/Computational Approaches
to Language and Psychology

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One of the most fascinating and sometimes contentious issues in psychology is the idea that our limited vocabularies—in Chomsky's terms, "the poverty of stimulus"—(Pinker, 1997, p. 30) can produce a practically infinite variety of sentences and meanings (Deutscher, 2005; Pinker, 1994). Just how *do* we take *prior* knowledge and experience and *create* novel ideas, sentences, solutions, images, etc? There are many manifestations of this ability to "go beyond what is given" (Bruner, 1997, p. 129) from the constituent elements of mental inputs. Something must be happening to the input information as it is being processed in the brain. Purely deductive approaches allow for "correct" conclusions from well-defined, "correct" premises, but this formal, truth-conditional perspective

cannot account for the inductive and inferential qualities of emergent meaning and creativity (Evans & Green, 2006).

Pinker (1994, 1997, 2000) makes a forceful case that this combinatorial capacity is a result of any language's two ingredients--a lexicon and a grammar or words and rules. When a person uses the tens of thousands of words in a typical basic vocabulary, multiplied by the number of combinations allowed by the grammar of her particular language, multiplied yet again by the thousands of thoughts, situations, and experiences she will need to describe the events and people and relationships in her life, the combinatorial power of language becomes obvious. Pinker (2000) does the math for an S-V-O (Subject-Verb-Object) language, in this case, English:

> The rules are *combinatorial*... the rule for a noun phrase allows four choices for the determiner, followed by ten thousand choices for the head noun, yielding 4 X 10, 000=40,000 ways to utter a noun phrase. The rule for a sentence allows these forty thousand subjects to be followed by any of four thousand verbs, providing 40,000 X 4,000= 160,000,000 ways to utter the first three words of a sentence. Then there are four choices for the determiner of the object (640 million four-word beginnings) followed by ten thousand choices for the head word of the object, or 640,000,000 X 10,000= 640,000,000,000 (6.4 trillion) five–word sentences. (p. 7)

Even if we discount the ungrammatical or otherwise nonsensical sentences, it is estimated that at every word-position in a given English sentence there are an average of about 10 choices which could produce about a million grammatically correct six word sentences from an English speaker with an average vocabulary (Pinker, 2000). Grammatical 20 word sentences such as this exact sample could have a feasible number of some 100 million trillion (Pinker). Other languages have similar potentials, though of course in different ways.

Deutscher (2005) gives a fine example from Turkish where a single word--with a number of grammatically allowed morphemes used as suffixes, prefixes, and internal signals--can carry not only a very subtle and specific meaning but where its "on-line" construction represents a series of choices from an equally astronomical number of possibilities: *sehirlilestiremediklerimizdensiniz*, meaning, roughly, "You are one of those whom we can't turn into a town dweller." This carries something like our rhetorical phrase, "You're not from around here, are you?" Such "sentences in a word" are the norm in some languages. Each part of the word involves lexemic choice and also meaning via particular order: sehir = town, li = someone from, les = become, tir = cause to, eme = can't, dik = whom, ler = those, imiz = we, den = one of, siniz = you are. Note also the apparent "strangeness" of the phoneme/"word" order; though it is completely normal to a native speaker of Turkish, the order seems almost exactly "backwards" to an English speaker, thus demonstrating another combinatorial aspect of any language, its syntax.

The combinatorial aspect of language—any language—should be obvious. But it is not simply a matter of memorizing all these combinations, even if it were possible, that is at the heart of our ability to communicate. Language is more than vocabulary; it "is much more than the sum of its words" (Deutscher, 2005, p. 21). This is where the computational aspects of our psycholinguistic prowess come to bear. The very structure of the words and sentences we use prompts understanding in listeners. As discussed above, Gladwell (2005), Frawley (1997), Pinker (1994, 1997, 2000) and Fauconnier and Turner (2002) note that part of our ability to understand each other in normal discourse lies in our ability to use a very small amount of information to construct an "in-progress"

analysis of intent and meaning. Gladwell (2005) calls it "thin-slicing," where we take a minimal amount of information and compute the probable intent/meaning with amazing accuracy and speed, and most of the time, we are right.

Like the combinatorial aspect of language, the computational aspects make a lot of sense. For most of our "conscious" life, we must make best guesses, based on incomplete information. We simply do not have the time to access and sort through all of our sensory input and social or personal history in making every decision. Nor do we have the time to analyze every possible meaning of every phrase we hear or see. This is where computational abilities, based on probabilities of intent, come to the fore.

I hope by now to have established that a cognitive linguistic approach to psychology has much to offer because such an approach takes these awesome psychological capacities into account. Thus my focus here has converged from the broadest foundations of psychology to the somewhat more limited field of cognitive linguistics. In the following section, I will develop an overview of cognitive linguistics and conceptual integration. I will also develop a conceptual framework for the application of the conceptual integration model to issues in educational psychology through analyses of student language.

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Overview of Cognitive Linguistics
and Conceptual Integration

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Because complex, symbolic language use is a uniquely human experience which both reflects and generates a practically infinite realm of thought, psychologists have long been deeply interested in understanding language in its many forms and applications. As cognitive psychology was being developed over the last generation, cognitive linguistics has also seen a concurrent growth (Evans & Green, 2006). But

cognitive linguistics is often referred to as a movement or enterprise, rather than a field or theory, because of its highly diverse range of research and theoretical approaches, assumptions, guiding principles, and perspectives. The enterprise is often seen as an alternative to the "form" approaches which dominate modern, purely linguistic studies. In common with other linguists, cognitive linguists study the functions, structure, and systematicity of language, but their driving purpose, however, stems from the critical assumption that language reflects patterns of thought (Evans & Green, 2006).

Cognitive linguists, then, study what it means to know a language, the various functions of language, the symbolic and social uses of language, systems and universals in language use, language acquisition, semantics, grammar, conceptualization, metaphor and metonymy, categorization, and, of course, cognition. Varela, Thompson, and Rosch (1991) made important theoretical advances which strengthened the case for approaching psychology as a distinctly human and subjective experience, departing significantly from earlier psychology's assumptions about a purely "objective" reality. Cognitive linguists do not generally deny the existence of a reality "out there," but hold the following:

> The fact that our experience is embodied—that is structured in part by the nature of the bodies we have and by our neurological organization—has consequences for cognition. In other words, the concepts we have access to and the nature of the reality we think and talk about are a function of our embodiment: we can only talk about what we can perceive and conceive, and the things that we can perceive and conceive derive from embodied experience. From this point of view, the human mind must bear the imprint of embodied experience. (Evans & Green, 2006, p. 46)

Two of the more prominent and recent areas of interest within the cognitive linguistics enterprise are the fields of mental spaces theory and meaning construction theory (Evans & Green, 2006). These in turn owe much of their existence to theories in conceptual metaphor, first postulated in the 1980s by Lakoff and Johnson (1980).

Conceptual integration has emerged as a recent field of study based on the intellectual blending of ideas from mental spaces theory and meaning construction theory (Figure 1), articulated by Fauconnier and Mark, respectively (Evans & Green).

The conceptual integration model of the way we think has been a burgeoning perspective in recent years (Fauconnier & Turner, 2002). The potential explanatory power of this model includes many of the neurological, social, psychological, and linguistic aspects of human thought; thus it deserves to be considered in research in the field of educational psychology. In the current research, I seek to answer several questions about teaching, learning, understanding, and assessment afforded by a conceptual integration approach.

Put very briefly, conceptual integration theory includes two central premises: thought is both *dynamic* and *creative*. In trying to describe and explain the rapid, "on-line," constantly flowing nature of "meaning construction," generations of earlier psychologists and linguists were stymied by the sense of static, linear understanding provided by less fluid, less robust models, such as the transmission or container model of teaching and learning (Mayer, 1999). This model assumes that students are merely empty vessels to be filled with instructors' knowledge. Was that knowledge a *thing* to be passed from one person to another? Where did this *thing* reside before and after transmission? How could the instructor give this *thing* to someone else and yet still have it? Among other things, this transmission/container model of teaching and learning implied that the meaning was somehow in the words themselves rather than being constructed by the people who were interacting.
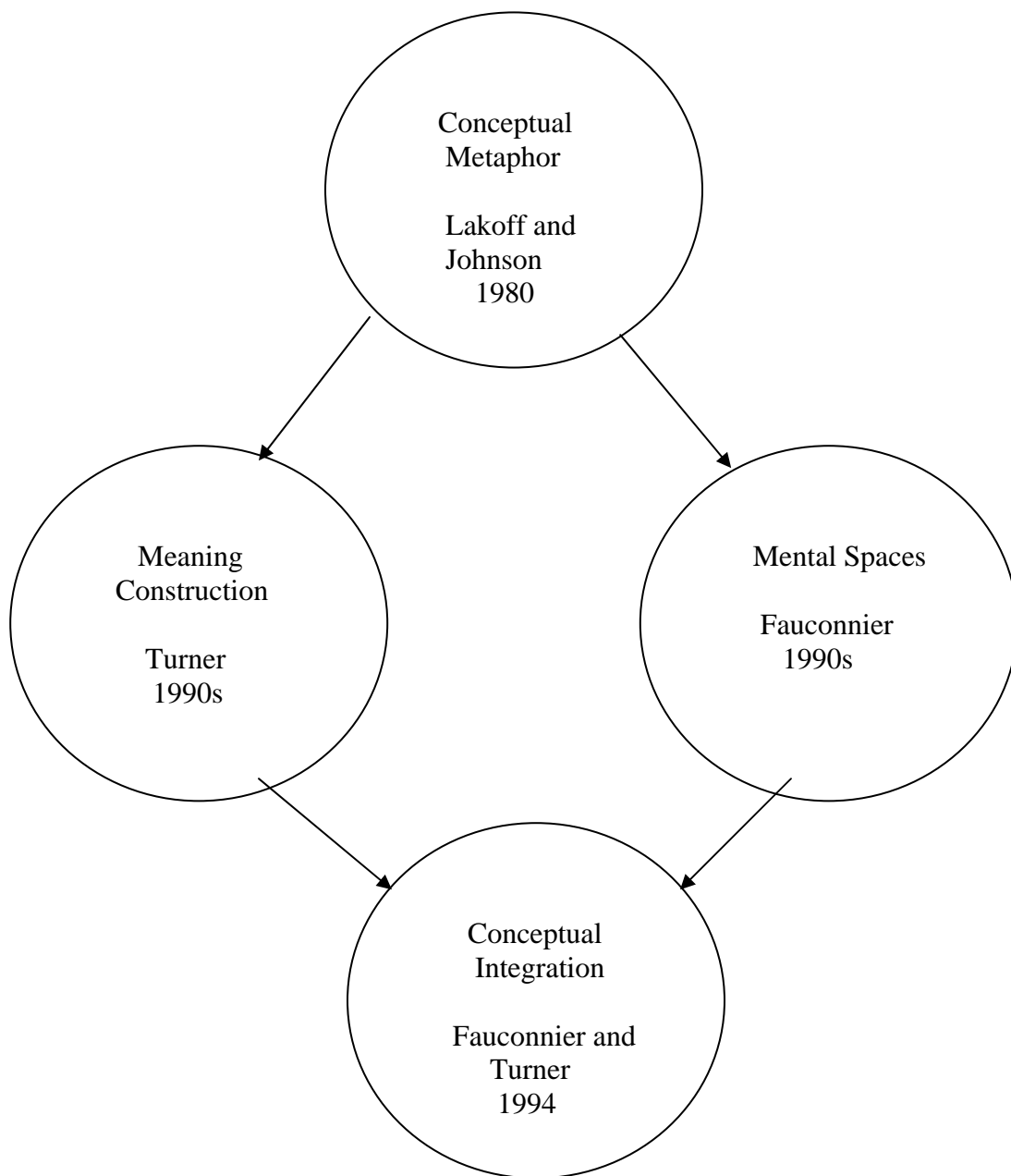
Figure 1. A theory is born. The cognitive implications of Conceptual Metaphor (Lakoff & Johnson, 1980) lead away from a "meaning is in the words" approach in understanding human communication. Turner explores the constructivist and linguistic dimensions of communication while Fauconnier explores issues related to thinking as dynamic, often temporary, mental responses to inputs from memory, speech, and context. By the mid-1990s, Fauconnier and Turner have begun to develop Conceptual Integration Theory.

Another major problem earlier researchers encountered was the fact that inputs to thought, either from social context or memory, could not by themselves entirely account for emergent meaning. In short, how do humans come up with *new* understanding and original utterances from previous constituent elements? This is precisely the issue in a number of studies and articles about the comprehension of metaphor (Deutscher, 2005; Evans & Green, 2006; Fauconnier & Turner, 2002; Gibbs, 2002; Hamblin & Gibbs, 1999; Lakoff & Johnson, 1980). By trying to model the creative and dynamic nature of thought, the conceptual integration model purports to describe these and many other processes more accurately and usefully than previous models of thought.

Because conceptual integration theory (Fauconnier & Turner, 2002; Turner & Fauconnier, 1995) evolved from earlier theories in the fields of conceptual metaphor theory (Lakoff & Johnson, 1980) and mental spaces theory (Evans & Green, 2006), any explanation and description of it will require some references to these precursors. Fauconnier and Turner aver that the capacity for conceptual integration is one of the hallmarks of distinctly human thought, allowing us to perform the practically infinite array of complex mental and social activities which characterize the human experience. Fauconnier was a leading researcher and proponent of mental spaces theory and Turner was deeply involved in the study of metaphor in literature when their work converged in the 1990s on the problems of meaning construction in normal language interactions (Evans & Green). Their work, individually and collaboratively, provides much of the current academic/research basis for the present research.

Terminology from Cognitive Psychology
and Cognitive Linguistics

In order to focus the following discussions, I provide a set of key terms in conceptual integration theory that have their origins in definitions from their use in cognitive psychology and cognitive linguistics.

Categorization. Our ability to categorize is taken as one of the hallmarks of intelligence (and is not limited to humans, by the way). This ability is deeply connected to conceptual domains, embodied cognition, and conceptual metaphor (Evans & Green, 2006; Lakoff, 1987; Varela et al., 1991).

Combinatorial thought/language. A practically infinite set of possible statements may be derived from combining a finite set of words and rules (Pinker, 2000; Deutscher, 2005). Distinct from computational thought, combinatorial thought allows us to imagine—and choose from— possibilities.

Computational thought/language. Information processed in the brain with a flow of neural activity corresponding to "If-Then-Else" type statements in computer programs (Pinker, 1994, 1997, 2000). Computational thought allows decisions to be made based on probabilities and incomplete information (Gladwell, 2005). In part, this idea was contributed to the field of cognitive psychology from artificial intelligence (Frawley, 1997; Wilson & Keil, 1999) but is not to be conflated with the vapid cliché of "The brain is a computer"; this trite metaphor is generally considered as having outlived its usefulness. It is interesting to note that the people who did calculations professionally were once called "computers."

Conceptual domain. "A body of knowledge which contains and organizes related ideas and experiences" (Evans & Green, 2006, p. 14). Essential to much of cognitive

psychology, conceptual domains are to be understood as an individual's systems of interconnected knowledge which may be activated or accessed by experience, language, or memory. In short, a conceptual domain may be understood as a person's knowledge about something (e.g., genes/genetics/ heredity in the case of the present research).

Conceptual integration model. A recent offshoot of several major theories in cognitive linguistics (Evans & Green, 2006). Conceptual integration (Coulson & Van Petten, 2002; Evans & Green; Fauconnier & Turner, 2002; Turner & Fauconnier, 1995) is explained and defined in much more detail below. As the central model guiding the present research, conceptual integration is claimed to account for a good deal of mental activity in much human interaction and thought, and is therefore critical to teaching and learning, which are the bases of educational psychology. The terms "conceptual integration" and "conceptual blending" are used interchangeably. The term "blend" refers to the blended mental space where the elements and relationships of the various input spaces have achieved final, though often temporary, content and structure based on information from the inputs.

Conceptual metaphor theory. Stemming from work on metaphor (see below), where one conceptual domain is described and structured in terms of another, Lakoff and Johnson (1980) proposed that entire groups of related metaphors represented conceptual domains. For example, phrases such as "He got a raise," "Hopes were high," "Climbing the ladder of success," etc., represent an overarching conceptual metaphor such as UP IS GOOD. (Per convention, mental concepts are indicated by small capitalized letters to distinguish them from the words used to describe them.) From conceptual metaphor theory arose both mental spaces theory and meaning construction theory (Evans & Green,

2006). In turn, work in these two fields led to the formation of the conceptual integration model (Evans & Green).

Dynamic systems. This term is applied to any hierarchical and actively changing network of networks. It is derived from work in physics and biology where scale, order, complexity, change, feedback, and recursion are used to explain the dynamic nature of the universe and its living creatures. Citing the brain's complex structure as an example par excellence of dynamic systems, psychologists have adopted this term as well (Briggs & Peat, 1989; Carter, 1999; DuPlantier, 2003; Evans & Green, 2006; Fauconnier & Turner, 2002; Wilson & Keil, 1999).

Embodied cognition. "This thesis holds that the human mind and conceptual organization are functions of the ways in which our species-specific bodies interact with the environment we inhabit" (Evans & Green, 2006, p. 50). Categorization and metaphor, as well as a host of other cognitive and linguistic activities, reflect this basic orientation to the physical world.

Inputs/input spaces. Any contributors to the architecture/ content of a mental space (Coulson & Van Petten, 2002; Fauconnier & Turner, 2002; Turner & Fauconnier, 1995; Wilson & Keil, 1999). A person's memory may provide input material, but so too do conversation, context, and experience. Here is an open-ended notion that enables us to consider *all* thought, not just language, as amenable to explication in terms of conceptual integration.

Lexical items. Words or phrases considered as *single mental units of information* which can be retrieved from memory (hence, a person's "lexicon"), the "storage" and retrieval of which terms is said to involve the process of lexicality (Evans & Green,

2006). When metaphors lose their novelty through repeated use, they slowly take on an aspect of "obvious" literality, and become lexicalized *as single units* of meaning. Lakoff and Johnson (1980) use the term "frozen" to describe metaphors which have become lexicalized. (See also the explication of "metaphor" below.)

Meaning construction. This is the mental work we do when we understand another person's language or make mental sense of an event (Evans & Green, 2006, p. 162). Another person's statements, signs, or writings are taken as prompts for building a conceptualization of what that person means.

Mental spaces theory. Mental spaces are considered complex, but temporary conceptual domains constructed *in the process* of thought or discourse (Evans & Green, 2006). They are very context-specific and allow people to communicate effectively on the basis of very sparse information. In combination with conceptual metaphor and meaning construction, mental spaces are used to describe the processes of conceptual integration, where much information is "compressed" into meaningful statements and comprehension (Fauconnier & Turner, 2002; Turner & Fauconnier, 1995).

Metaphor. This term comes from the Greek, "carry across," where meaning from one domain is carried across to describe another. The Latin equivalent of the term is "transfer," that is, from one domain to another. It should be noted here that the use of the term "metaphor" is somewhat different in psychology or cognitive linguistics than in literature. Though the two fields overlap considerably with regard to this topic, the central thrust of psychological understanding of metaphor is about *any* use of figurative language, not the more narrowly defined use in the study of literature as a direct comparison of two things without the use of "like" or "as" (McKechnie, 1983).

Thus, as part of the following review of literature, the reader will note a variety of studies involving production or comprehension, that is the "use," of idioms (Abrahamsen & Smith, 2000: Hamblin & Gibbs, 1999; Horn, 2003; Norbury, 2004), proverbs, irony (Dennis, Purvis, Barnes, Wilkinson, & Winner, 2001; Power, Taylor, & Nippold, 2001), similes (Chiappe & Kennedy, 2000), metaphors (Carroll & Mack, 1999; Corts & Meyers, 2002; Lakoff & Johnson, 1980; Linzey, 1997; Newsome & Glucksberg, 2002; Ozcaliskan, 2005; Schmidt, 2000; Sopory & Dillard, 2002), or any other kind of figurative—that is to say, non-literal—language to which I will apply the generic term "metaphor." Further, it should be noted here that the present research does not attempt to address the surprisingly thorny cognitive linguistics issue of what can be understood as "literal."

Technically, metaphor is often represented by the form "X is Y," where the target/topic conceptual domain "X" is described by the relevant properties of the source/base/tenor conceptual domain "Y." In the statement "War is Hell," the source domain, Hell, provides the descriptive properties and structure for the target domain, War. Though the nomenclature in the literature varies, hereafter I will use the terms "target" and "source" to refer to the two types of contributing domains. The XY format demonstrated here is in keeping with a later version in a somewhat different context. The letters are used here to describe content domains. These domains are mental "places." Nouns, as the words which grammatically name places, are what are being labeled with X and Y, not "domains" or "source" or "target." Nouns can become elements in mental spaces and carry the XY nomenclature with them. Such an analysis, described more fully in Chapter IV, is performed on various open-ended participant responses in this study.

As noted above, a metaphor may be called "frozen" (or "dead") when its use has become lexicalized and so conventionalized as to carry little potential for new understanding. Further, a metaphor is called "opaque" when the constituent parts cannot be used to calculate its meaning. A "transparent" figure of speech is one where the meaning *can* be derived from its constituent parts. As the current work progresses, we will see a number of such terms from the studies of figurative language come into play in developing a conceptual integration approach to the analysis of subject responses. (See also Linzey [1997] and Deutscher [2005] for more complete "lifespan/natural history" approaches to metaphor.)

Polysemy. Literally, this word means "many meanings" (Evans & Green, 2006). Not only do many individual words have multiple meanings, even entire phrases can prompt for different meanings in different contexts. In the first case, "Sick" may mean something twisted and evil to one generation of English speakers, but many of today's American teenagers use the term as a very positive adjective. The phrase "Round the corner" can describe a restaurant chain (noun), an action of autos or horses (action verb), a person in relation to a physical street corner (preposition), or a psychological milepost-- "She rounded those corners long ago." A person working a lathe or throwing a clay pot on a wheel might round corners as well. With so many possibilities of understanding, the conceptual integration theory tries to account for how a given meaning can be constructed for virtually any phrase. In conceptual integration, most meaningful phrases can be "reverse engineered" to derive the original inputs.

Radial meaning. This term relates to polysemy (Evans & Green, 2006). When a term has many possible meanings (or "senses," technically), those meanings are modeled

as being more or less distant (that is, radiating from) from a central, standard, prototypical meaning.

     Scaffolding. The metaphor used by Vygotsky to describe the processes of instructional interaction where the idealized intellectual "distance" between the teacher/expert and the student/novice represents areas of potential growth, the now-famous Zone of Proximal Development (ZPD), and the instruction provides a purposeful and specific framework for the student's conceptual attainment in a given domain (Bruner, 1996).

     Situated learning. Almost all learning—language acquisition, values, habits, formal and informal teaching and learning, etc.—takes place in some kind of social context (Lave & Wegner, 1991). Derived from Vygotsky's work (1934/1987), this view has slowly been replacing the "transmission/container" model of teaching and learning, where knowledge is a "thing," given from one person to another. Notice how "context" is a basic element of mental spaces theory as well as a primary element of meaning construction (Evans & Green, 2006). Much of what is understood as accurate comprehension is directly dependent upon context—especially social context—for appropriate meaning construction.

     Theory of mind. A developmental stage in which people come to the understanding that other people have different thoughts (Wilson & Keil, 1999). Though this usually occurs in childhood, the consequences of *not* developing this notion can be devastating. Some symptoms of autism--such as taking statements only literally, or fixating on things rather than social implications, or incessant or obsessive self-talk/role-

playing, or completely ignoring social cues--may be described as forms of cognition that do not display a "theory of mind."

Universal grammar. As linguists--most notably Noam Chomsky— began to discern commonalities underlying even the most "different" of languages, it became apparent that those "differences" were largely superficial. The impact of these findings in linguistics has revolutionized cognitive science by implying similar—that is, "Universal"—neurological and mental structures in all humans, especially in the use of language. This is not to be conflated with the standard language-specific type of "grammar" taught in formal language instruction. Rather, it refers to the common/universal human cognitive capacity to acquire and use language (Deutscher, 2005; Evans & Green, 2006; Pinker, 1994, 1997, 2000).

Applications to Educational Psychology

Having developed a general context within cognitive linguistics for the current research, I now turn to an overview of the central thrust of this research--the application of conceptual integration theory to issues in educational psychology. The reader will recall that conceptual integration theory is a specific hybrid of two models within cognitive linguistics: mental spaces theory and meaning construction. Briefly put and explained with more detailed research findings in Chapter II, this research uses a conceptual integration approach to the analysis of two experimental teaching conditions.

In this research, I measure and describe, in both quantitative and qualitative ways, relative change in the participants' understanding due to exposure to the two different instructional metaphor conditions.

The focal point of this proposed research in educational psychology is at the nexus of cognitive psychology, language, and learning. An individual's psychology is physically "embodied" (Evans & Green, 2006; Varela et al., 1991), neurologically impelled (Marcus, 2004; Pinker, 1994; Thomas, 1990), and socially "situated" (Lave & Wegner, 1991; Vygotsky, 1934/1987). These psychological maxims must be also true of a crucial aspect of psychology--learning. At the most basic level, it is clear that most direct, institutional instruction and thought is in the form of language. Researchers from two entirely different generations reinforce this. First, consider Vygotsky (with a telling reference to Piaget):

> A basic, indisputable, and decisive fact emerges here: thinking depends on speech, on the *means of thinking*, and on the child's socio-cultural experience. The development of inner speech is defined from the outside. As Piaget's research has shown, the development of the child's logic is a direct function of his socialized speech. This position can be formulated in the following way: the development of the child's thinking depends on his mastery of the social means of thinking, that is, on his mastery of speech. (p. 120, emphasis in the original)

Some 70 years after Vygotsky's death, Frawley (1997) asserts that "to understand the compatibility of Vygotskian theory with cognitive science, we need a framework that gives language a role in both the social and computational mind" (p. 34). Because the conceptual integration model purports to account for these crucial aspects of human psychology, it may provide just such a framework; the current research is an attempt to test this potential.

Next, I begin to develop concepts of how the conceptual integration model may be fittingly applied to some of the perennial issues in educational psychology--the science of teaching and learning. Although one could argue that most of the learning a person does in a lifetime is outside of the classroom, formal and institutionalized learning

situations are undeniable facts of life in our modern times. The focus and resources

(Current Expenditures for Public Elementary and Secondary Education, 2006; Largest

Military Expenditures, 2006) provided by societies for their children's schools (nearly as

much as for the military in this country) attest to the attempt to go beyond what was

expected of children and cultures not so long ago. Where once a child would be well

served by the natural teaching and learning in a family or, at most, the tribal unit, those

days are gone in the modern world.

With such a huge investment of money and time in education, people everywhere

have a keen interest in the quality and content of how their schools are serving their

children. Effective schools, then, are the concern of all constituents and effective teaching

and learning practices are the academic focus of educational psychology. In order to

serve our children most effectively, we educators need to use all the tools at our disposal

to provide the best possible educational experiences for our students. These tools are

much more than the superficial trappings of fine facilities, higher-level classes for "top"

students, and special education programs. We must use what we are learning about the

brain and mind from all branches of psychology to serve our students and communities as

effectively as possible--the purpose driving this research.

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Overview and Summary of Purpose, Scope,
and Methods of Present Research

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The present research is designed to apply theories from the field of conceptual

integration to a realistic teaching and learning situation. I used different metaphoric

components in teaching an otherwise identical lesson about the same topic to two groups

of participants. The control group received the instruction without any overt metaphors.

In contrast, the second experimental group received instruction with brief, scripted

references to two different metaphoric descriptions of the topic, Genes, Genetics, and Heredity: Genes are Blueprints and Genes are Recipes. I then analyzed both qualitative and quantitative results of the pre- and-post-instruction assessments using both traditional techniques and techniques developed specifically to apply several of the principles of conceptual integration to some of the qualitative response sets.

This research is designed to show how the conceptual integration model may be employed in explaining how some of the instructional interactions between teachers and students actually affect the thinking processes—and thus, the *learning—*of the students. By applying principles of conceptual integration theory to learning situations, I hope to provide insight into both individual and social elements of learning through the analysis of changes in students' language about specific instructional content. I offer several ways of identifying and describing processes of thought at work in learners as they develop new understanding as evidenced by changes in the pre- and post-instruction performances. Using a conceptual integration approach could eventually lead researchers to find new ways to improve both teacher effectiveness and student learning.

Through this research and the application of new techniques developed specifically for this work, I illustrate several key points. First, there are a number of associations between quantitative and qualitative results in pre-and posttest performances. This research deals with the idea that learning will be reflected in changes in patterns of language use described by the conceptual integration model. Correlation analyses of the different quantitative results provide intriguing findings, described more fully elsewhere in this paper. Second, I also describe different levels of mimicry of the two core instructional metaphors between the two groups of participants. This provides a direct

link to Vygotskyan theory (Lave & Wenger, 1991; Vygotsky 1934/1987) where

individual meaning is at least partially derived from specific context and learning is at

least partially (if temporarily) described as social copying (mimetic learning; Blackmore,

1999). Third, I tested the idea that there would be significant differences in the

effectiveness of either of the two instructional conditions. For example, differences which

emerge based on academic major, perhaps, or levels of prior knowledge or disposition

toward a target or source, may make one or the other metaphor a better teaching tool for a

given audience. Such differences are in people, not words, a core tenet from the

constructivist view of cognitive linguistics. Finally, I elicited metaphoric elaboration and

creativity from the participants as part of the post-instruction data collection process to

ascertain whether or not there could be a measurable connection between high

metaphoric skill and the ability to learn (at least from this kind of instruction).

Furthermore, there is the strong possibility that any teachers—not just science teachers—

could benefit in general from the findings of this research.

Each of the above points required different types of questions, data, and analyses,

resulting in a mixed methods research approach. First, I analyzed quantifiable data from

traditional pre- and-post-instructional selected-response assessment scores. Then, I

compared selected-response and open-response performances of the different

instructional groups for two reasons: (a) to determine the relative efficacy of the

respective metaphoric lesson components/ conditions; and (b) to address the central issue

of this research, which is to describe how changes in learning are reflected in changes in

language. Additionally, I analyzed two types of qualitative data from participant-

constructed responses. One data set included two main types of responses: (a) the

participants' elaboration of their own novel metaphors ;and(b) the participants' opinions

about the relative merits of the standard, "received" metaphors used in the past. Another

data set was a third-party accuracy rating of participants' open-response statements.

Finally, I analyzed and recorded the frequency and type of conceptual integration

networks employed by the participants before and after instruction (see Chapters III and

IV).

Thus, to summarize the purposes for which I conducted this research, I offer the

following: (a) testing recent theories in cognitive linguistics, especially conceptual

integration; (b) applying those theories to realistic teaching and learning situations

appropriate to research in educational psychology; and (c) making a timely, unique, and

genuine contribution to the field.

One constraint was the fact that I obviously could not try to account for all

learning in all people in all situations. Further, the focus was necessarily limited to a

narrow focus on a brief instructional interaction and a small set of linguistic variables,

those being several metaphors about the same topic. To progress beyond the transmission

model of teaching and learning, researchers need to demonstrate not only that emergent

meaning, as evidenced by changes in metaphor production or other language patterns, is a

natural product of conceptual integration. To the extent that research supports the validity

of a conceptual integration approach to educational and psychological issues, researchers

also need to assist other educators in learning to use the concepts provided by conceptual

integration theory to enhance teacher practice and student learning.

In Chapter II, I review classic views of and more recent research in the use of

metaphor, especially in both metaphor comprehension and production. This sets the stage

for discussing how the production of metaphor may reflect new understanding. That is, I begin to make the case that students' use of metaphor is likely to reveal a reflection of teachers' use of metaphor. Additionally, I provide several classic examples of metaphors used in teaching. At last, given the above, I connect all of this to educational psychology and the questions this research is intended to answer.

Then in Chapter III--Design, Methods, Materials, Participants, and Procedures, I demonstrate how the conceptual integration model may be applied to specific research questions and hypotheses involving several types of measurable evidence of student learning in relation to two specific instructional metaphor conditions.

CHAPTER II

REVIEW OF LITERATURE

Traditional Perspectives and
Theories in Metaphor

Although the focus of the first part of this chapter is on metaphor per se, I will

also be alluding to various aspects of metaphor in light of the conceptual integration

model, of which metaphor is a distinct subset. In a later section of the chapter, I will

overtly address the terms and techniques of the conceptual integration model in much

greater detail.

The power of metaphoric, non-literal language to describe and explain the world

has long been recognized (Evans & Green, 2006; Lakoff & Johnson, 1980; Wilson &

Keil, 1999). As discussed elsewhere in this work, the history of the study of metaphor has

developed over many centuries. From Aristotle's ancient musings about metaphor as a

poetic gift, figurative language has at last come to be recognized as a standard feature of

daily discourse. Traditional research views of metaphor comprehension and production

continue to be represented in the literature (Abrahamsen & Smith, 2000; Hamblin &

Gibbs, 1999; Horn, 2003; Nakamoto, 2003; Newsome & Glucksberg, 2002; Norbury,

2004; Temple & Honeck, 1999). Most of this work uses speed and accuracy of

participants' comprehension as measures of metaphor use and generalized

linguistic/cognitive ability.

For example, Nakamoto (2003) measured response time (RT) for comprehension among groups of Japanese students to make a point about the necessity of asymmetry in metaphor. Comprehension speed in Nakamoto's study was significantly better when subjects read paired samples of clearly asymmetrical target and source domains. In using metaphor, listeners/readers are said to understand a given target by way of thinking about a different concept--the source. Thus, when Romeo says of Juliet, "She is the sun," the qualities of the source—"sun"—such as brightness, warmth, giver of life, etc., are carried over to the target, Juliet. Though earlier thought about metaphor stressed *similarity*— called a comparison model, the roots of which view go all the way back to Aristotle— between target and source, it is clear that similarity alone is not the source of power of metaphor (Nakamoto). Without asymmetry as well, metaphors can be weak or ungainly or provide no emergent understanding about a topic. Therefore, crucially, both similarity and dissimilarity appear to be essential, though not sufficient in themselves as individual factors, in fully comprehending metaphor. Similarity is one of the 15 vital relations aspects of the conceptual integration model (Fauconnier & Turner, 2002) described in detail later in this chapter as is its conceptual opposite, dissimilarity, under the heading "Disanalogy." For now, vital relations may be thought of as various cognitive mechanisms which are always "on call" to perform various cognitive tasks, as in this case, inferring Similarity and Dissimilarity from a metaphoric prompt. Thus also, in the inclusion of asymmetry—that is, Disanalogy—the conceptual integration model accounts for more of the cognitive salience of metaphors, providing a clearer, more multidimensional understanding of a target domain.

Other research (Temple & Honeck, 1999) in the traditional literature deals with the primacy (in time and comprehension) of literal meaning. Temple and Honeck (1999) compared the respective comprehension times for different types of phrases: literal, non-literal, and neutral. The results suggested that literal meanings were first in line to be processed; if no sense could be made at that stage, the reader/listener was thought to move into a mental search for possible non-literal meaning. However, their work has not fully resolved the issue of literal primacy in figurative language comprehension because the implication of stages in comprehension falls far short of describing the dynamic processes and outcomes involved in figurative language comprehension. Though the definition of what may be understood as literal remains problematic, primarily because this relies on a meaning is in the words approach, Temple and Honeck's work reinforced at least the idea that the ease and speed of lexical access may rely at least somewhat on internal, experiential familiarity as well as external contexts of event, place, time, and social environment. But their work clearly bears upon issues of polysemy and conceptual bases and suggests a multistage figurative language process, thus lending support to a linear/serial/sequential processing model rather than a parallel/distributed (open/direct multiple-points) access model. In cognitive linguistics, this would be taken to confirm the radial meaning model of lexicality--comprehension speeds would be based not on an "either-or" choice, as implied by the yes/no, right/wrong, go-directly-to-the-right-answer direct access model described above.

The radial meaning model is probabilistic, but sequential, implying that mental processing and meaning construction might take a bit longer to process, starting from the hearer's initial sense of a metaphoric phrase and moving to an acceptable approximation

of the speaker's actual intent by testing possible intent at further and further conceptual distances from the originally held sense. This very constructivist model of natural conversational metaphor use holds the elements of conceptual integration: with a meaningful phrase, a speaker prompts a listener to construct a mental network, the construction of which involves the use of various cognitive mechanisms in discernable linguistic and conceptual patterns.

Pinker (1994) puts it nicely: "Though most common words have many meanings, few meanings have more than one word. That is, homonyms are plentiful, synonyms are rare" (p. 151). That we can make "probably correct" guesses about polysemy and other types of figurative language much more often than not is yet another aspect of the universality and automaticity of metaphor use among humans (Fauconnier & Turner, 2002; Gladwell, 2005; Lakoff & Johnson, 1980; Pinker, 2002). The conceptual integration approach purports to account for polysemy and any other types of figurative language, providing a model for the interactions, intentions, implications, inferences, inputs, and outputs/emergent understandings which characterize our everyday speech interactions.

Researchers in human communication (e.g., Abrahamsen & Smith, 2000) also take interest in figurative language. Abrahamsen and Smith worked with children with communication disorders on understanding idioms. The researchers used both face-to-face classroom instruction and a computer based teaching model, and found that the success of both models hinged on explaining idioms that were presented in context. Interestingly, gains for specifically trained idioms did not generalize to untrained idioms; this suggests that for some speech-disordered children, direct instruction of specific

idioms should be practiced. These results and inferences underscore three ideas relating to conceptual integration.

The first of these ideas is that figurative language is a deeply natural phenomenon; those who struggle with it are at a serious disadvantage psychologically and socially (Abrahamsen & Smith, 2000). Second, the fact that specific idioms can be taught might indicate that people who learn them in this overt fashion have "lexicalized" the terms. That is, their ability to use these particular terms after training, but not to use new terms without training, could indicate that these children had learned to use the items as literally true, static, stored memories, similar to other basic "vocabulary." This could indicate a rather interesting difference between this type of strategic cognitive accommodation and the fluid, "on-line" meaning construction and comprehension we usually attribute to natural dialog. Third, the critical element of context allowed these students to successfully integrate specific terms into their language comprehension abilities. There seems to be further evidence to reinforce both the precepts of Vygotskyan socially situated learning (Lave & Wenger, 1991; Vygotsky, 1934/1987) and the tenets of conceptual integration.

Vygotsky (1934/1987) and his modern successors in social views of learning such as Lave and Wenger (1991) asserted that most learning, especially learning from direct instruction, is highly dependent on the social context, the partial result of which is that successful learning is often socially defined. Likewise, the conceptual integration model allows for—indeed, requires—both internal and external prompts for understanding. That the social contexts help define the linguistic and psychological frames of reference for the

speakers and listeners in that situation may seem obvious, but the mental processes at work are both quite subtle and powerful as well.

Other communication research (Norbury, 2004) on idiom comprehension grapples with issues of memory, language skills, and general mental capacity. In this case, Norbury compared comprehension accuracy and memory of idioms between a control group and several subgroups of children with communication disorders. The Norbury study demonstrated that normal comprehension of figurative language involves elements of both top-down—contextual processing— and bottom-up—that is, semantic analysis. The study suggested that differences in the types of disorders represented in the children were contributors to the different types of strategies and different levels of ease and accuracy the children displayed in interpreting idioms. Both theory of mind (explained below and elsewhere) and automaticity of using contextual clues were addressed in the study. The participants who struggled with these factors performed significantly worse than those whose impairments were not related to theory of mind or automaticity of using context to infer meaning.

As seen with metaphor per se, questions revolve around whether the idiom is stored as a lexical unit, whether its meaning can be derived from understanding its constituent parts, how and if the idiom is comprehended via context, what correlation there may be between general language skills or general mental capacities and idiom comprehension, whether literal understanding helps or hinders comprehension, etc. As seen across the spectrum of works to be described in this chapter, context—often social context, to be exact—is indeed a major factor in understanding almost anything, including figurative language.

Additionally, as a subset of the general social context, we see from developmental psychology that much meaning is constructed specifically as a result of inferences made from a *theory of mind* (Wilson & Keil, 1999). By definition, a theory of mind is inferred when a listener understands that a speaker is expressing a point of view that comes from a different individual. This is yet a further example of the social context mentioned above, continuing to lend credence to Vygotsky's work. Though adults tend to take a theory of mind for granted, it is nevertheless a developmental milestone in communication. Children who have not attained this sense that other people have other thoughts have difficulty comprehending the social context and hence the meaning of utterances made by other people.

In another research example specific to the study of metaphor—but from a perspective of grammatical analysis— Hamblin and Gibbs (1999) arrived at the threshold of a need for the dynamic explanatory power of conceptual integration. They analyzed the non-decomposable elements of the idiom, "kick the bucket." That is, no constituent element lends to the understood meanings of dying and dying quickly. The whole phrase is understood by fluent, idiomatic speakers and listeners as a lexical unit meaning to die (quickly). This is precisely the example used by Norbury (2004) where this idiom is labeled "opaque." But this points once again to the limitations of a reductionist approach, which in this case presupposes a storehouse of discrete and unexplained lexical items (including such "frozen" metaphors/idioms described above), which are somehow both accessed and changed, and which further derive emergent, dynamic meaning from a static existence.

Whereas Hamblin and Gibbs' (1999) work stopped at the point of suggesting that figurative meaning—even in frozen metaphors such as the one used in their study— is shaped by particular metaphoric verbs, a conceptual integration approach would suggest specific dynamic mechanisms and conceptual frameworks—in short, an integration network—which could explain the meaning of the phrase being analyzed. As explained below and elsewhere, the different levels of lexicalization of these conceptual metaphors, as they are called, became a critical factor in coding and analysis.

Here, in addition to the terms frozen, transparent, and opaque, I distinguish between what Lakoff and Johnson (1980) call conventionalized or "dead/frozen" versus "novel" metaphors. Conventionalized metaphors began as novel metaphors but repeated use has absorbed them into everyday language—that is, they have become "lexicalized" as a unit of meaning. This idea has been discussed and expanded at some length by Linzey (1997) as the lifespan of a metaphor. On the other hand, novel metaphors "create new information about the target" (Sopory & Dillard, 2002, p. 390). In terms of conceptual integration theory, this would be paraphrased by saying that comprehension of a metaphor results in a blend which displays emergent meaning and the conventionalized figures of speech may provide one or more frameworks for input spaces.

Lending further credence to the conceptual integration idea that we structure our phrases to prompt for understanding in our listeners, Horn (2003) tackles issues of opaque vs. transparent idioms. Although the distinctions he draws have more to do with linguistics than the main thrust of the current work, it is worth noting that the idea of entire phrases being used as lexical units (opaque, i.e., not understandable by knowing its parts; or frozen, i.e., stiffly unchanging in use or syntax) versus using phrases which may

be understood by virtue of their contexts and semantic composition (transparent) is precisely in line with a conceptual integration perspective. Like the other kinds of figurative language studied by the researchers cited here, listeners/readers are given clues (technically, prompts) to meaning by speakers/writers; it is up to the listeners/readers to construct meanings appropriate to the intent of their discourse partners. This is an example of how meaning construction theory has been recruited for use in a conceptual integration model of metaphor comprehension.

Another aspect of metaphor use which suggests the viability of conceptual integration theory is the concept of filtering. Newsome and Glucksberg (2002) compared older and younger adults' metaphor comprehension and found that people in both groups both enhanced metaphor-relevant properties and filtered out metaphor-irrelevant properties. The study was conducted to determine if age-related mental decline would emerge in tests of metaphor comprehension. To their pleasant surprise, the researchers found no evidence of decay in this critical mental ability among the elderly participants. This is a typical example of research showing life-long patterns of metaphor use. In conceptual integration terms, enhancing would mean using the selective projection and highlighting of certain properties of the target and source domains. Filtering out is a concept common in conceptual integration, basically to account for the fact that we cannot think of everything all the time; our consciousness needs an effective filtering system to function normally. Note that these terms carry much of the same notion of amplifying or regulating specific meaning, quite similar to the neural feedback or inhibitory processes described previously in this paper.

An older article by Carroll and Mack (1999) was both prescient and provocative, although it was originally written in 1984. It made the case for what they called active learning via metaphor. They wrote that in the field of the psychology of learning, prior knowledge was the equivalent of the elephant in the room, the thing that everyone knew was there but refused to talk about; for cognitive scientists, prior knowledge was "a complication that theorists…could not well accommodate. [They] focused empirical work on simple and artificial concepts and skills, *precisely* to avoid the complication of prior knowledge" (p. 385). But in conceptual integration, prior knowledge is accounted for as a source of any number of relevant input spaces and as a provider of frames of reference and inputs into emergent understanding.

Their work in artificial intelligence led Carroll and Mack (1999) to believe that metaphoric application is the way learners process new knowledge (and produce emergent meaning) in the light of prior knowledge. They saw the value of metaphoric thinking as lying in its open-endedness, which invited construction of mental models: "metaphors are kernel comparison statements whose primary function in learning is to stimulate active learner-initiated thought processes" (p. 386). In discussing then-current approaches to metaphor, Carroll and Mack reviewed problems with both mental-operational and linguistic-structural approaches, and called for an explanatory model which would include both accurate attributes of and relationships among the various elements of successful metaphors. Once again, the conceptual integration model takes into account the relationships between and within input spaces for the construction of any metaphor.

Further, and equally important, Carroll and Mack (1999) note that a more viable approach to metaphor would also explain the dynamic process through which metaphors are not only understood but produced.

> [A] theory of real learning will need to directly confront the processing problems of how corresponding nodes and relations are recognized as such…Such an account of the *mechanisms* [of metaphorical understanding] would tell us *why* one or more metaphors are useful and *how* they are generated and then used to support learning. (p. 391, emphasis in original)

In speculating about how such mechanisms might ultimately be described, Carroll and Mack (1999) used a set of terms that would be used again later in the specific parlance of conceptual integration theory (and its two primary precursors, mental spaces theory and conceptual metaphor theory): retrieve, integration, compress, framework, structural mapping, inferential processes, construct, and interact. The writers also insisted on the importance of viewing learning as an active process, not the learner-as-passive-container paradigm. "Metaphors can facilitate active learning…by providing clues for…inferences through which learners construct…knowledge…" (p. 393). The present research makes use both of specific metaphors in teaching scientific concepts and also a conceptual integration analysis as a measure of how participants' language changed as a result of learning. Further, in this research, I measure the educational impact of the instructional metaphors, and describe and explain the results from a conceptual integration perspective.

<div align="center">

Current Perspectives and
Theories in Metaphor

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The seminal work for this generation's researchers in the psychology of metaphor was Lakoff and Johnson's *Metaphors We Live By* (1980). In developing the theory of conceptual metaphors, they started to bridge the gap between linguistics and psychology.

By defining metaphors not as lexical units, but as clusters of related concepts, they allowed for a more dynamic, in-progress process of metaphor use and meaning construction. Earlier similarity/comparison models of metaphor were predicated on analyses of the linguistic devices of figurative language use, where virtually all of the meaning of an utterance is inherent in the words themselves (Evans & Green, 2006). Lakoff (1987) and Johnson's (Lakoff & Johnson, 1980) work signaled a major shift of focus away from such linguistic "form" approaches to metaphor toward the logical analysis of meaning construction in the context of natural discourse, thus engendering the first phase of the more modern approach to the psychology of figurative language.

Soon after Lakoff and Johnson (1980) began to advance the case for what would become known as conceptual metaphor theory, Lakoff (1987), Rosch (2002), and Varela et al. (1991) established that human use of *categorization* was both a result of and an impetus for human psychological capacities including the prime example of complex, symbolic language (see also Greenspan & Shanker, 2004). One tenet of conceptual metaphor theory holds that the human ability to categorize experiences or objects is a crucial part of our ability to remember, learn, and communicate (Lakoff; Lakoff & Johnson; Rosch). The very act of mentally grouping concepts allows us to establish a number of domains of thought from which we can compare and contrast new experiences. These domains allow us to draw conclusions about language and other social, mental, and physical experiences by allowing us to bring to mind different mental frames of reference. These mental frames (explained in detail in Chapter IV) inhabit and inform many of the mental spaces which are created during thought. An example of how categorization may be considered in light of conceptual integration is found in Heit

(2002) where he makes the case that the "*integration* process refers to how prior knowledge serves as an initial *representation*, which is *subsequently revised* as new observations are made" (p. 828, emphasis added).

The robustness of conceptual metaphor theory is due partially to its application to any language. Recent research by Ozcaliskan (2005) demonstrates that the prototypical metaphoric source/target domains of "motion in space" is evident in Turkish speaking children as would be predicted by the embodied mind concept (Varela et al., 1991). But it is accepted (Lakoff, 1987) that categorization and metaphor (Deutscher, 2005) are bound together in the psychology and language of all people. It is essential to understand the contribution of these psycholinguistic elements to the understanding and application of conceptual integration theory.

Schmitt (2000) uses Lakoff and Johnson's (1980) work in making a case for understanding subtle similarities and differences within and across cultures, as well as in individuals. Part of the beauty of the conceptual metaphor approach is in its applicability to any culture or language. For example, Schmitt makes a distinction between the American concept of "war" against AIDS and a local African concept of the AIDS virus as an "eater" (p. 3). Also, he uses his native German to confirm a physically experienced "path of life" (p. 2) metaphor which Lakoff and Johnson cite as a nearly universal concept.

The next phase of the more modern approach to metaphor began about 10 years ago as the study of the psychology of figurative language was taking on some distinct characteristics along two main lines of thought: (a) the traditional view of metaphor as a comparison grounded in a lexical/form approach using models of semantic memory and

(b) a newer view, which was focused on issues of production and emergent meaning, where figurative language was viewed as on-line and context-bound (Katz, 1996). This was about the time Turner and Fauconnier (1995) were making their first inroads into conceptual integration theory in an article claiming—contrary to the prevailing wisdom of communication theorists of the time— that "there is no encoding of concepts into words or decoding of words into concepts" (p. 14). Going beyond the standard two-domain model of describing metaphor, they proposed a many spaces model, including not only mental spaces for two inputs, but mental spaces for multiple contributions in addition to spaces for blends with emergent meaning, inherited from the inputs, and with new structure of their own. Linguistic expressions in natural discourse, they averred, are structural prompts by a speaker for retrieval of structure and construction of meaning by a hearer. Thus, many of the first threads of what would become conceptual integration theory were developed specifically in work on metaphor.

Equally important is the fact that the conceptual integration model accounts for the interactive and contextual aspects of learning. Though today socially situated learning is seen as obvious (Lave & Wegner, 1991), some of Vygotsky's intellectual heirs were considered fairly radical in developing social approaches to psychology and learning not so long ago. In the foreword to *Situated Learning* (Lave & Wenger), William Hanks describes the newer perspective as that

> which treats verbal meaning as the product of speakers' interpretive activities and not merely as the "content" of linguistic forms…[with the] premise that meaning, understanding, and learning are all defined relative to … contexts, not to self-contained structures. (p. 15)

Further work on metaphor production, as distinct from comprehension, can be found in Corts and Meyers' (2002) study of the organized and purposeful production of

metaphors in several sermons delivered by Baptist clergymen. The participants' speech patterns were found to display bursts or clusters of figurative language involving a central root metaphor representing the topic at hand. This suggests that rather than an even dispersal of figurative language throughout a prepared speech, one might expect several extended references to a metaphoric core image to occur in relatively close proximity to each other. By contrast, in the present work, participants were young college students writing extemporaneously about a recent lesson, rather than professional speakers (i.e., preachers) who have written and rehearsed a specific text. If the burst effect does not turn out to be the case in extemporaneous utterances, it may indicate that metaphor production is affected or even focused by the act of writing, as distinct from speech acts, rehearsed or not.

A recent call for papers for the 5th International Conference on Researching and Applying Metaphor (Gineste, 2002) attests to the continuing academic viability of the topics being discussed in the current work. The conference theme was Metaphor, Categorization and Abstraction: A Multidisciplinary Approach and had the following as a list of sub-topics: Metaphor and similarity; …categorization; …language acquisition; …translation; …modeling lexical networks; …emergence of meaning; …metonymy identification; …analogy; Metaphors, idioms, proverbs and second language learning; and Metaphor (production and comprehension) and pathology.

Modern metaphor analysis continues to play a major role in traditional psychoanalytic venues as well. Moser (2000) makes the case that metaphor analysis provides a "multifaceted research perspective" (p. 3) with the following points:

> 1) Metaphors influence information processing [because the metaphors we use] influence our cognition of the self and the world. 2) Metaphors are a reliable and

accessible operationalization of tacit knowledge … because metaphors are a linguistic manifestation of tacit knowledge. 3) Metaphors are holistic representations of understanding and knowledge. 4) Conventional metaphors are examples of automated action [because they are employed automatically and, like so many features of language, rather unconsciously]. 5) Metaphors reflect social and cultural processes of understanding [in addition to being part of an inner psychology of an individual, metaphors are context-sensitive, reflecting social and cultural meanings as well]. 5) [Psychologists can profitably use metaphor by] combining quantitative and qualitative approaches to metaphor use. (p. 4)

Moser suggests frequency and correspondence analyses of categorical data, which will indeed be part of the current study. But he also makes the case that "the full potential of metaphor analysis can only be reached when combining it with a qualitative approach" (p. 5).

In Moser's (2000) essay, we find a case of a psychoanalyst espousing linguistics in general (and metaphor, in particular) as essential tools for the professional psychologist. Though Wachtel (2003) makes a compelling argument against an uncritical reliance on metaphor analysis for psychoanalysts, he also writes, "it is difficult to imagine how psychological inquiry can be pursued in any meaningful manner *without* extensive use of metaphor" (p. 6, emphasis in the original).

But psychoanalytic therapy is not the only use of metaphor studies. A number of researchers (Dennis et al., 2001; Johnson, 1991; Kazmerski, Blasko, & Dessalegn, 2003; Power et al., 2001) have used metaphor comprehension to determine various cognitive capacities. For example, Kazmerski et al. found evidence suggesting that metaphors are processed automatically as opposed to the more traditional view that metaphor is a special gift accessed by artistic talent or extra mental effort. This too fits with another tenet of conceptual integration theory, which specifies metaphoric language as automatic and natural (see also Wilson & Keil, 1999.)

Further, Kazmerski et al. (2003) combined IQ tests with measures of metaphor comprehension and found that lower IQ subjects exhibited lower quality metaphor interpretations, and that higher IQ was correlated with more interference in metaphor comprehension, suggesting that more frames of reference might slow comprehension among higher IQ subjects. Again, from a conceptual integration perspective, these results were quite plausible, suggesting that there was some period of testing possible frames of reference for a likely meaning, given the context. This also fits nicely with the probabilistic processing described above regarding the Temple and Honeck (1999) study.

Kazmerski et al. (2003) contended that their results were most consistent with a constraint satisfaction approach to metaphor comprehension. That is, as people construct their understanding about the meaning of verbal prompts, they calculate and select probable intentions from a possible variety of meanings until one seems to fit the circumstances. Higher IQ participants may have a larger repertoire of possibilities to consider. Constraint satisfaction implies that we employ a function of our understanding based on whether certain logical conditions of comprehending figurative language are satisfied. This interpretation is not at odds with either conceptual integration or with the probabilistic decision-making implied by a computational view of the mind (Fauconnier & Turner, 2002; Frawley, 1997; Gladwell, 2005; Pinker, 1994, 1997, 2000). Marcus (2004) specifically addresses the "if-then"—i.e., computational—logic used by both genes and neurons at key activation junctures as well, suggesting at least the likelihood of enabling neural structures and functions in force for this type of mental operation.

Some research into issues of comprehension of literal vs. non-literal language deals with risk factors among children with head injuries. Dennis et al. (2001) showed

that closed-head injuries (CHI) in children could lead to significant difficulties in comprehension of irony and deception. The in-progress, dynamic meaning construction we take for granted in normal conversation may become difficult or impossible for CHI victims. Here, the inability to think metaphorically is symptomatic of a disorder. Again, this is consistent with the conceptual integration perspective where it is a given that metaphoric thinking is the norm.

Other research in figurative language continues to go beyond the more traditional view that figurative language is an anomaly; rather, that it is automatic and essential. The more current view centralizes, rather than marginalizes, the role of metaphor in everyday communication. Power et al. (2001) studied the ability of children and adolescents to discern between literally true and literally false proverbs; it found the results to be consistent with the idea that figurative language comprehension was early-emerging and that its use was a "direct, automatic, and natural reflection of the way people think, reason and imagine" (p. 1). Evidence of this capacity for figurative language use suggests that it emerges developmentally earlier than the traditional perspectives recognized and that it also continues to develop in subtle ways into adulthood.

The issue of developmental differences in metaphor interpretation was also addressed by Johnson (1991) in a study that also examined the roles of general language proficiency as well as general mental capacities in interpreting metaphors. Participants' responses in Johnson's study were coded on a five-point scale reflecting no or inaccurate responses through basic, then advanced/elaborated paraphrases of a set of specific metaphors. Johnson's subtle and meticulous work confirms the idea that there are indeed developmental aspects to metaphor interpretation; she introduces the concept of cognitive

complexity in scoring subject responses, a concept which will be used as part of this work's application of conceptual integration to the analysis of formal instruction and learning. Later in this study, I analyze elaboration and complexity as part of a larger examination of student production of metaphors. I explain Johnson's analysis technique in more detail in the fourth chapter--Analysis and Coding Procedures.

<div align="center">Metaphor in Psychology and Education</div>

An excellent meta-analysis by Sopory and Dillard (2002) explored a comparison between different explanations of why metaphor can be so effective in making a point in contrast to literal language. Sopory and Dillard tested six explanations of why metaphor seems to have an advantage over literal language in persuasive impact: pleasure/relief, communicator credibility, reduced counter arguments, resource-matching, stimulated elaboration, and superior organization. The last explanation, superior organization, was most supported by the results of their study. "Metaphor is credited with the capacity to structure, transform, and create new knowledge, as well as evoke emotions, and influence evaluations" (p. 382). Note how closely this fits with the perspective advanced by Carroll and Mack (1999) as well as the later information in this work regarding conceptual integration. According to Sopory and Dillard, three theories of the understanding of metaphor are considered as being most representative of the diverse schools of thought on the subject.

First is the *literal-primacy* view which we have seen above in work dealing with comprehension of a metaphoric phrase or after a literal understanding has been tried and rejected as false (which we may take as the most traditional view of metaphor, holding that it is an anomaly in otherwise truth-conditional discourse). Second is the *salience-*

imbalance view in which the attributes of the source and target domains are weighed as being more or less appropriate, giving the metaphor relative strength. Third is the *structure-mapping* theory which holds that metaphors convey a system of connected knowledge people use to seek a relational mapping between attributes (Sopory & Dillard, 2002, p. 385). The mappings for a given metaphor produce a unique psycholinguistic topology of content, context, implications, inferences, and relationships. This last theory --which includes not just attributes, but relationships among attributes--derives from associative network models of memory and is thus most closely related to the theoretical bases of conceptual integration, namely conceptual metaphor theory and mental spaces theory (Evans & Green, 2006; Fauconnier & Turner, 2002). Note that an associative network of memory is quite close to what has already been described as a conceptual domain, a body of *related* knowledge. Readers will recall that the entire mental space structure engendered by a given moment of discourse may be called a conceptual integration *network*. This fits well with the previously cited work in dynamic systems theory (Wilson & Keil, 1999) where systems are networks of networks with capacities for recursion, hierarchies, and different levels or scales.

The current study compares the effectiveness of two specific instructional metaphors/conditions. I used several suggestions from the Sopory and Dillard (2002) meta-analysis in designing the lessons. Sopory and Dillard state, "When a metaphor is non-extended, single, placed early in a suasory message, novel, and with a familiar target, its impact can be substantial" (p. 407). Therefore, for the experimental group, I overtly explained only two metaphors, not several and not in depth, to teach the lesson; placement of the overt metaphors was near the beginning of the lesson's script.

Pre-instruction data collected in this study were used to determine the participants' base-level prior knowledge of the target domain. Other data, in the form of a power-ranked survey, demonstrated how participants rated the relative effectiveness of the various classic metaphors used to explain the given topics. More details of the design rationale are explicated in Chapter III.

The modern era of metaphor studies may be said to have begun with Lakoff and Johnson's (1980). By casting figurative language in terms of conceptual thinking, the writers pushed the topic away from being understood as mere literary décor; at that point, metaphor studies became recognized as a powerful tool in cognitive psychology. So far in this paper, I have described research and theory attesting to the study of language in general and figurative language—metaphor in particular--as important to understanding psychology and learning. Rather than the more traditional view that the use of metaphor is out of the ordinary, it is now being regarded as an essential part of everyday language.

The more modern view is reflected by Deutscher (2005) who argues that metaphor is a chief contributor to both the vocabulary and structure of all languages; it is also a primary agent of change in language which keeps a language alive.

> [We] began with a view of metaphor as an ornamental figure of poetic art, but as we probed more deeply, the picture changed beyond recognition. Metaphors turned up everywhere, dead or alive, hiding behind even the plainest words of ordinary language. It transpired that metaphor is an essential tool of thought, an indispensable conceptual mechanism which allows us to think of abstract notions in terms of simpler concrete things. (p. 142)

Further, aside from its many practical applications in human communication and social interaction, metaphor's value as a reflection of individual psychology and learning is continuing to be discovered. The current research is part of that discovery process. While more purely linguistic approaches held that the meaning of words was somehow in

the words themselves, these views became limited in their explanatory power because these concepts required a kind of store and sort approach, unexplainable in terms of what was being learned about the brain. Technical and theoretical advances in the subtlety and power of understanding brains and minds have forced and allowed cognitive linguists to gain a more complete view of the workings of language within and between brains/minds (Evans & Green, 2006). The combinatorial and computational nature of thought and language are reflected in the very structure and functions of the brain (Deutscher, 2005; Marcus, 2004; Pinker, 1994, 1997, 2000).

It becomes more and more evident that metaphoric language is central to our linguistic and psychological capacities. I have tried to make the case that metaphor deserves to be examined in light of its potential to shape and reflect the very specific human capacity to learn through linguistic interaction. Readers will recall some of the linguistic research topics/issues cited above: idioms, irony, communication, proverbs, primacy, similarity, polysemy, and metaphor. Readers will further recall psychological research topics related to metaphor: conceptualization, categorization, development, social context, therapy, injury, brain studies, evolution, artificial intelligence, creativity, learning, etc. Consistently, I have tried to draw attention to connections between comprehension and production of metaphor and learning. Likewise, I have tried to build a case for considering how metaphors can be understood in light of a conceptual integration approach, which I will explain in much more detail in the next section.

Thus, I have used a traditional background in theory and research as a starting point. I have also explored the more modern theories of conceptual metaphor, meaning construction, and mental spaces in arriving at a more complete and up-to-date theory of

metaphor use that is included under the aegis of conceptual integration theory. Though

Fauconnier and Turner (2002; Turner & Fauconnier, 1995) and Evans and Green (2006)

made a number of statements about the obvious connections to education and learning

implied by this theory, to my knowledge there has been no independent research to

explore these claims in specific educational applications. If conceptual integration theory

is indeed a viable theory of the way we think, it would have to include learning as part of

what it explains.

In the current research, I apply the conceptual integration model to the analysis of

metaphor use in a realistic teaching and learning situation in a project specifically

designed to elicit a new type of measurement of learning using tools derived from

conceptual integration theory. Thus, the research makes an original contribution to the

field of educational psychology through the practical application of current theory in

cognitive linguistics and, more specifically, conceptual integration theory. In the next

sections, I discuss details of conceptual integration processes and how they may be

applied to the analysis of student learning. In brief preview, the purpose of the current

research is to develop a conceptual integration analysis of learning and the use of

instructional metaphors.

<div align="center">

Definitions, Principles, and Examples
of Conceptual Integration Theory

</div>

Types of Conceptual Integration Networks

To adequately explain the methodology used in this research, I must now explain

the key terms and concepts I used and explored in applying the conceptual integration

model to teacher-learner interactions. In brief, the first part of this section reflects

Fauconnier and Turner's work (2002). Conceptual integration networks are to be

understood as models of dynamic neurological activation patterns emerging from both external stimuli: speech prompts, other contextual input, and internal frames of mental references such as memories or imaginative concepts. Four major categories of networks are considered: simplex, mirror, single scope, and double scope.

A generic diagram of a conceptual integration network includes at least four mental spaces, each of which may be understood as culturally, linguistically, historically/experientially, contextually, or even creatively generated in a person's mind (Figure 2). Though from the above we may be confident that neural activation accompanies these processes, it should be noted here that the accompanying figures are not to be taken as literal mappings of neural patterns but as models of psychological processes. Any given mental space may be formed by activation of any number of neural signals, clusters, or pathways. Marcus (2004) explains, "Just as there is no simple one-to-one mapping between genes and brain areas, there is no simple one-to-one mapping between brain areas and complex cognitive functions" (p. 129). That said, I now move on to the central thrust of this work--a practical application of conceptual integration theory to the field of educational psychology, especially in the use of and relative effectiveness of metaphors for teaching and learning.
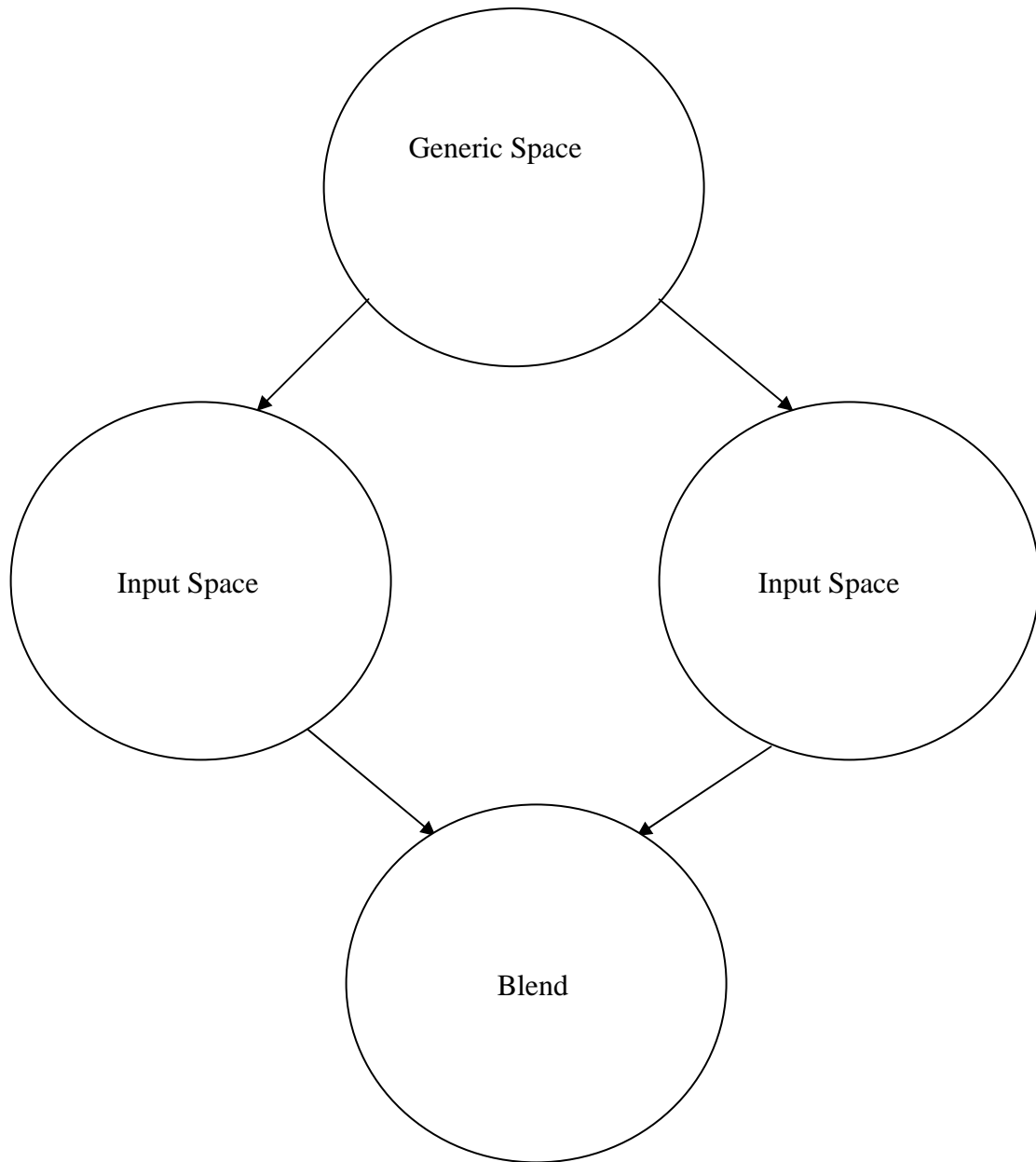
Figure 2. Generic elements of a conceptual integration network. Differences in relations within and among these mental spaces provide the keys to understanding different types of conceptual integration networks. Any mental space implies neural activity.

A conceptual integration network starts with a mental space for a generic concept. Thinking then enlists concepts from at least two other mental spaces--input spaces. Certain elements from and between these three mental spaces are then blended into an emergent concept called, simply, a blend. The four network types are named according to the types of blending resulting from different types of elements in the input spaces, the relations among these elements, the unique and also shared contributions of these elements, and the structure of the final blends. The various structures in all blends may be said to have certain topologies as a result of the single and combined elements from the input spaces and the blends. Connecting these topologies is a mapping of elements within and among the mental input spaces. "The blend is an integrated platform organizing frames of the mental space inputs for organizing and developing those other spaces" (Fauconnier & Turner, 2002, p. 133).

For example, a Simplex Network (Figure 3) is so called because it is particularly simple and ubiquitous. Culture and biology often provide the elements of the different input spaces such as our understanding of the roles and values involved in saying "Claire is the daughter of James." A generic space for males and females starts the network and an input space for family roles explicates the parent-child roles, while another input space provides specific values" (i.e., specific people with certain names). The various elements of the inputs are entirely compatible, and we take it as self-evident, though as is usually the case, there is much going on "inside the black box" of our brains of which we are not aware. This compatibility between the organizing frames of inputs is part of the reason for using the term simplex to describe this kind of thought. As we shall see, this is not always the case; other kinds of networks and blends are prompted by different mental
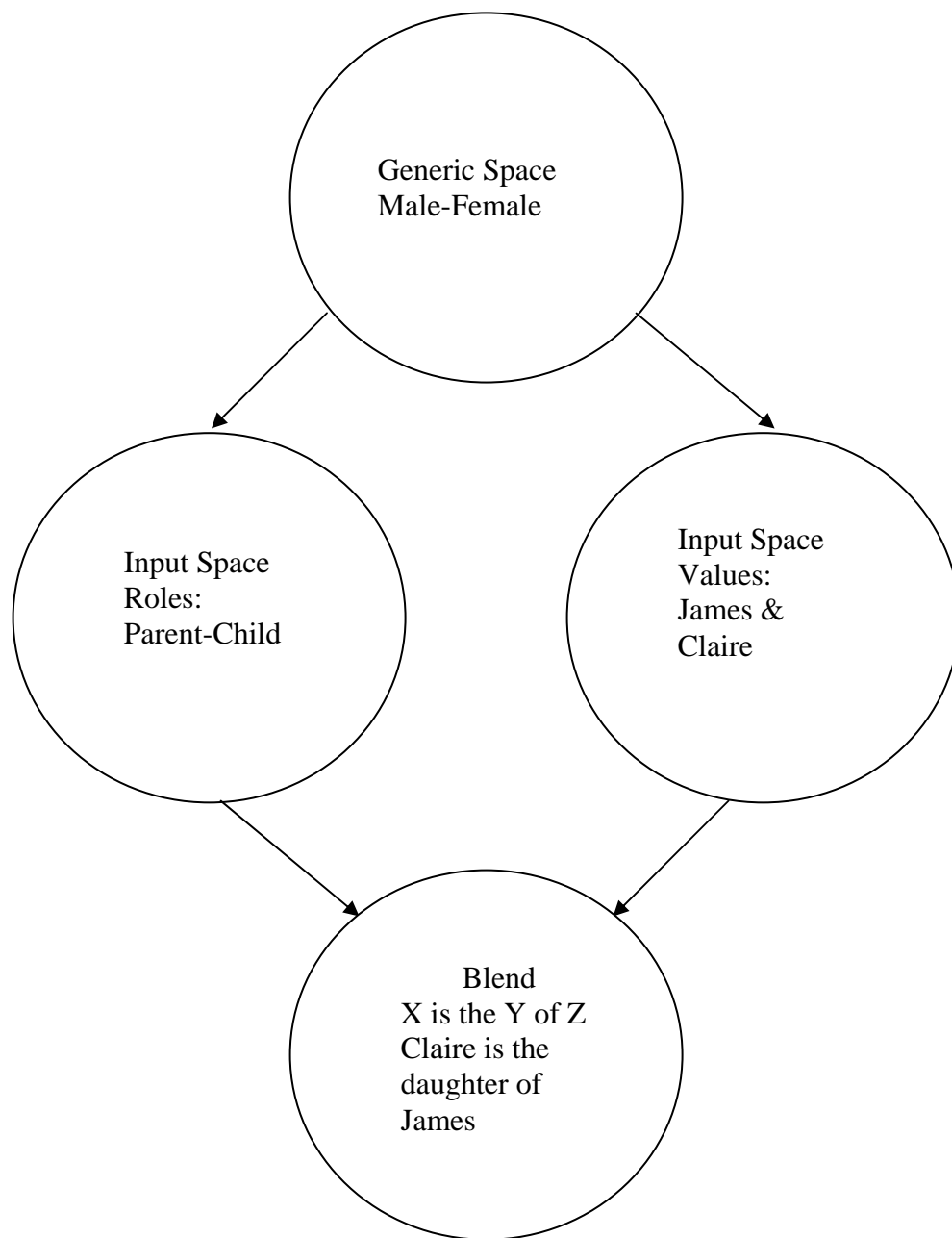
Figure 3. A simplex conceptual integration network. A combination of specific people in specific roles has emerged as a blend which began with generic concepts. X is the Y of Z (D(c,j)) is a common construction with nested elements; a simple task for most people, but a telling problem for those who have difficulties in understanding these types of statements.

frames, elements, inputs, and relationships. Nevertheless, the grammatical construction

"X is the Y of Z" is a kind of general prompt for constructing any type of integration

network. Thus, in texts and tests, when students find this construction, they are being

asked to construct a specific—that is, often, but not always, a simplex— conceptual

integration network. Fauconnier and Turner (2002) add:

> [X is the Y of Z] is taken to be the prototype of semantic composition, easily expressible in … logic as [D(a,b),] where [D is daughter, a is Claire, and b is James]… What we have just discovered is that … logical forms correspond to the cross-space mappings in simplex networks. The blended space in such networks is compositional in the sense that the entirety of the relevant information from both inputs is brought into the blend. This composition is truth-conditional in the following sense: the sentence counts as "true" in a world if the blend fits the current state of that "world."…the simplex network is nothing but our old friend "framing" as studied in artificial intelligence and as captured formally in predicate calculus notation! …it is wonderful to discover that first-order logic and blending are not antagonistic; one is a simple case of the other…This brings parsimony to our description; but, more important, it captures a deep generalization about the phenomena being studied. *There is a great variety of conceptual integration networks, and this variety accounts for the variety and creativity in the way we think*. (pp. 120-121, emphasis added)

The Mirror Network (Figure 4) contains elements in which all spaces--generic, inputs,

and the blend—share an organizing frame. An organizing frame specifies the relevant

activity, a ski competition, which is carried throughout the network. This example is from

the 2006 Winter Olympics when television camera technology was used to show different

skiers on the same track at the same time, showing their relative positions, though each

racer skied alone, and at different times in the real world and real time. Technology here

was used to do what we do easily in our mental worlds when we compare any kinds of

performances or events which may have happened in different situations, places, or

times.
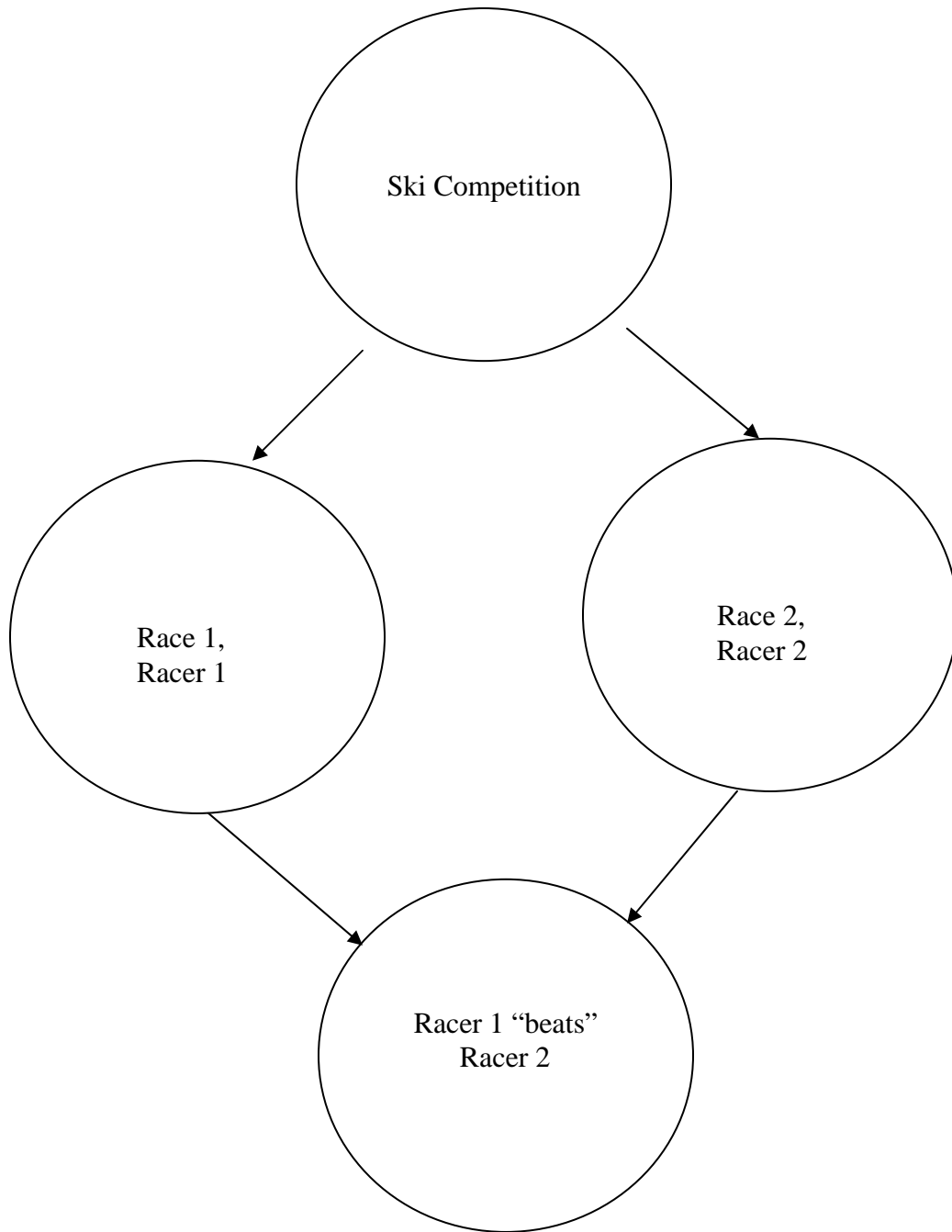
Figure 4. A mirror conceptual integration network. Here, elements from the inputs are closely matched (mirrored). The organizing structure in all frames is essentially the same, though the blend usually goes beyond the original in some meaningful way.

The situations are mirrored in that they share the same organizing frames: the generic frame of competition, in this case, is combined with inputs providing information about different contestants in that contest, even though in reality they may never have met in a face-to-face, real time competition. The other inputs provide information about the competitors: the fact that they are competitors, though seemingly obvious, is nevertheless essential to this blend; the competitors now have roles to play as competitors. They also have what are called values, specifying one competitor as uniquely different from the other. Roles and values are explained in more detail below.

The final blended space not only contains the same organizing frame as the other spaces, but that frame often inheres in a yet richer frame that only the blend has (Fauconnier & Turner, 2002), in this case an imaginary concurrent race between Racer 1 and Racer 2. The organizing frame provides a shared topology between the spaces that allows them to mirror or correspond to each other, but the blended space also includes differing details for both racers at the same time such as color, shape, angle, line of attack, relative locations, etc. This would seem to be the basis of the popular Fantasy Football Leagues where players from different eras compete against one another. The shared organizing frames about football are reflected in the final blends; however, the details about each contest, while maintaining the original organizing frames, differ.

Next, a Single Scope Network (Figure 5) is so called because there is a one-sided contribution to the blend from one of the input space's organizing frames but not the other. The overt, relative contributions to the final blend from the input spaces is highly asymmetrical with the main contributor providing a reference topology that is emergent in the blend. This type of network is evident in metaphor comprehension and use, and
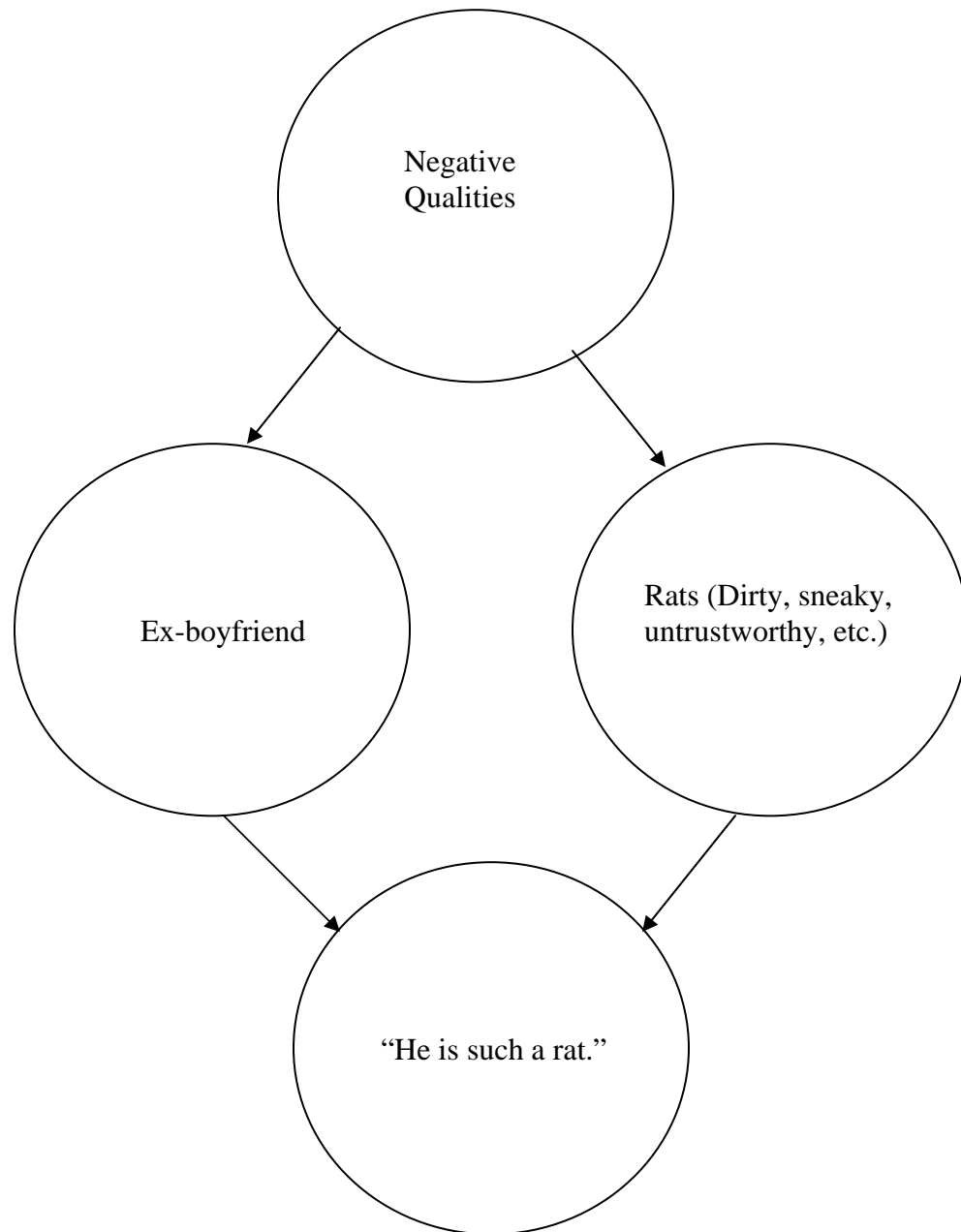
Figure 5. A single scope conceptual integration network. Here, an asymmetrical contribution of one input (hence, single scope) compared to the other is implied. This is the prototypical situation in metaphor--where one input provides a way to understand another; meaning or salience comes from the blend, which draws from the source domain to describe the target.

holds for much of this present work's focus. In the accepted psycholinguistic tradition, metaphor provides a shared but asymmetric comparison between two conceptual domains: (a) the target domain is that part of the metaphor which is being described and (b) the source domain carries the most vivid descriptive/explanatory semantic power of a given metaphor. Thus, for example, in a phrase such as "He is such a rat," the person being described is the target and the negative qualities of rats is the source of the attendant details, power, and relevant meaning (in metaphor studies, often called the salience) of the description. Therefore, in single scope blends, we see the exploitation of one input (an organizing frame/source) for understanding another, the focus (target) input.

The rather obvious conceptual dissonance of the two inputs is believed to be a source of our feelings of insight when we experience the final blend as a psycho-neurological event because the blend remains actively connected across the network of mental spaces and supporting neurological structures. From this perspective, this is the "Aha!" moment of relatively sudden global insight; most of the network is still on-line. Slower realizations, alas, because they evolve over much longer time periods, cannot provide the same feelings.

Finally, Double Scope Networks (Figure 6) usually result from blending concepts in such a way that not only is each input a major contributor to the blend, but the inputs each have quite different internal topologies and the meaning in the blend is structured differently than either/any of the inputs. This sense of structure through contrast or clashing elements of the different organizing frames gives us the term Double Scope because, in contrast to the shared (i.e., unified) structures of the organizing and blended
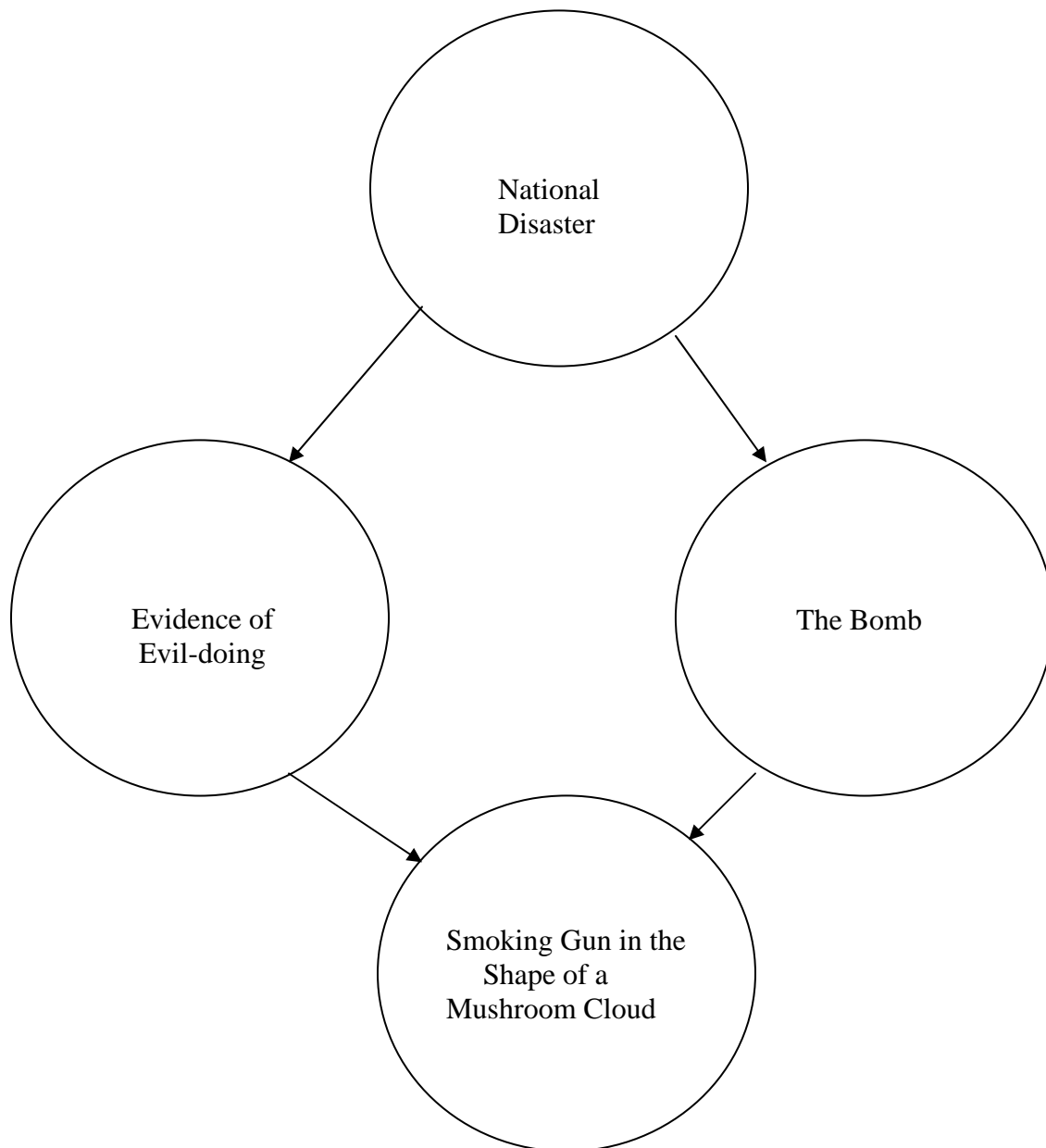
Figure 6. A double scope conceptual integration network. In this example, very different input frames clash with each other, and the blend not only takes some of its salience/ meaning from each, but also adds new meaning of its own. As in all blends, compression has been achieved; in this case, vital relations such as roles, intentionality, identity, change, uniqueness, and disanalogy have done the compression.

frames in a Single Scope network, there are contributions to an emergent blend from the quite different (i.e., Double Scope) structures of the various contributions and combinations of the organizing frame inputs and emergent blend. Since the inputs for a double-scope network are by definition quite different from one another, the blend they create will necessarily involve the selective projection of quite specific--though different—elements from their respective mental spaces.

To clarify, asymmetrical contribution of inputs is a feature of both Single Scope and Double Scope blends, but the latter will display clashing details between and among the various specifics implied by different elements and actions provided by the inputs. A defining and distinguishing feature of Single Scope or Double Scope blends is whether the contributing inputs clash or not; each combination of contributions is reflected in the construction of one or the other type of emergent blend. Logically, then, two more points should be noted here: (a) some metaphors can go beyond the more straightforward Single Scope construction and take on the form of a Double Scope blend; (b) not all metaphors are Single Scope blends, nor are all Single Scope blends metaphors.

A final distinction on this point for now should allow readers to continue more confidently; the specific suite of cognitive mechanisms implied by the use of metaphor is the same for any Single Scope blend. However, the grammatical approach in the more traditional two-space target-source configuration is taken as the canonical starting point for the analysis of metaphors. In conceptual integration theory, metaphor is considered a somewhat special, though ubiquitous case of single scope networks, not because it is rare—which it is not— but because of the way it is achieved (see Chapter IV for more complete explanations.)

A recent and extreme example of a Double Scope blend (Figure 6) has come from American politics –with world-wide repercussions—lurching to life as a mixed metaphor. Beyond making English teachers everywhere cringe, the resulting decisions have meant life or death—literally—for tens of thousands: "We cannot let the smoking gun come in the shape of a mushroom cloud" (Bush, 2003). Notice how the smoking gun metaphor as one input is understood to demonstrate irrefutable guilt of recent criminal activity, while the other metaphor of the mushroom cloud implies the irrevocable catastrophe of a nuclear war. Here are two very different input structures—each one a metaphor in its own right, coincidentally— giving us a double scope structure coming together into a blend which at the time carried enough new dread to justify war in spite of the convoluted grammar.

The work these conceptual integration networks do performs a function called compression. Conceptual integration networks are said to compress the input from different mental spaces into a final (though often temporary) blend, wherein lies emergent understanding or global insight--that "Aha!" moment. Compression usually occurs along one or more dimensions of thought called Vital Relations.

Definitions and Examples of Vital Relations
and Compressions

These vital relations (italicized in this section's examples for clarity) with brief descriptions, examples, and educational applications are as follows:

1. Analogy. Blends here allow us to compress different input information, such as George Washington and George Bush, into a single role—U.S. President. Political cartoons that refer to stereotypes use this kind of compression often. The cigar-chomping big shot/business tycoon, the redneck country boy, the tree-hugging

environmentalist, and many other stereotypes are readily recognizable. A current use of the word "beater" uses *part-whole* and *analogy* compressions to give new meaning to an old word. What used to be a term for a type of kitchen tool (an egg beater), a percussion mallet (a drum beater), a type of hunter's helper who literally beats the bushes to flush game into the open, or more recently an old--i.e., "beat-up" and abusable car or pick-up truck—now has been enlisted for use as a modern slang term for a type of sleeveless t-shirt after the stereotypical image of a beer-swilling lout who beats his wife and wears just such a tank-top-like t-shirt.

2. Category. Categorization, as one of the hallmarks of human thought, very likely has its beginnings in animal brains; however, the human level and use of this ability may be a prime source of language and human cognition (Lakoff, 1987; Varela et al., 1991). Categorization is also an implicit aspect of metaphorical thinking in particular; as such, it deserves close attention in our later analysis of student responses. This mental function allows us to use both *property* and *similarity* to produce a blend.

A modern yet already classic case here is a term such as computer virus. Enough of the properties and similarities of biological viruses were easy to interpret in the context of work with computers as to make this blend an instant success among millions of people. Notice also how the frames of reference have changed along with the metaphors. In the late 1940s and early 1950s, computers were hailed as "super brains" (Wilson & Keil, 1999). Soon thereafter, psychology employed the information processing metaphor to describe mental activities where brains were being described as computers. As discussed elsewhere, the time is ripe for a new metaphor and metaphoric

thinking requires categorization as part of its ability to evoke powerful insight (Lakoff, 1987; Varela et al., 1991).

3. Cause-effect. We continually make mental assumptions about cause and effect, e.g., knowing the dog must have wanted out, though we don't see the dog. The stain (or worse) on the carpet is the effect and we surmise the cause (Fauconnier & Turner, 2002). We are not always necessarily accurate in making these assumptions. Much of folk psychology and folk science are built on what is both obvious and yet not necessarily true (Wilson & Keil, 1999). It is obvious that the sun goes around the earth. Likewise, it is obvious that "those people" aren't like us. Indeed, the English word we got from the Greeks regarding outsiders—barbarians—seems to be derived from disdainful mimicry of their "foreign" languages as "babble," according to my undergraduate classics professor.

Cultural chauvinism, such as practiced by European sociologists at the height of the colonial period, took it for granted that non-European cultures and peoples were inferior. The effect--world domination—was seen as a natural consequence of the cause: namely, the inherent superiority of the Europeans. As students of World War II know, schoolmasters in Nazi Germany routinely argued that Jews and other "undesirables" would be in favor of their own extermination if they only had the mental capacity for understanding how inferior they were (Johnson, 1983). Feelings of moral superiority often derive from misguided cause-effect thinking. Of course, Europeans are by no means the only peoples burdened with convictions of their own cultural superiority.

In science education, misunderstandings are often quite difficult to supplant (Wandersee, Mintzes, & Novak, 1994). Classic, yet unfortunately still current, examples

include cause-effect fallacies about the changing seasons or the phases of the moon as demonstrated regularly in earth science classrooms around the country. The films *Minds of Our Own* (1987) and *A Private Universe* (1987) demonstrate this with unnerving candor. In the films, misunderstandings about science concepts still hold in even bright, well-educated students' views of the world.

4. Change. A very general job of the mind is to recognize various types of change--change over time, change from experience, or change as a result of an event. Blends can reflect many types of *change*. Another recent television phenomenon again uses its technology to produce a blend of this type. A recent Mercedes advertisement uses a mere 30 seconds of images to show a race that represents over 110 years. How? In every scene/cut, the car has evolved into a newer version. It starts with a model from 1894 that seamlessly morphs to the newest, sleekest design. This is but the most recent example of a long-standing use of image technology by advertisers to compress the effect of years into mere seconds. These are now iconic changes in television advertising, e.g., the change from Granny's kitchen to today's, or the change from child to adult. As with many vital relations, change is often used in a suite of cascading vital relations as we use several at once or in sequence to process our thoughts.

The concept of change is essential in education as evidence of academic, personal, or social growth or development. Sometimes we are aware of growth in others more readily than we are of growth in ourselves. But in education, change is an absolute essential; it is a primary objective. Evidence of purposeful change is a hallmark of educational success. Thus, when educators want to measure learning, we look for

different types of change, represented and measured both quantitatively and qualitatively.

5. Disanalogy. Built from a sense of *analogy*, this allows an important type of mental comparison where things which may be closely related in some way can be distinguished from one another. It is difficult to specify fully what is different about two things that are already quite different, e.g., a rabbit and General Motors; it is much more evocative to consider how General Motors and Toyota, or George Washington and George Bush, are different. Notice in this example a grouping of similar vital relations where *roles*, *properties*, *analogies*, *disanalogies*, and *similarities* help us compress our conceptual frames of reference into some kind of usable *categories*.

We often use such thinking for counterfactual statements: "You're comparing apples and oranges," or "I knew Jack Kennedy… [and] Senator, you're no Jack Kennedy" (Bentsen, 1988), or "I'm not your mother, so you had better learn to clean up after yourself around here." In thinking in general, and in learning in particular, disanalogies are an important part of understanding.

6. Identity. Identity is possibly the most basic vital relation. We understand that one person is still "that person," whether an infant or an elder. Notice that identity can actually help us establish *change* in one person. On the other hand, statements such as "He's just not his usual happy self today" or "I feel like a new man" are forms of identity statements built into counterfactual—that is, disanalogous— references. In education, *identity*, *change* and *disanalogy* are woven together in statements such as "I can't believe I used to think geometry was so hard."

7. Intentionality. This covers a host of expressions involving desire, hope, fears, etc. This concept is very basic to our understanding of the world and each other. Titles such as *Death Becomes Her* or *The Importance of Being Earnest* play on our sense of *intentionality*. Phrases such as, "I'd like to see you try that," or, "I hope you'll change your ways, young man," or, "I'm afraid it's going to snow tomorrow" all use intentionality in some way. By ascribing intention to others' actions, we are using a very basic psychological tool, a "theory of mind," which implies a sense of psycho-social maturity on the part of the person making such inferences. Readers will recall the definition of a "theory of mind" provided in the previous section. This is precisely where implicit intentionality comes in.

8. Part-Whole or Whole-Part. Synecdoche is the technical term; however, this linguistic activity is often reasonably understood as metonymy, the use of one name to name another, associated thing, a very common mental/linguistic activity. Many slang terms, such as "Brass" to refer to military officers, use a part-to-whole compression. Street slang is often at the forefront of linguistic part-whole compression. References to pop/street-culture have little social cache if they are considered out of date. The chain of referents leading to a 1990s phrase such as "Chillin' wit muh homies in the crib" may be obvious, but one would betray a pitiful lack of "street cred" if one used such a phrase today, only a few years later. More recently, "bling" has been used to describe ostentatious jewelry, using just a "sound effect" about the shiny gleam (part) to refer to an entire (whole) range of expensive, flashy clothing accessories. Using abbreviations, as exemplified in much of the recent text- and instant-messaging phenomena such as LOL

(usually for Laughing Out Loud) or LYLAS (Love Ya' Like A Sister), are also clear cases of part-whole mental compressions.

Advertising not only uses this element of psychology as part of its on-going attempts to influence shopping habits but often becomes a catalyst for even more linguistic change. In the 1980s, "Where's the beef" came from a Wendy's fast food commercial and played on the cliché of "having a beef"—conflict/problem—with someone, and became a compression for any reasonable complaint. Likewise, "Awesome," from a Nissan auto commercial from that same time period, came into parlance as descriptive of any good thing. The former has faded while the latter is still with us, probably because its meaning already had practical use in the language, IMHO (i.e., In My Humble Opinion).

The Michael Jordan basketball empire inspired movies, ads, and many linguistic frames of reference. In the movie *Space Jam*, Bugs Bunny calls Jordan "Your Airness," and it makes perfect sense. Here also is a case where sheer imagery alone has come into being as a cultural referent; both the flying basketball player and the Nike "Swoosh" are proprietary trademarks, embodying this *part-whole* compression without a word.

9. Property. Blending allows us to compress a *property* into an inherent descriptive quality. A person who is a shining example of athleticism may warrant being called a "star." Many of the adjective/descriptive noun phrases that are constantly evolving (Deutscher, 2005) follow this pattern. Over time, noun phrases and verb phrases evolve into shortcut phrases, taking on--through compression—new meanings and uses as other parts of speech or grammatical tools.

10. Representation. When we see a play, we know the actors represent characters; likewise, if we see a photograph and say, "That's my boy," we are using *representation*. We are not under the illusion that the piece of paper is also at the same time a human being. Representation helps us compress a lot of information into small usable statements. Notice how a phrase such as "The White House said today…" uses a combination of *part-whole*, *representation*, and *identity* compressions.

11. Role. Many of our most common descriptive statements, such as "She is the boss" or the metaphor "He is a just a big fish in a small pond," are blends where *roles* have been compressed. Notice here that such statements also elicit the sense of *identity*. Educators could look closely at their students' remarks about roles to understand how much the students know about a subject. There is already a tradition in educational psychology of attribution theory (Ormrod, 2006) where remarks about success or failure are used to understand a student's locus of control. That is, statements are interpreted as to what *roles* are played by different people and events in bringing about a given state of affairs (Wilson & Keil, 1999).

Roles are often balanced by, associated with, and expressed in terms of values in cognitive linguistics and conceptual integration; values are the specific players of the various generic roles in statements. Thus, in "James is the father of Claire," "James" and Claire" are the values and fatherhood (and by implication, daughterhood) are the respective roles played by James and Claire.

12. Similarity. We seem to be neurologically equipped and disposed to perceive *similarity* (Levitin, 2002). This is reflected in relations between inner mental spaces. Face recognition modules are an example of this neurological proclivity. This deep-seated and

early-manifesting ability has implications for both biological and social survival. We not only recognize relatives or strangers and friends or foes but also emotions and other types of non-linguistic messages. This vital relation paves the way for a closely related capacity, *categorization*. In specific regard to the issue of similarity, traditional studies of metaphor have used similarity theory or comparison theory as a defining aspect of metaphor, the roots of which go back to Aristotle. See Chiappe and Kennedy (2000) for recent work along these more traditional lines of inquiry where the researchers test the relative strength of metaphors and similes.

13. Space. Like *time*, *space* can be mentally blended. We can be in one place physically but mentally visit another quite easily. Imagination often prompts for concepts of being somewhere else. A soldier in battle may wish to be in a safer place, a lover may wish to be in the presence of the significant other, or a student may wish to be outside instead of in the classroom taking some dumb test. Einstein was said to have extra matter in the sections of the brain where spatial thinking occurs--with parietal lobes about 15 percent wider than average and a missing Sylvan fissure, leading to speculation about an abnormal ability to make mathematical connections and spatial speculations (Ackerman, 2004). Much of what counts as imagination and creativity derives from our ability to make blends involving compressions across time and space. Interestingly, since Einstein, Space-Time is often used as a hyphenated compound word/concept, indicating the new concept that what were formerly considered two is now considered as one. Worth noting here is Deutscher's contention that all languages, through common intuition, have long since related space and time through metaphor; "there is no known language where spatial terms are not also used to describe temporal relations" (2005, p. 134).

14. Time. We compress *time* into blends in many ways. We have memory, a sense of continuity, a sense of causation, and notions of simultaneity, for example. In a statement where one says something like "I'm not the person I used to be," that person is implying at least three vital relations: change, identity, and time.

15. Uniqueness. Blends often have *uniqueness* as a prime factor for having been made in the first place. Further, it is often the uniqueness of the separate elements going into the blend that allow the uniqueness to emerge in the blend itself. Jokes or witty sayings often have meaning because of a unique blend of mental inputs: whether "a man bites a dog" or "the fault lies not in our stars, but in our selves," each part of the blend derives from unique mental input spaces. The blend itself carries into new, unique, emergent meaning, distinct from the previous ones.

Examples of Vital Relations, Compressions,
and Conceptual Integration Networks

For some representative examples of how these vital relations do their work in creating conceptual integration networks, we may look at a few applications to some of the examples of the different types of networks discussed above. When we say "Claire is the daughter of James," this simplex network compresses vital relations of role, identity, category, and uniqueness. A listener is given this much information in a mere six words, half of which are nouns. If we say Olivier's Hamlet is more convincing than Burton's, we have set up a mirror network where the inputs of the same dramatic role structure the listener's understanding along the vital relations of analogy, role, identity, property, disanalogy, and representation. Most of our uses of metaphoric language are examples of single scope networks: whether we think of genes as blueprints or recipes, we are taking what we know about blueprints or recipes to describe genetic processes; what we know

about the source domains (of blueprints or recipes) is compressed by vital relations such as analogy, category, cause-effect, change, part-to-whole, property, representation, and similarity into our understanding of genes, the target domain.

For an example of compression across a number of vital relations in a double scope network, where the input spaces have little in common, consider a long-running joke among a group of my friends (Figure 7). As teenagers, we fancied our wit to be extraordinary and were pleased with ourselves when we realized various words in English used the suffix "-taneous." Collectively calling ourselves the "Taneous Brothers," that is, Instant Taneous, Simul Taneous, Spon Taneous, and Subcu Taneous, we laughed at our fine word play many times over the years. Years later, while explaining this to another friend, we challenged him to come up with another name for a new Taneous brother, hoping to challenge the friend and also perhaps to learn of a new word with the –taneous suffix. For whatever reason, the new friend said, apparently out of the blue and just to be silly, "Ike." The surprise was complete because Ike didn't fit at all with the expectation, and again, they roared with laughter, especially when one of them summed it up this way: "Ma and Pa Taneous lost the thread." For this simple sentence to encapsulate the whole story, an impressive amount of compression has taken place.

First, a generic space, such as baby names, was enlisted years ago. Then an input space for the fictional Taneous brothers was developed, at least in part through a mental space of puns from a specific group of non-naming words in English. Here is a clash between an input with naming words and one with non-naming words. Over time, the fictional Taneous family name migrated through much use to a position of acceptability

Baby Names

The
Taneous Brothers:
Instant, Simul,
Spon, and Subcu

Ike Taneous,
The New Brother

"Ma and Pa
Taneous lost the
thread."
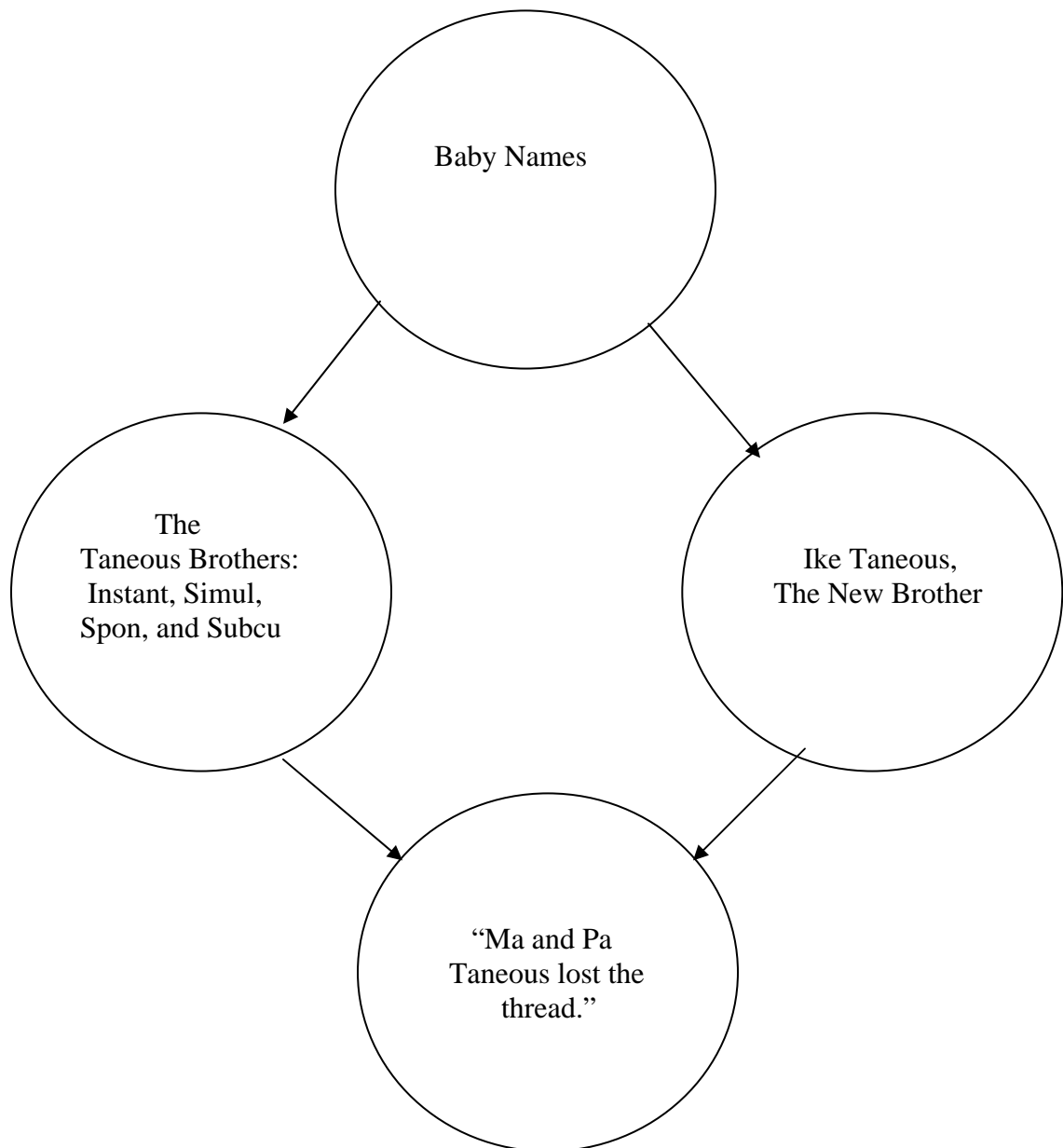
Figure 7. Reverse-engineered joke. Very different, clashing, inputs make for a double-scope network. The blend takes information from all inputs to create emergent meaning via compressions of uniqueness, intentionality, category, disanalogy, representation, similarity, change, time, and cause-effect.

and common use among the jokesters as an input space for a legitimate family name, at least for the purposes of the on-going joke. Once again, the new name, Ike, came from an input space which was totally at odds with the Taneous punch line because unlike Instant, Simul, Spon, and Subcu, Ike really is a name (and there is no immediate dictionary connection to "iketaneous")! How could all of these inputs, which share so little, be compressed into an expression which allows for all the input spaces to be accounted for, yet which prompts for a new, logical, yet also accurate understanding? The Subject-Verb-Object sentence, "Ma and Pa Taneous lost the thread," will do quite nicely in recruiting a number of very different mental spaces toward a unified blend which shares some structure with the inputs, yet also has structure beyond the constituent elements of the inputs.

The use of "Ma and Pa" implies both parenthood and perhaps a not-so-sharp or not-so-educated mentality as well. The metaphoric phrase of "losing the thread" implies that they may not have had much to hold onto in the first place, intellectually speaking, and even that was now gone. So the pattern to which the Taneous parents had clung, naming the first four boys to create the dictionary words instantaneous, simultaneous, spontaneous, and subcutaneous, was now broken; Ike's brief appellation was the surprising result. This demonstrates that many inputs may be at work in a given integration network, and that the inputs may be elaborate and long-standing or quite temporary ad hoc statements. The various inputs have very little structure in common, yet the seven word blend has its own unique structure, nevertheless derived from its precursors. This little bit of autobiography is a real world example of how vital relations such as uniqueness, intentionality, category, disanalogy, representation, similarity,

change, time, and cause-effect are used to compress information in remarkably fluid and

potent ways.

It must be emphasized that the fluid and rapid rate of blending and compression

into other blends may involve any number of these vital relations in dynamic interplay;

many variations and combinations are possible.

> There are canonical patterns of compressions over these vital relations that we will encounter time and time again. Compression can scale Time, Space, Cause-Effect, and Intentionality. Analogy can be compressed into Identity or Uniqueness. Cause-Effect can be compressed into Part-Whole. Identity itself is routinely compressed into Uniqueness. It is also a fundamental power of the way we think to compress Representation, Part-Whole, Cause-Effect, Category, and Role into Uniqueness…

> There are also canonical patterns of proliferation of Vital Relations. Cause-Effect can be added to Analogy. Intentionality can be added to Cause-Effect. Change usually comes with Uniqueness or Identity.

> Vital Relations are what we live by, but they are much less static and unitary that we imagine. Conceptual integration is continually compressing and decompressing them, developing emergent meaning as it goes. Certain basic elements of cognitive architecture make blending and compression possible. (Fauconnier & Turner, 2002, p. 101)

It must also be reiterated that these mental functions are not limited to language.

However, because the present work is primarily focused on language and because such

huge amounts of our mental processes deal with language, most of the examples here are

couched in the context of language use. It is these types of patterns which the current

research is designed to elicit and analyze. If any patterns can be found to be prevalent in

natural, emergent (but topical and prompted) discourse from students on the basis of prior

knowledge or instructional metaphor condition, we may tentatively interpret such results

as indicative either depth of understanding and/or the relative persuasiveness of

metaphor, respectively, both of which could have significant impact on how teachers may

evaluate the effectiveness of their instruction and the validity and reliability of their assessments of student learning.

The primary goal for all compressions is to achieve human scale (Fauconnier & Turner, 2002). Any of the vital relations described above will eventually, through whatever necessary combinations and sequences, bring about a blend which will reflect human scale for the purpose of understanding. The sub-goals of compression serve the primary goal. Sub-goals include the following: (a) compress what is diffuse, (b) obtain global insight, (c) strengthen vital relations, (d) create a story, and (e) go from many to one. From both a neurological viewpoint (Wilson & Keil, 1999) and a systems perspective (Gleick, 1987; Waldrop, 1992), the idea of scaling is a feature of hierarchical systems of networks. As elements of various inputs are recruited into the blend, they are connected through compression which allows for both this human scale and global insight as well.

Governing Principles of
Conceptual Integration

A final set of principles must now be developed to understand conceptual integration theory. Fauconnier and Turner (2002) describe these as governing or optimality principles. Briefly put, with all other things being equal, we will find blending requires principles of (a) topology, where the useful topology of the inputs is reflected in the blend; (b) pattern completion, where existing patterns in the inputs can be used to correctly understand patterns in the blend; (c) integration, the essence of a blend; (d) maximization of vital relations, where vital relations have the most obvious presence and salience; (e) mental maintenance of the web of appropriate connections without additional surveillance or effort; (f) unpacking, where a blend can be unpacked or

reverse-engineered to reconstruct the entire network; and (g) relevance, where any element in the final blend is somehow directly related or linked to elements from the various inputs from which the blend was formed. These principles help differentiate between statements which are blends and those which are not blends, because it is worth noting here that although blends permeate our discourse, not every statement is a blend.

<div align="center">

Examples and Conceptual Integration Analyses
of Metaphors as Instructional Models/Tools

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The history of using metaphors to teach lessons is long and well-documented even without including religious storytelling or innumerable instances of "at-momma's-knee" types of life lessons. The following is a brief sampling of well-known instructional metaphors with representative, selected analyses using a conceptual integration approach.

1. The allegory of the cave. In Book VII of *The Republic* (Plato, trans. 1961), Plato wrote of human consciousness as a kind of fleeting, removed, ephemeral experience, much like watching one's shadow dance on a cave wall in the flickering firelight. He was not the only philosopher to address the issue of human consciousness, of course, but the image created by this metaphor has had staying power for over 2000 years. The image is something of a cultural icon and would be easily accessed as a framework for an input space for almost anyone with a basic knowledge of the history of Western philosophy. Thus, the image may be accessed through memory or by a cultural cue if, for example, one saw a cartoon about this in *The New Yorker*. The conceptual integration model would include the potential for a person to employ this image as an initial input space which could be derived either from prior knowledge or contextual clues such as language.

2. A folk tale (points of view). The parable of the blind men and the elephant (Kazlev, 2004) is common to many cultures. It can be used with adults to discuss bias or with children or literature classes to discuss theory of mind/point of view. Because the listener knows what the characters don't know—that is, that the one thing all the blind men are touching is an elephant, the listener has made a compression of many to one, that is, part-to-whole. Each of the blind men's conjectures creates an input space in the complex integration network the story elicits in the listener. The listener also recruits enough information about other inputs derived from experience or basic knowledge to make sense of the men's comments. An input about trees helps when one man describes the legs, an input about snakes helps when another man describes the trunk, etc.

3. A sail and a wing (physics of flight). Flight instructors often use a metaphor with sailing to explain the phenomenon of Bernoulli's principle--the similar shapes and function of sails and wings. Because this metaphor is based on similarity of multiple aspects of shape and function, we might label the frameworks of both inputs as being nearly equal contributors to the blend, yielding a mirror blend. Sailing instructors use the idea of a sail as a vertical wing to explain propulsion for their boats, lending further credibility to the balance of the inputs, mirroring one another.

3. Earth scale (biology/ecology). A typical science class activity for middle school children might involve drawing large (10 feet or more in diameter) circles with chalk. The width of the chalk represents the depth of the biosphere, the home of all known living things, including the oceans and atmosphere (perhaps 10 or 12 miles thick, at most); the diameter of the entire circle represents the diameter of the earth (roughly eight thousand miles). By bringing the size of the earth and the very small relative size of the

biosphere into human scale, teachers are using the metaphor of the drawn circle to compress several ideas about the environment and human impact into one brief lesson with symbolic representation.

4. Sun scale (space science). In earth and space science, it is typical to use a football field to teach students some of the elements of relative size and distance. With the sun represented by a basketball on one goal line and the erstwhile planet Pluto on the other (smaller than a BB), teachers use this exercise in compression to human scale to give students insights into planetary distances. It is no accident that Einstein used a metaphor to describe the speed of light. He famously imagined riding a beam of light from the sun on an outward journey from the sun through the solar system. Physically, this seems to be impossible. However, the image is easy to visualize because we have the capacity to create mental spaces/inputs at will, regardless of the actual feasibility of an act or scenario.

5. Body as machine or temple? Professional sports trainers may talk about high performance, fuel, stress, pounding out work, work-loads, RPMs ("reps"), or the like, and be perfectly comfortable using a whole system of metaphors of the body as a machine. People who have a different body metaphor will likely employ a different set of statements. If the body is a temple, there will likely be sacrifice, cleansing, spirituality, or perhaps protection. Our metaphors for life provide many of the mental space inputs we recruit for everyday conversation and understanding. That our psychology is both physically embodied and culturally embedded are issues the conceptual integration model tries to address (Fauconnier & Turner, 2002; Greenspan & Shanker, 2004; Lakoff, 1987; Pinker, 1997, 2002; Varela et al., 1991).

6. Math symbols. Because they use information about one domain to create information about another domain, symbols of any kind have metaphoric qualities. The open (or big) end of arrows eventually gets to be learned as greater-than. There really is a lot of balance involved in balancing an equation. Exponents mean a lot and don't take up too much space. Social conventions of all kinds, including language and math, are richly coded and can become prompts for input spaces at any time because our brains are dynamically and subtly responsive to both internal and external inputs.

7. "Life is…" statements are often metaphoric, compressing so much information into seemingly simple statements that we sometimes fail to appreciate how we can construct so much meaning from so few words. Consider the evocative power of the following various statements. Life is a journey. Life is a vale of tears. Life is full of surprises. Life is not for the weak of heart. Life is a test. Life is a contest. Life is a trial, a struggle, a climb…a trip!

Whether we are children or adults, whether we are in classrooms, homes, or places of work, metaphors are in constant use around us, not only as clever, special language, but as teaching and communication tools of the highest degree. The mechanisms with which we understand and produce metaphor are so natural and automatic that we should continue to explore this area of human interaction in order to discover what more we can learn about language, learning, and psychology.

<div align="center">Instructional Metaphors in the
Teaching of Genetics</div>

Having by now established the viability of the study of metaphor as a topic which continues to demonstrate a richness of potential for both psychology and education, I will now discuss the particular pair of metaphors examined in the current research. Of course,

metaphor has long been acknowledged as a teaching tool par excellence (Deutscher, 2005; Marcus, 2004). Science teaching in particular has maintained a lively debate and even started a cottage industry in developing metaphors to help explain certain concepts to students at all grade levels (Aubosson, Harrison, & Ritchie, 2006). Science teachers—and all effective teachers, really—are keenly aware that good metaphors help their students learn concepts; likewise, an ill-chosen metaphor can serve to merely confuse students rather than to illuminate subject matter. One problem, of course, is that no one metaphor can be as completely accurate as a teacher or student—or any set of speakers and listeners— might want it to be. It is accepted that metaphoric descriptions are and, to some extent, must be incomplete and partial (Fauconnier & Turner, 2002; Lakoff & Johnson, 1980). Often, an element in a metaphor that highlights one aspect of a concept well may carry with it elements which limit or distort a student's ability to understand other aspects of the concept accurately.

A now-classic case in point--and one which a recent study by Condit et al. (2002) has made devilishly more complex--is the use of either the blueprint or the recipe metaphor for teaching and learning about genes, genetics, and heredity. In their study, Condit et al. analyzed explanations by their participants in choosing one or the other of the metaphors as more effective and found a wide range of opinion regarding the instructional usefulness and accuracy of each metaphor. These mixed results seem to have been based on factors the participants had internalized about recipes and blueprints long before their participation in the study. Some subjects described each metaphor as being superior or inferior for the same reasons, e.g., helping the subjects think about the organizational aspects of genetic information or being too deterministic. In other words,

the participants' prior experiences of, and dispositions toward, the source domains of recipes or blueprints were far too varied to predict the effectiveness of transfer of any given salient qualities of either metaphor to the target domain: genes, genetics, and heredity.

For one thing, the science of molecular genetics in the last 50 years was advancing so rapidly that it was regularly outstripping the metaphors used to describe its wondrous processes (Condit et al., 2002; Marcus, 2004). The blueprint metaphor held sway as an important contributor to student learning until criticism mounted in the mid-1990s, declaring that the mental model emerging from this metaphor was too deterministic. If there was a gene for everything, and genes controlled everything through perfectly replicated patterns, humans—and all organisms—were mere pawns of genetic destiny. Of course, as previously mentioned, no metaphor is complete or completely accurate. As we have seen already and as will continue to come up in later discussions, part of the power of metaphors lies exactly in their incomplete or partial nature (Fauconnier & Turner, 2002; Lakoff & Johnson, 1980).

Critics of the blueprint metaphor advocated for a recipe metaphor instead (Marcus, 2004), claiming it better represented the processes of molecular genetics, allowing for natural variation and the effects of the environment. Further, it was a superior metaphor because it did not imply a specific, one-to-one mapping from a particular gene sequence to a particular trait or attribute of the organism. As cited in Marcus, geneticist Richard Dawkins wrote the following:

> The genetic code is not a blueprint for assembling a body from a set of bits; it is more like a recipe for baking one from a set of ingredients. If we follow a particular recipe, word for word, in a cookery book, what finally emerges from the oven is a cake. We cannot now break the cake into its

component crumbs and say: this crumb corresponds to the first word in the recipe; this crumb corresponds to the second word, etc. (p. 1)

Marcus further cites British zoologist Patrick Bateson:

The idea that genes might be likened to the blueprint of a building… is hopelessly misleading because the correspondences between plan and product are not to be found. In a blueprint, the mapping works both ways. Staring from a finished house, the room can be found on the blueprint, just as the room's position is determined by the blueprint. This straightforward mapping is not true for genes and behaviour, in either direction. (p. 6)

The proposed shift to the recipe metaphor was embraced by specialists in genetics, the media, and some science writers. However, as Condit et al. (2002) write,

use of the recipe metaphor has not fulfilled the critics' aspirations for it… [and this] can be attributed to a faulty theory of how metaphors function… This approach assumes that metaphors have innate, monosemic meanings that determine the mindsets of those who use them. (p. 303)

What the geneticists expected in espousing a different metaphor as a more effective teaching tool came from a meaning is in the words approach. But it has become clear that in different contexts, metaphors, like other language devices, can have different meanings/functions. This study addresses a resulting issue in Chapter VI: if meaning is not in words, can there be meaning in metaphors made of words?

Condit et al. (2002) approached the gap between the geneticists' expectations and the less-than-hoped-for outcome of their efforts by taking into account the difference between larger sets of potential metaphoric meanings and smaller, filtered sets of contextually activated metaphoric meanings. Condit et al. contend that the geneticists could have done a more effective job by approaching the newer metaphor not as a replaceable part, or as something merely to be inserted into the heads of learners (using the old "container" model/metaphor of learning), but as something that already had meaning in the population of learners and, moreover, as something that would prompt

learners to continue to process and construct their own meanings from a living, active metaphor.

The practical difference of the two models is this. If the meanings were in the words and also in the metaphors made of words, the container model would be supported by significantly increased scores for the experimental group with the enriched metaphor condition relative to the scores of the control group. If, on the other hand, the container model was not supported by increased post-instruction scores among the experimental group, one logically remaining possibility is that no learning at all has taken effect. This possibility may be rejected because there are positive, significant differences in virtually all pre- and post- instruction measures for all participants reported in Chapter V. Another logically possible choice would be that the given metaphors were inappropriate for the tasks. Because the two primary metaphors and the other classic metaphors were developed and used by instructors since the beginning of instruction in the content domain of genes, genetics, and heredity, this possibility, too, may be discounted. Another logical choice is that because the instruction relies merely on telling information about the topic—even with more metaphors—rather than engaging participants in more cognitively constructive activities than unguided, passive listening, teaching and learning opportunities may have been squandered.

In the present study, by assessing the learning/meaning construction process via analysis from a conceptual integration perspective, I test some of the dynamic meaning-via-context approaches advocated and explored by Condit et al. and I also elicit data about the use of metaphors in the relative instructional effect of the two given instructional conditions. Design decisions are described in more detail in Chapter III.

Conceptual Integration, Metaphor,
and the Present Study

The reader will recall from Carroll and Mack (1999) the list of terms (presented here in verb form) they used in calling for an approach to active learning: retrieve, integrate, compress, frame, map, infer, construct, and interact. It is worth restating that these same verbs are used throughout discussions of conceptual integration theory as well. The use of instructional metaphors also requires students and teachers to retrieve, integrate, compress, frame, map, infer, construct, and interact. When we consider the way we think, communicate, and learn, these and similar, related ideas must come into play.

Until conceptual integration theory had been formulated (Evans & Green, 2006; Fauconnier & Turner, 2002; Turner & Fauconnier, 1995), many elements of psychology and learning seemed impossible to connect. Where was knowledge stored? How do people understand each other? How does learning take place? Are we merely passive containers of information? How can we understand one another when words and phrases can have so many meanings? How does language—and metaphor, in particular— work as both an interactive yet also internal psychological process? In brief, simply recall the question posed on the first page of this paper: Just what happens psychologically when students learn something new from classroom instruction?

By using the conceptual integration model, these types of questions seem to have some hope of being satisfactorily answered. The field is new and no doubt many obstacles remain. But the unifying effect of one theory which accounts for biology, social interaction, language use, situational context, and much of what we call psychology has tremendous potential. Academic interest in conceptual integration is just beginning. But

the possibilities are immense since the combinatorial and computational aspects of human thought and language are so succinctly addressed by this theory.

In this research, I examine the use of conceptual integration as an analytical tool in a classroom learning situation where I test some of its claims, refine our understanding, and apply its precepts in the pursuit of helping teachers and students improve their abilities.

<div align="center">Sample Conceptual Integration Analyses of
Two Core Instructional Metaphors</div>

With the foregoing definitions, examples, and guidelines now in place, I now turn to the specific elements of the practical applications and implications of these concepts in the present research. As previously discussed, any metaphor carries the potential to hide and highlight certain elements of a concept (Fauconnier & Turner, 2002; Lakoff & Johnson, 1980). Teachers know that it is a real art to find and express metaphors well enough to truly help their students learn. I turn to a debate in the field of science teaching regarding two such useful and yet incomplete metaphors.

In this research, using the specific metaphors "genes are blueprints" and "genes are recipes" as studied in research by Condit et al. (2002), I test not only if an enriched instructional metaphor condition is more effective than a less-overtly metaphoric condition but also, from an analysis of participant responses after instruction, if there are any patterns of conceptual integration networks that indicate different levels of understanding or different mental strategies used to process instruction and communication.

I also discuss and describe different aspects of mimetic processing as part of the conceptual integration processes among the participants. That is, I investigate what gets

copied by the participants from each of the given metaphors and what changes appear in the participants' written patterns of conceptual integration. Such mimetic behavior may be taken as a specific instance of Vygotsky's (1934/1987) contention about scaffolding as an instructional framework which is developed, initiated, and supported by the teacher, and which eventually develops—often through overtly copied behaviors—into the learner's conceptual, internalized command of given material.

When an instructor uses a given metaphor, the student is prompted to construct a set of mental spaces which accurately represent—if only temporarily at first—at least some of the elements of the instructional input, the given metaphor. Such mental representations become some of the inputs in the student's conceptual integration network. A student in a class about genes, genetics, and heredity has a topic—that is, a target domain—very well defined by the highly structured instructional context. The question here becomes this: What will the student learn as a result of the instructional prompt to think about the target domain (genes, genetics, and heredity) in terms of a specific source domain (e.g., blueprints)? Using the generic framework for a single scope conceptual integration network because of its typical association with metaphor, we may imagine a number of scenarios.

A single scope, conceptual integration network for this metaphor might start with a generic space for life science/biology class because this represents a student's initial mental framework for what she is experiencing. When the instructor uses the blueprint metaphor, the student is prompted to extend the generic life science/biology class input space toward a specific target, genes, which becomes an input space of its own. Any information already in this space which the student is able to bring to bear may be

considered prior knowledge or memory. The source domain, blueprint, has also been prompted by the instructor and represents a third input space.

But here is the critical moment where a blend will or won't be achieved. The success or failure of the blend prompted by the teacher determines the level of meaning construction—that is, learning—by the student as the student constructs blends in response to the teacher's prompts. In this study, I examine the changes in the number, types, and veracity of statements and constructions (blends and otherwise) before and after the teaching/learning exchange, allowing me to discover and discuss what factors are most relevant to the successful use of instructional metaphors (see research questions below and Chapter VI.)

From the conceptual integration perspective, the moment in question is when the information in the student's input spaces—generic space: science class, first input: genes, genetics, heredity (target domain); second input: blueprint (source domain)—will provide enough input to lend structure and content to an emergent blend, a fourth mental space which by definition will contain a uniquely structured representation, with qualities and relationships among those qualities relevant to specific content provided by both of the inputs. The extent to which the emergent blend reflects an accurate understanding of the given elements and their relationships is the extent to which the student may be said to know about genes, genetics, heredity, at least insofar as they relate to the functions of blueprints. Examining students' statements in light of conceptual integration techniques could give rise both to a more subtle understanding of the specific problems given student may be having and to more effective teaching and learning solutions to those problems.

But here lurks the dilemma: the use of a given metaphor—in this case, genes are blueprints—assumes that the student's knowledge base includes at least something about blueprints. What definitions, qualities, process, or products does the student associate with blueprints? It is immediately obvious that with a greater knowledge of the source domain, blueprints, a student will have a greater likelihood of meaningful application of the relevant qualities of blueprints in relation to the target domain, namely genes, genetics, and heredity. A student who has no idea of what a blueprint is will clearly be at a loss. Levels of age-level appropriate vocabulary acquisition may be one explanation for a child's not knowing what a blueprint is, but there are others. There are considerations of gender, socio-economic status, education, ESL status, access to technology, cultural perspective, and so on. The teacher who uses any metaphor thinking that it will be equally helpful and obvious to all students is in serious danger of making an unwarranted instructional assumption.

To extend these considerations to two hypothetical students representing the conceivable extremes of these elements, first consider how valuable meaning construction will be for a student whose command of English is limited and whose life experience has never included the word or concept of a blueprint. At most, working with the constituent parts—that is, Blue and Print, he might conclude that genes/genetics/ heredity have something to do with the color blue or with print as a kind of writing done by hand or machine. Although genes are found in chromosomes, which by definition (from the Greek for colored bodies, which earlier geneticists found in a brief, specific stage in cell division) do have something to do with color (McKechnie, 1983), it is not really their "blueness" that is important. Likewise, the student may be technically correct

about how print might be connected to the target concepts, but only in the most trivial and superficial ways. A conceptual integration interpretation of this situation would predict little, if any, emergent meaning and therefore, little, if any, advancement in learning for this child. The source domain's poverty of content and structure makes it very unlikely that the student will be helped in understanding anything about the target domain by this particular instructional metaphor.

On the other hand, consider a precocious, articulate student from a privileged background. Perhaps her father is even an architect who sometimes brings home both actual blueprints per se but also has had occasion to explain to his daughter how they are used, what they mean, and how computer-assisted design has created whole new fields of visual representation for architecture and construction. This hypothetical student may readily understand many things taught to her about genes, genetics, and heredity precisely because of the depth and accuracy of, and ease of access to, information in her well-nourished and elaborate source domain. She will draw on the source domain to build an emergent blend where genes, genetics, and heredity will be understood to have some of the qualities of blueprints such as organization, scheduling, parts working together, planning, communication, and so forth. These two hypothetical students are highly dissimilar, but teachers know that in most real classrooms, this level of diversity is actually quite typical and is reflected not in just two students but in scores of them.

In this research, I tally and employ components from conceptual integration theory including the four different types of integration networks (simplex, mirror, single scope, and double scope) and 15 different vital relations (i.e., analogy, category, cause-

effect, change, disanalogy, identity, intentionality, part-whole, property, representation, role/value, similarity, space, time, and uniqueness) compressed into blended statements.

From exploring the basic question I posed at the beginning of this paper—What happens psychologically when students learn something new from classroom instruction?—I hope to have established the basis for asking research questions about student learning as reflected in a conceptual integration approach. The primary research question became this: How is learning reflected in changes of conceptual integration patterns? To answer this, I compared how different instructional metaphor conditions impact learning as measured by traditional quantitative analyses. I also collected and analyzed participants' open-response production of various metaphors before and after instruction. After performing these types of analyses, I was prepared and able to assess some of the accompanying tenets of conceptual integration theory as they apply to classroom practices (Chapter VI).

<div align="center">

The Present Study: Research Questions and
Overview of Methods and Data Analysis

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This research is designed to show how the conceptual integration model may be employed in clarifying some of the psychological implications when intentional teaching and learning have taken place. By applying principles of conceptual integration theory to learning situations, I analyze changes in participants' written language about specific instructional content. In determining the pre- and post- instruction changes in conceptual integration patterns participants used to articulate their understanding, I explore ways of identifying and describing processes of thought that must have been at work—according to conceptual integration theory— in the participants as they developed and demonstrated new understanding. A conceptual integration approach could eventually lead researchers

to discover ways to improve teacher effectiveness and student learning through improved

diagnosis, content, planning, and activities.

Research Questions

Four primary questions and their corollaries drove this research:

1. How is learning reflected in changes of verbal (written) conceptual integration patterns?

2. Does metaphorically "richer" instructional content lead to significant group differences either in selected-response scores or any open-response measures?

3. To what extent, if any, does mimetic learning apply to the use of instructional metaphors by participants as measured by either (a) change in metaphor use or (b) change in conceptual integration patterns? Corollary 3.1: What is the relationship, if any, between mimetic post-instructional metaphor use and selected-response scores?

4. Can participants develop effective novel metaphors of their own? Corollary 4.1: Do participants who demonstrate higher creative metaphor ability also score higher on the selected response/ recognition part of the assessment? Corollary 4.2: Do participants who demonstrate higher creative metaphor ability also score higher on the open-response part of the assessment (in relation to accuracy ratings for the open-response data)?

Overview of Methods and Data Analysis

In order to apply the theory of conceptual integration to a realistic teaching and

learning situation, I used different two metaphoric conditions in teaching an otherwise

identical lesson via a video recording about the same topic to two groups of participants.

The control group (Group C) simply took the pretest and the posttest without any overt

references to metaphors in their version of the instruction. By definition, their scores

provided a baseline. The experimental group (Group E) viewed the identical instructional

video with the addition of blueprint and recipe metaphors, both embedded in the

instruction. I analyzed pre- and post-instruction open responses as well as results of pre-

and post-instruction selected response assessments.

Respectively, all of the research questions above required different types of assessments, data, and analyses, resulting in a mixed methods research approach. I applied both traditional quantitative techniques as well as principles of conceptual integration to the analysis of the qualitative response data.

First, I analyzed quantitative results from the different instructional/experimental groups to determine the relative efficacy of the respective instructional metaphor conditions. Then, I analyzed qualitative data from the participants' open responses in several ways. I determined if there were unique or typical patterns of conceptual integration networks used by individuals or groups of participants before or after instruction. I analyzed participant responses across dimensions of instructional group and program major according to the frequency and type of conceptual integration networks (along with their respective vital relations) employed by the participants before and after instruction. Further, pre- and post- instruction differences either in metaphor use or specific metaphor elaboration could logically reflect mimetic learning and this work developed these issues as well.

Further, final qualitative analyses were made via the results of (a) a survey of the participants' dispositions regarding the various given metaphors including the two primary metaphors, and (b) the creative metaphor exercise. Each shed a good deal of light on several of the topics at hand.

Expected Results

Through this work, I expected to illustrate or test three key points. First, there should be relationships between quantitative and qualitative changes in performances. That is, learning, as measured by pre-and-post-instruction quantitative assessments, will

be reflected in changes in patterns of conceptual integration as measured by pre-and-post-instruction qualitative assessments.

Second, I tested for significant differences in the effectiveness of the two instructional metaphor conditions described above. The pair of metaphors provided to the experimental group should help those participants more than the non-metaphoric condition helped the control group. This tested the common sense notion that using multiple metaphors will help students learn more (from more metaphors). Again, the assumptions of success here lay with the traditional "container" model of teaching and learning, the most pertinent corollary of which, in this case, was "more is better."

Third, I assessed the different levels of mimicry (and presumably internalization as well) of the two specific instructional metaphors among the participants. Differences could emerge based on levels of prior knowledge of or disposition toward a given metaphoric source domain.

In the next chapter, I explicate the research and data collection procedures designed to answer the above research questions, relating specific elements of the design to the various theoretical issues this study addressed.

CHAPTER III

DESIGN, ANALYSIS, METHODS, MATERIALS,
PARTICIPANTS, AND PROCEDURES

Introduction

In this chapter, I describe in detail the sources and types of data I collected and

analyzed in pursuit of answers to the preceding research questions. Further, I discuss

design decisions, experimental procedures, and the goals, means, and context of this

research. I also explain how the pilot test played into the decisions for the final drafts of

the instruments and assessments employed here. Additionally, I describe the details of the

procedures employed in the preparation, conduct, and completion of the study. I also

review the assumptions and implications derived from the theoretical framework of the

conceptual integration model, especially as it pertains to understanding more about the

nature of teaching and learning.

Design

Because the nature of the research questions is an essential contributor to design

decisions, the four primary research questions are listed in order of importance here to

establish the hierarchy of subsequent decision-making. This in no way establishes the

sequence of procedures, which is a different matter entirely, also addressed in this

chapter.

Research Question 1: How is Learning Reflected
in Changes of Conceptual Integration Patterns?

In order to develop data to address this question, my design had to include the

following elements: quantitative evidence of learning against which to compare

qualitative changes, qualitative evidence for change in conceptual integration patterns,

and dimensions of teaching and learning to create a realistic scenario from which the

above types of evidence could be elicited (as evidenced by a variety of pre-post-

measures).

For this phase of the design, I developed a conceptual integration frequency

matrix (Appendix C) to determine the types and frequencies of integration networks used

by the participants in their written responses before and after instruction. I later analyzed

the matrices of blend types and vital relations for face value evidence of change in the

types of conceptual integration networks and vital relations employed in the construction

of those networks by the participants.

The coding of this most essential data was so specific to conceptual integration

theory that I dedicated the entire next chapter to the explication of that process. As

described in Chapter IV, the raw data was rich enough to be categorized for use in a more

purely descriptive report—provided in Chapters V and VI—of face-value pre-post-

changes in patterns of blends and vital relations, specifically produced from a teaching

and learning scenario. The application of conceptual integration theory to a learning

situation was precisely the purpose for gathering this data.

But the open-responses provided another more general opportunity for applying

conceptual integration to analyses of learning. I first tallied and compared the frequencies

of student responses using Simplex, Mirror, Single Scope, and Double Scope integration

networks as a single number of "Blends" in the Production Data. But because of the concurrent nature of the qualitative and quantitative aspects of this research, the conceptual integration data, which provided the core of evidence relating to the primary research question, required me to analyze phrase construction frequencies of many kinds, of which conceptual integration data would be a subset. Therefore, in the process of analyzing the data for a more specific research goal, I was required to apply a number of standard qualitative analyses, eliciting an additional set of frequency data to bring into consideration. An additional value of the data lay in the fact that both qualitative and quantitative data were in the specific contex of a given content domain, which permitted a number of additional comparisons and interpretations across a broader range of variables. For example, I later compared the frequencies of specific blend types to selected-response data and accuracy data.

In addition to an observational analysis of changes in conceptual integration patterns, I used MANOVAs and paired *t*-tests to compare construction frequency data drawn from the texts the participants produced. This allowed the numeric tallies of the pre-instruction open-responses to be compared to post-instruction open-response tallies. Next, the data permitted another analysis regarding the relative overall usages of the four types of conceptual integration networks the participants produced in the texts of their sentences before and after instruction. If the frequency and type of conceptual integration networks used by the students in their open responses were shown to change significantly, whether or not in accordance with any one of the metaphor conditions, this provided strong confirmatory evidence of the construct validity of the conceptual integration model in general and, specifically, of the validity of applying the conceptual

integration model to educational concerns. Such changes would have significant

implications for psychologists, test-makers, teachers, and students.

Research Question 2: Does Metaphorically "Richer"
Instructional Content Lead to Significant Group
Differences Either in Selected-Response Scores
or Any Open-Response Measures?

Another phase of analysis focused on how participants responded to metaphor use

in teacher discourse, described elsewhere throughout. In this phase of the study, the same

open responses (in addition to the forced-choice section on metaphors) created by the

participants in the conceptual integration analyses (above) and the mimetic analyses

(below) were used to examine an aspect of metaphor elaboration, first shown in

Johnson's research (1991) on developmental aspects of metaphor use. It was anticipated

that students with higher test scores on both pre-and-post data would also demonstrate

more metaphoric elaboration, regardless of their group.

Research Question 3: To What Extent Does Mimetic
Learning Apply to the Use of Instructional
Metaphors by Participants?

If students in a given instructional group use that group's metaphor in articulating

and improving their understanding, we may infer that the instruction has been effective.

If students move from being unable to provide any metaphor before instruction to using

their group's specific instructional metaphor after instruction, and if those students'

quantitative scores improve beyond a reasonable estimation of priming and practice

effects, the theoretical implication—in the Vygotskyan view, at least— is that the

scaffolding provided by the metaphor has allowed the students to internalize some

aspects of the concept in question.

Another important analysis may be made here concerning the different experimental conditions and the effects of mimetic learning strategies. The overt instructional strategy of enriching metaphor conditions might be predicted to have significant mimetic effects on student qualitative responses. The group with no overt metaphor would be expected to demonstrate either (a) no use of any particular metaphors or (b) less overt mimetic copying (of more fossilized, deeply lexicalized terms/metaphors such as "code" or "twisted ladder").

If so, this could indicate that metaphors in question were somehow more naturally used by some students in learning about a target domain. Should this turn out to be the case, this would support some of the basic tenets of meaning construction theory, where the meaning is not in the words but develops via listeners' cognitive responses to—and perhaps also as a result of their prior knowledge of or dispositions toward— the words used by the speaker. If the qualitative responses fell along these lines, this would provide confirmatory evidence of the work of Vygotsky (1934/1986) and Blackmore (1999), where both social context and its corollary, mimetic learning, are at work in individual cognition.

Research Question 4: Can Participants Develop
Effective Novel Metaphors of Their Own?

To provide participants with a sense of learning and closure, and to take proper advantage of the analytical opportunities presented by the content and circumstances of this research, participants were prompted to create and elaborate their own novel, yet fitting metaphors about genes, genetics, and heredity. The ability to do so was taken as a sign of content mastery, linguistic development, and cognitive complexity (Johnson,

1991). In Chapters V and VI, I report and discuss the results and implications of this exercise.

Data Analysis

Quantitative Analyses

Traditionally, quantitative data generated by the selected-response questions would simply be compared across both groups and between pre- and posttest results. The design allowed for correlations, MANOVAs, and *t*-tests to be performed on pre- and post-instruction quantitative test results. Results of the selected response tests were used as the dependent (Y) variable for variance and correlation calculations. Here, I did a traditional analysis in the context and as the basis of a more extended series of assessments and interpretations. Quantitative comparisons of group means allowed me to determine the relative effectiveness of the metaphor conditions as measured by selected response assessments.

A serious and classic problem in the more limited traditional approach would emerge if we failed to take into account more--and more subtle—ways to measure just what and how people learn. Simple pre- and- posttests too often reflect learning in the old "container" or transmission model, where the teacher pours the knowledge into the students' heads. Those students who remember words easily or do well on quizzes because of the relative ease of selected response formats might *appear* to have learned more than other students but possibly in a very superficial way. It was also likely that there would be some students who would perform worse in a selected response format than they would with other types of assessment. The point here was that such exams often did not do justice to either the students or the subject matter. As but a small part of a

larger assessment context, the traditional approach was clearly valuable in its own right, but it should be only the beginning of a deeper examination of the interaction of teaching, learning, and subject matter.

In this study, instructional treatment groups defined the levels, and pre- and post-instruction test results provided dependent variables for quantitative analyses. Test scores were compared between the control group (with no metaphoric instruction) and the experimental group (with a double dose of overt metaphoric instruction). I also compared the sheer amount of change in the test scores and written statements of the two groups.

However, with the traditional measures of learning as a starting point, I attempted to pose and answer more subtle questions. If groups clearly differed in their respective performances, what was the source of these differences? If the groups performed equally, what did that say about the different instructional metaphors? Whether the groups scored differently or not on the selected response posttests, how would that be reflected in or related to the frequency and accuracy of conceptual integration patterns in their constructed responses? How would narrative accuracy be related to test scores? This led to the need for analyses of the language the participants used to describe their understanding. Thus, I moved beyond the initial quantitative scores to qualitative analyses of participant-constructed responses.

Qualitative Analyses

I collected pre-instruction qualitative data in the form of written responses about participants' familiarity with the treated-as-a-single topic: genes, genetics, and heredity. These responses were readily analyzed for face value statements of high or low levels of prior knowledge for each respondent. Also, I analyzed the statements for any uses of

metaphors. All such evidence was compared to the same participant's post-instruction responses. Thus, for each participant, there were two sets (pre- and post-) of open-responses to analyze, averaging some 10 to 20 sentences.

But there was also a third source of data: a section which called for the participants to think about and be creative in their own use of metaphors. The participants' responses to metaphor elaboration instructions also provided a venue for survey data by asking them to make a forced choice among several options of previously used metaphors for genes, genetics, and heredity. A last bit of data about participant use of metaphor emerged from a prompt encouraging participants to be creative in developing an appropriate metaphor of their own. Most of the use of metaphor has been traditionally studied through the lens of comprehension; however, there is relatively scant research on metaphor production. But in this research, metaphor production, elaboration, and creativity were taken as potential evidence of learning because of their emergent qualities.

Therefore, the qualitative, textual, open-response data served both for straightforward analyses of metaphor mimicry, elaboration, and creativity and also, primarily, for an analysis of the uses of, and changes in, the conceptual integration networks used by the participants, both individually and in experimental groups. Open textual responses provided data that were potentially more natural, and quite possibly more telling about the levels of understanding a person attained than selected-response data.

Understanding the cognitive mechanics of metaphor production has the potential to be a powerful means of conceptual and educational analysis. Will participants

internalize a metaphor enough to copy it? Will they extend it into new conceptual

territory? That is, will participants be able to use metaphors more adeptly in transferring

concepts to new problems?

Participants could be expected to perform better on selected response posttests,

regardless of their exposure to either instructional metaphor because of practice effects.

But because a further analysis of their constructed responses could provide a more well-

defined profile of their knowledge in any case, pre- or post-, experimental or not, I

analyzed participants' responses for elements of observable change in light of the

conceptual integration model. I discussed correspondence between the two types of

categorical variables developed from the four types of conceptual integration networks in

relation to the 15 types of vital relations, both before and after instruction. Changes in

pre-and –post instruction conceptual integration patterns would presumably reflect

changes in participants' understanding of the topic.

Using the 4 X 15 matrix of the four network types and the 15 vital relations, I

obtained a profile of conceptual integration use for each student and each group of

students before and after instruction by performing observational analysis. This included

the number of conceptual integration networks per paper and the relative proportion of

the different types of conceptual integration networks. The analysis provided a means of

testing the implication from conceptual integration theory that the different instructional

conditions would somehow be reflected in changes in the types of blends produced by the

learners. Later, I analyzed not only changes in network types but also changes in the uses

of vital relations.

Additionally, by inviting students to use metaphors in their written responses in the feedback section, I hoped to collect enough responses to analyze for a confirmatory study of metaphor elaboration as developed by Johnson (1991) who created a five point scale (0-4) to rate students' use of metaphors. In her work, Johnson demonstrated a developmental link to the elaboration of metaphors. Older students in her research were much more likely to add information or extend metaphors as they described their understanding. Those who scored a zero rating were unable to even copy the given metaphor, clearly indicating a lack of understanding. Students who scored at level one were able to repeat the given metaphor but added nothing else. Those who were rated at level two added a single minute change. Those who were rated at level three showed a clear change beyond the given metaphor, either numerically or creatively. Those who scored a four rating were clearly creative in providing more or more unusual responses that showed understanding and new dimensions of thought about the given metaphors. The present study did not address developmental issues but Johnson's use of metaphor elaboration as evidence of cognitive complexity was completely in keeping with the precepts of conceptual integration and provided this research another interpretive perspective of the data.

To summarize the qualitative analyses afforded by the participant-generated open-responses, I performed the following tasks, all within the context of a conceptual integration approach to teaching and learning via instructional metaphors:

1. When technically acceptable, participant responses were categorized as one of four types of conceptual integration networks and were analyzed according to the compressions via the given 15 types of vital relations described in Chapter II. Patterns

that were discernable within and between groups according to instructional group and the implications of such patterns for teaching and assessment purposes will be described in detail.

2. Because conceptual integration was derived from conceptual metaphor and both were part of the larger cognitive linguistic enterprise, comparisons were properly made between changes in conceptual metaphors and blends. I discuss the particulars of this analysis in the next chapter.

3. Participant responses were analyzed according to elaboration of metaphors (Johnson, 1991).

4. Finally, some of the data reflected simple copying of a given instructional metaphor, providing at least some evidence of mimetic effect (Blackmore, 1999). The research design, represented in Table 1, was a mixed-methods study based on the traditional pre-post assessment procedure. The design allowed for a control group (Group C) and another experimental group (Group E). A unique feature of this particular design was that it also allowed for both quantitative and qualitative data to be concurrently gathered and cross-compared in the same experiment.

A Pilot Study

In order to assist in the design, production, and integration of the final research instruments, I conducted a pilot study during the spring term following my Research Committee's approval of my doctoral proposal the previous fall. After obtaining the University's IRB approval, I designed, produced, and administered the 22 item, three page assessment to 20 participants from the School of Psychological Sciences participant pool.

After analyzing the participants' performance on the pilot assessment, I discussed many content and design related issues with subject-area experts. I made the following decisions to improve the accuracy, clarity, probity, and difficulty level of the various assessments. The pilot instrument presented 12 selected-response/matching items, three selected-response/forced-choice items, five fill-in-the-blank/short answer items, and two open-response prompts. The final pretest instrument presented eight selected-response/matching items, three selected-response/forced choice items, and two open-response prompts.

Table 1

Research Design

Pretests	Groups	Treatments	Post-Instruction Assessment	Post-Instruction Assessment	Posttest Survey and Metaphoric Creativity
Selected Response (Y 1) + Open Response (QUAL1)		Instructional Videos/ Metaphors	Open Response (QUAL 2)	Selected Response (Y2 + Y3 = Y4)	Forced Choice + Open Response (QUAL 3)
(Y 1) + (QUAL 1)	C	X (Control)	(QUAL 2)	(Y2 + Y3 = Y4)	(QUAL 3)
(Y 1) + (QUAL 1)	E	X (Experimental)	(QUAL 2)	(Y2 + Y3 = Y4)	(QUAL 3)

Instruments

Pre-1, Pre-2			Post-1	Post-2	Post-4, Post-5

Note. Where Y=DV (selected-response data); Q1 AND Q2=qualitative open-response data; Q3=survey and metaphor data

Research Design Components

First, the five item set of fill-in-the-blank questions was jettisoned because of too many possibilities for either multiple legitimate answers or blind guesses. More importantly, the open-response data were clearly of greatest value to me in terms of being able to analyze relatively natural, content-focused student language. Accordingly, more writing space was provided in hopes of encouraging a greater number of written utterances. Also, both the general open-response instructions and the specific instructions for the pre- and post-tests were revised to elicit more elaborate and more focused responses. Instructions throughout were improved for clarity.

The facts that no one scored zero nor did anyone score 12 (of 12) suggested that (a) the selected-response/matching item set could be reasonably leveled in terms of participant vocabulary and (b) the spread of scores suggested the set could be of some discriminatory use. The wide range (1-10), low mode (2), and modest mean scores (41%) reinforced this. A real surprise about the qualitative data became evident through a quantification exercise: of 116 total sentences written about the topic (genes, genetics, and heredity), only two presented overt metaphoric descriptions, slightly less than one overtly metaphoric statement per 50 written sentences. However, learning that from the pilot study prepared me for a similar performance in the actual research. Because I expected there to be few spontaneous uses of overt metaphor from the pilot test results, I did not rest my research hopes on a great amount of initial metaphoric productivity by participants. This was part of the rationale for developing the metaphor index scores that were derived from the forced-choice items and the open-response prompt for a novel metaphor. This index allowed me to obtain focused, individual data about all participants'

cognitive abilities in metaphoric thinking, rather than being forced to deal with the very few spontaneous metaphors (only 2 in 146 sentences) produced in the pretest phase.

Instruments

In response to the results of the pilot test, the final drafts of the assessment instruments (Appendix B) were constructed as follows, in order of presentation to the research participants. This organizational structure is repeated later in this chapter in the description of the procedures. I have chosen this organizational strategy for these two sections to allow readers a sense of the participants' experiences during the research sessions. Below is a description of all other necessary materials and equipment.

The Pretest

The first page provided space for students to write as much as they could recall about the related target domains--genes, genetics, and heredity. Lines were provided for any text the participants might be able to produce in summarizing their knowledge of the domain. The second page consisted of eight selected-response items. To minimize guessing by process of elimination, 12 possible answers (eight correct answers plus four plausible distracters) were provided for the matching section. Scores from this selected response section were the basis for many other measurements and interpretations in this work.

The Video Lessons

Every vocabulary item on the test was written into the lesson's script (Appendix A) verbatim (with minor concessions dictated by standard grammar and usage). Likewise, every vocabulary item was shown onscreen as text during the first mention of the item, either as a subtitle or as part of the text on the graphic being shown at the time.

The two lessons were on separate DVDs. The videos were brief, about 20+ minutes in length, with very few specific images and words to go with the two specific scripts. That is, for the brief sections of the videos which differed, the metaphor scene included background shots of a set of blueprints dissolving to a building and a recipe book dissolving to a cake--there was no such pair of scenes in the control group's video. The videos were professionally produced with everything but the metaphor scene exactly duplicated in each.

Thus, after the videos had been produced, very little in the way of further materials, except for the assessment packets, was necessary to produce. Further material needs included backup copies of the various videos and a television and DVD player. The script and the items were written in accordance with information from a variety of sources (Freeland & Hurst, 2004; Gonick & Wheelis, 2005; Jenkins, 2000, 2003).

The Posttest

The two assessment packets (the pretest and posttest) had essentially the same selected-response and open-response prompts with some exceptions. The selected-response posttest (Appendix B) included four additional selected response items to answer in order to allow participants some sense of growth in understanding rather than a static, exact duplicate of the first assessment, thus mitigating, it is hoped, at least some of the expected effects of both practice and fatigue. Also, the order of items was changed for the same reason. These quantitative data were used in two primary ways: for traditional comparative analyses and to explore the possible relationships between (a) the participants' performance on the open-response sections of the assessments, especially (b) participants' production of metaphors, and (c) participants' patterns of conceptual

integration. The final two pages of the posttest (Post 4--the forced-choice survey of historic metaphors, and Post 5--the creativity exercise) were distributed only after the posttest open-response and selected-response sheets had been turned in.

It should be noted that all of the selected-response items were original to this text and research. Whatever the arguments against this might be, one positive aspect of this was that I could and did refine all of the instruments (including the qualitative prompts) used in this research. The improved content-area vocabulary was both more accurate and up-to-date. The definitions of all of the vocabulary items were expanded. The items and definitions on the written assessment were practically exact matches for their counterparts in the lesson's script discussed below and elsewhere.

In the current research, I used four of the pilot test items as a separate cluster of novel items for the posttest in addition to the other eight items I used in both the pre-and posttests. Compared to the overall item difficulty level of the pretest, the level of this four-item mini cluster was at least as or more difficult based on my intent to design a question set including items which asked for some greater level of novelty, detail, or subtlety.

Now with the pilot test behind me and the assessment items in late-draft form, it was time to work up the script for the video lessons based in part on the exact language of these written assessments. Over the next six months, I completed two full drafts (and productions) of the video lessons, developed a final research schedule, and, under the auspices of IRB approval, conducted the research in the spring semester of 2009.

Having completely redrafted the assessment instruments and the lesson scripts, I also needed to acquire and use various physical folders and types of data files to create in

order to accommodate the variety of papers, questions, answers, and information which evolved over the course of this study.

The only other materials participants needed were the assessment packets themselves. The first sheet for the participants was an IRB informed consent form describing the basics of the research and verifying their participation for class credit received in exchange for their participation. The last sheet for the participants was the IRB-required debriefing sheet.

In addition to assessment and IRB materials for the participants, I needed to have the completed videos at hand. The small numbers of participants made for simpler logistics than were originally planned. Only one proctor and one room at a time were necessary. Adding to the simplicity and reliability of the process was the one traveling A-V cart and one projection system. With the people, instruments, materials, and equipment in place, the research proceeded as follows.

<div align="center">

The Research: Participants, Settings,
and Procedures

</div>

With one "no-show" exception, all other students presented themselves on time for every session. Sessions were quite uniform and straightforward in procedure.

Participants

Over a three week period (before and after spring break), 25 psychology students participated in the research in groups of one to four. Their demographic data are presented elsewhere in this section. Eleven timeslots were provided but one was cancelled due to a snow closure of the university and one session had a no-show. All research was conducted in one of three classrooms arranged in advance in the campus education building. All rooms were well-lighted, reasonably warm, and quiet; no major

distractions occurred during the course of any session. Participants were provided with pens in the rare cases where they did not bring their own. Participants were seated at their discretion in a group in the center of the room with one or more desks between them but in adequate proximity to the video screen.

Although use of locally available participants imbued an element of convenience sampling in terms of the demographic profile of the group of participants, I contend that the number of participants was enough to provide useful data for the purposes of this study. Further, as described above, no particular type of participants were sought or excluded from the study, resulting in at least a nominal degree of reflection of the generalized demographic profiles of the university's service area and undergraduate student population.

Participants were students from an introductory psychology course (PSY 120) typically offered by the university with the knowledge, approval, and cooperation of the university Internal Review Board. Therefore, student demographics reflected the university's rather diverse, "middle-of-the-road," rural/suburban, socio-economic, and educational status, rather than a preponderance of special populations (that is, populations reflecting extremes of socio-economic status, ethnicity, or non-English speaking linguistic groups). I asked participants to give two hours of their time for this research, which matched the required class requirements for this type of activity. The total number of participants was 25, affording enough participants to create a control group (Group C) with $n = 11$ and an experimental group (Group E) with $n = 14$.

Of the 25 students who became participants, sixteen were females and nine were males (ratio 1.78:1). As it happened, the classes available to the participant pool (Psych

120 students) during this term were much more evenly gender-balanced (1.2: 1) than the sample group. The female to male gender distribution for the two research groups (C and E) was seven to four and nine to five, respectively, providing a corresponding gender ratio for each group of 1.75: 1 and 1.8: 1. Participants ranged in age from 18 to 22. Such a small total age range predicted the miniscule and presumably insignificant differences between the mean ages of Group C (19.8 years) and Group E (18.78). Possibly the most problematic information to emerge from analyzing the demographic data of the sample group of participants was that the control group had one outright biology major, perhaps enough of a curve-breaker to skew their results undeservedly upward. Equally problematic was the fact that the experimental group—though there were no biology majors, per se—had three people whose majors were in related fields-- medicine and nutrition. They, too, might have skewed their group's results undeservedly upward.

Settings

The locations for all phases (pretest, instruction, and posttest) of all research sessions were in medium-to-large classrooms in the College of Education building. Thus, at all times, students were in relatively familiar academic settings.

Procedures

Consent was obtained from the university, the college, the instructor, and the students who agreed to participate in full accordance with all the policies of the UNC Institutional Review Board. Copies of all necessary forms in this regard are included in Appendix D. The university allowed students to register for participation in the study when the IRB process had been completed. All scheduling for such participation was done on-line.

Phase one: Pretest. Using a script to enhance the standardization of the procedure, I introduced the entire project to each participating group, and distributed and collected the IRB informed consent sheets. As the assessment began, I gave the participants the open-response sheet first, followed by the matching quiz pretest. All question and answer sheets except the final two were distributed and collected one at a time in order to help participants avoid distraction by seeing too much too soon, or by over-thinking what they had already written and therefore losing the sense of authentic, natural, ad hoc language I tried to preserve at every stage.

Phase two: Instructional treatments and posttests. The primary instruction and assessment exercise occurred at this time when participants were shown identical videos (with the exceptions of the metaphors as described above). Group assignments for a given day's film were random and based on the number and gender mix of participants who had signed up for that day's research session. The two groups (Groups C and E) were shown instructional videos with two different metaphor conditions (impoverished or enriched, respectively). The control group—impoverished—(Group C) simply took the posttest, having seen the video without specific metaphoric instruction. Group E—enriched—saw the instructional video with both of the metaphors.

Immediately following either video presentation, the second assessment—the posttest, described above— was administered in the same order but with the following variations in the instrument. The second page displayed the expanded 12-item matching section. No distracters were provided for this section. Upon completion of the posttests, participants handed in their answer sheets. Then, they were given the last two sheets,

assessing their disposition toward and ability to create novel metaphors, especially in relation to the target domain.

Phase three: Survey and creativity exercises. At this time, all students had the opportunity to write brief descriptions of their thoughts about the usefulness of the various instructional metaphors with which they had been presented. This was a final opportunity to collect some qualitative data (in the forms of a survey and a creative exercise) to analyze in light of metaphor production and conceptual integration. After the post-instruction assessments were completed and turned in, I gave debriefing sheets to each participant and the session was over.

Summary

The time for participant involvement entailed about five minutes for the greeting, introduction, and informed consent forms. Participants usually took about 20 minutes to complete the pretest. No time limits were imposed on completing any of the written work. The videos ran at about 23 and 25 minutes, respectively. The posttests took about another 20 minutes, and the final written assessments and comments took about another 20 minutes. The total of time for each session was about 80 minutes.

Participants provided quantitative data via pre- and post-instruction, selected response assessments for a range of traditional quantitative analyses. All participants took the pretest as a baseline for later quantitative and qualitative analyses and interpretations.

All participants had several chances to produce textual responses for qualitative analyses as well. All participants wrote pre- (QUAL 1) and post-instruction responses (QUAL 2 and QUAL 3). These data were analyzed in a number of ways: (

1. The written responses were analyzed by performing analyses of statements generated before and after instruction according to the (a) frequency and type of conceptual integration networks used and (b) the sets of vital relations at work in each network;

2. Mimetic responses, copying, or using the metaphors from the respective instructional videos were noted by changes in the sheer number of post-instruction references to any of the given metaphors.

Two elements of particular interest emerged here (reported in detail in Chapter V). First, and most importantly, I was able to test for some relationships between changes in quantitative results and qualitative results. Second, I was able to compare mimetic responses across the two groups.

Group C received no overt or elaborated instructional metaphors and, thus, were treated as the control group (Xc). Group E received instruction mentioning both metaphors (Xe). In addition to the traditional posttest, final written questions for all participants included a list of nine possible other metaphors used over the years to describe the target domain (genes, genetics, and heredity): archive/ library, blueprint, code, instruction manual, program, recipe, switch, and trigger (Marcus, 2004; Ridley, 2003). Participants were asked to choose and explain in detail their three top choices from the list for the metaphoric comparisons they perceived as being most helpful in understanding the domain. All participants were also asked to provide and explain any new metaphorical descriptions of the topics, if possible.

Appendix B presents the pre- and post- instruction assessments. As with the pilot test, I obtained full cooperation from the university and participants, who were recruited

and treated according to all applicable IRB policies, guaranteeing confidentiality and lack

of inappropriate exposure to any intrusive or harmful tests, effects, or misinformation.

Indeed, since both groups were afforded overtly and purposely beneficial instruction,

there should have been no ill effects for either group. Appendix D presents the consent

and debriefing forms.

<div align="center">Integrity and Security of Data and Process</div>

A number of precautionary steps were taken to avoid unnecessary problems with

bias, practical quality, and handling of data, etc. First, of course, participants were not

allowed off-task access to the materials or to each other. I and/or my research advisor

were present at all times during all sessions.

1. I used the same brief written introduction, instructions, and transition

statements for all sessions (see Appendix A). When participants completed each writing

task, I collected their papers in a manila envelope without looking at or consciously

reading any texts. I looked only at the spaces on the first page to check that the

demographic information had been filled out. Back-up photocopies of all response sheets

were made.

2. I scored the quantitative quizzes immediately upon returning the materials to a

locked office after the participants left. This was not only effective use of time; I saw no

input beyond individual letters in answer spaces. This process allowed me to be as

unfamiliar as possible to the contributions (and of course the identities) of the individuals

and to their group membership. Because I also would be performing the qualitative

analyses, I needed to have typed transcripts of all the participants' open-ended, textual

responses for my work in order to keep this faux handicap as intact as possible

throughout the rest of the analyses. Specifics of the blind analysis process are detailed in the next chapter.

      3.   The familiarity of settings, the identical videos, and the scripted administration of the exercises should provide for standardization of procedures, thus reducing unrelated variability of responses within and between different groups. Appendix A includes scripts of the administration instructions and the video presentations.

      The detailed specifics of coding texts according to conceptual integration theory are described much more fully in the next chapter.

CHAPTER IV

ANALYSIS AND CODING PROCEDURES

In this chapter, I initially address issues of quantitative and qualitative data analyses as separate, though complementary, components. They are described here in the relative order of pertinence to the research questions, a structure and technique I preserve through the remaining chapters. To close the chapter, I integrate the various types of analyses used, summarizing the theoretical and practical grounds for this research. Numeric, graphic, and narrative results are presented in Chapter V.

Quantitative Procedures

I began the data analysis by scoring the bedrock of quantitative procedures in this study, the traditional selected-response sections of the instruments. I separated the pages immediately after each research session and scored the identical eight item Pre 8 and Post 8 items and the imbedded four item cluster (Post 4) of new items as part of the 12 item Post 12. The results of these tests are used as dependent variables (Y_1, Y_2, Y_3, and Y_4, respectively) in various conventional statistical operations such as correlations, MANOVAs, and t-tests.

Traditionally, the selected-response assessments results would be enough to measure the relative effectiveness of the two conditions. Here, however, the traditional data are used primarily to provide a background against which other data, both quantitative and qualitative, may be compared. In this research, these other data may be

of greater interest but they have little or no meaning without accounting first for the quantitative dimensions. Those dimensions go beyond quiz scores, as shown below.

Participants wrote 147 pre-instruction sentences and 200 post-instruction sentences. These provided many more data points to consider, far beyond the confines of the traditional tests. Much of that data lies in frequency counts of various pre-post grammatical constructions: word and sentence counts and words per sentence; overt use of metaphor; implied (conceptual) metaphors; key (historic examples of domain-specific) metaphors; identity statements; blends; and mega blends. Each item in the foregoing list, in fact, became a data variable for pre-post comparisons in this research. This productivity data--in my own terminology—is one important way to quantify, measure, record, and compare the qualitative data produced by the participants.

Frequency counts are of value here because of the confirmatory potential of a plinth of cognitive linguistics: language reflects cognition. The theoretical extension of this premise is that changes in cognition—in this case, *learning*—will be reflected in changes in language. This goes beyond issues of developmental stages in vocabulary, grammar, and syntax. Many of the linguistic changes individuals make in their language are automatic and unconscious; understanding the patterns in these changes could lead to any number of improved teaching practices. Accounting for speech pattern frequencies— either those generic to language studies or those reflecting a conceptual integration approach, as this work does—is a beginning, but there is still more. Taken together, the qualitative sections of the instrument, especially in combination with the quantitative sections, provide a much richer representation of the cognitive processes at work in the learners than the traditional quantitative analyses alone could.

Qualitative Procedures

The qualitative data presented by the pre- and post open-response statements represent the primary source of the information this research had to develop in order to answer the central research question: how is learning reflected in changes of conceptual integration patterns? In the following section, I explain the handling and coding of this primary asset.

Another source of qualitative data was tapped in the Prompted Metaphor section of the assessment by including a survey of preferences (and explanations) for given historic metaphors (here called "key" metaphors), opportunity for comments about the key metaphors, and an opportunity to demonstrate creativity in metaphor productivity. The instrument for this data included a list of key metaphors and instructions to rank and explain their choices of the three most effective ones. I combined each respondent's survey ranking of the three most effective metaphors into a power point score: a first place vote was credited with three points, a second with two, and third with one. This information, reported in Chapter V, provides a sense of individual and also group dispositions toward or against any of the given key metaphors. As part of the same exercise, participants were prompted to provide three or more aspects of how each of their top three choices of key metaphors is (or perhaps isn't—any specific comment beyond the original two-space/target-source metaphor, pro or con, would count as an elaboration) applicable.

The creative metaphor page completed each research session. Participants were prompted to create a novel metaphor and to describe how it could highlight or hide certain aspects about the topics: genes, genetics, and heredity. Data from this source are

in the form of novel elaborated metaphors about the topic, lending the entire body of this data to descriptive analyses, presented and discussed in the succeeding chapters.

My research advisor typed the transcripts of the handwritten open-response data. My subject matter expert proofread the transcripts. I used the typewritten pages they produced as worksheets for each participant and coded all responses according to the detailed processes described below. Because of an internal coding system for the response sets used by my colleagues, I was blind to the identities, the pre-post status, and the group membership of the participants until after I had analyzed each worksheet. Only after all available data had been recorded did I use identifying codes to connect the work of individuals across the spectrum of analyses I would be performing and to organize the individual data sets appropriately. I then entered all the data I had collected as single large sets in Excel, still blind to any other information. In the following sections, I describe the procedures I used to analyze the open-responses for patterns of metaphor use and blending.

<div align="center">Coding Procedures</div>

The logic and coherence of the coding processes described below permit an integrated interpretation of the results. This work takes a pragmatic approach to language analysis, which means I focus on phrase-level statements. Focusing on phrases-level statements opens a way to understand utterances more holistically than a semantic, fine-grained, look-at-every-word-as-an-independent-data-point level. Cognitively, this is a better match to the way most utterances are expressed. That is, a pragmatic approach— although constructed on a foundation of semantics—allows researchers to investigate further aspects of context, grammar/syntax, motive, memory, etc., to account for how we

speak/write and what we mean, rather than solely focusing on what meaning (the iconic definition of semantic) may have been vested in a particular word. That is, although the pragmatic level focus is on conceptual blending, that cannot be achieved without a great deal of detailed semantic level work in advance as explained below.

As described at the end of this chapter, I eventually created a corresponding graphic model for each of the 340 blends in the data, the components and interrelationships of which allowed me to confirm not only that the statement in question was a bona fide blend but also what kind of blend it was. But this final categorization was only possible as the result of prior detailed analyses of the texts following conventional procedures in the field (Evans & Green, 2006). What follows, using a simple-to-complex approach, is how I analyzed the participants' open-responses, not only for conceptual integration networks but all other open-response variables used in this research as well.

Coding Conventions

Much of the basic coding performed on the typed transcripts follows the accepted conventions; noun phrases, verb phrases, prepositional phrases, etc., are marked with capitalized initials or abbreviations. Also per convention, *X* means a single element, probably a subject. A basic identity statement ("Heredity is traits" [sic]) is symbolized as "X is Y" or "XY" where the two elements X and Y are linked by the lexicalized verb "is." With just a bit more information, we can prompt for a simplex blend (e.g., Genes are sections of chromosomes), symbolized by XYZ, or X is the Y of Z. XYZ statements are common in much of our speaking and writing and can prompt for other blend types as well. Convention in mental space literature encourages such cognitive modeling of statements.

Most of the other coding is equally straightforward. I will explain the details from the simple to the complex. First, I determined what to include or exclude from analysis on a word for word basis. The first to go were throw away phrases/verbal ticks such as "like," personal disclaimers such as "I'm sorry," off-topic statements, some transition statements such as "such as," etc. Such constructions in no way add to the more focused and authentic responses; they are very unevenly distributed, fairly rare, and would serve only to muddy and skew the more robust data (and less problematic grammar-level issues) we have in the large majority of cases. The interest here lies not in improving writing skills but in making principled judgments about inclusion or exclusion of data. The data of interest lie in participant statements about the content domain.

Articles (a, an, the), numbers, and conjunctions are usually subsumed as part of larger phrases and therefore not considered as separate pieces of evidence. This is in keeping with the pragmatic vs. semantic approach as described above. It is technically possible that exceptions to this coding decision could be made based on a given use which might be specifically or exceptionally germane to understanding a given blend or metaphor.

Then I picked out elements, prepositional phrases, noun phrases, verb phrases, identity statements, and blends in successive sweeps through text. Nouns, noun phrases (NPs), and pronouns (Pro)—even the most complex—are counted as *elements*. At the simplest level, an element is one distinct part of a mental space. Elements are usually the nouns and noun phrases/gerund phrases in sentences and sub-phrases. An unusually strong or evocative element may prompt for the construction of an entire mental space (for example, so-called "loaded" terms such as terrorist or patriot); however, elements

usually do not foster the creation of mental spaces in and of themselves. Mental spaces usually require more than named "things." They require some kind of structure, some kind of content, and at times, some kind of narrative agent/agency or relationships among the elements to rise to the level of cognitive event implied by the construction of a mental space. (Noun phrases are in fact a special case, described later in this chapter.) Prepositions, by implying more to follow, are usually considered to be space builders, words which are used to indicate an important speech element to follow: prepositions have their objects which themselves can be other single elements or even entire other phrases. Several other space builders are discussed below as a group. Slightly more complex is the notion of frames.

The cognitive structure implied when we construct a mental space is called a frame, simply defined as a mental scene. Frames offer and prompt for much more information than elements. Frames are not necessarily equivalent to mental spaces, but they can be. Often, frames are entrenched mental spaces created via cultural practices or individual experience. From a conceptual integration view, memory and prior knowledge—which are assessed in this work's pretest phases—are caches of accessible frames to be used as input spaces. An input space includes some kind of information which helps us frame the prompts and responses of our conversations reasonably and effectively. Different frames provide different types of information. If the frame provides a great many details, concepts, examples, or ideas, it is said to be a conceptual frame. On the other hand, a frame may provide less fine-grained detail but more generic context or background against which the other frame's content is arrayed. Such a frame is said to be an organizing frame. A blend, as the product of a least two input spaces, may borrow its

organizing frame from one input and its conceptual frame/content from the other, for example, which is one reason frames are really not the same as mental spaces. Another reason is that frames may have lasting qualities through many people, cultures, and years, while mental spaces are private, ad hoc, and temporary.

The content of mental spaces may range from the grand to the minute and from the vague to the specific. Often, as described above, a mental space will contain some kind of over-arching idea which shapes all of its internal elements and workings as a kind of frame, reference point, or scene. One participant uses the word *heritage* to mean some things which s/he re-describes in the phrases that follow the term. "[Heredity is our] heritage, the background of [sic] where we come from." This person has been kind enough to overtly display the often hidden contents of a verbal element-turned-frame-turned-concept in a mental space: in this case, Heritage. There is enough information provided about the participant's understanding of the term heritage that we know what the person means, much more than if we were given only the single word by itself.

The implication in the participant's use of heritage as equivalent to heredity is that the particular mental space for the concept Heredity may be valid, technically speaking, but perhaps sparsely populated. Here heritage is simply followed by a list of terms which rename and define it: the background of where we come from. Conceptually, the sentence is really a simple pair of linked identity spaces--heredity and heritage--with the space heritage weakly linked to the NP--the background of where we come from.

By contrast, in blends, some input spaces might be crowded with details or with robust, cognitively resonating frames such as when one participant in this research listed numerous relevant and interconnected examples of a novel metaphoric concept on the

final prompt: Genes are like a graduating class at college. The participant gave many examples on a number of levels, discussed at more length in following chapters.

Other Space Builders

In addition to the prepositions-as-space-builders mentioned above, other types of words function as space builders. One group of relatively rare but cognitively evocative, robust words and phrases used as space builders are termed Counterfactuals: words like *if, but, no/not, dis-prefixed words, other/another*, etc. Counterfactuals imply and prompt for mirror opposites of the given, overt elements. When counterfactuals are in use in a blend, several vital relations, in conceptual integration terms, are at work: disanalogy—and by implication—analogy, and often identity as well. Thus, in analyzing the cognitive implications of the open-response data, certain details are properly left out (as are articles described above) but certain other details (such as the prefix "dis-") must be included because they play such crucial roles in determining the intent and the effect of the phrase.

Even some otherwise lowly terms such as conjunctions--and, but, however, or, also, too--can be space builders as well, again by implying something to follow." Another group of words usually treated as space builders in cognitive linguistics are what grammarians would call indicative/interrogative pronouns/adjectives (e.g., this, that, these, those, how, when, when, which, who, why). This type of use is often more along the lines of a conjunction where the word in question, such as "where" in this sentence, joins the space it has just prompted ("the word in question") with a previously prompted space ("of a conjunction"). These are considered space builders because they usually indicate a substantial amount of information to follow, preparing the hearer/reader for lists, phrases, redefinitions, examples, etc.

These provide a classic case of how humans sometimes compress a lot of information into very small, conceptual packets. As is the case with all the words in the data, it is not their size, commonness, or location which determine their inclusion or exclusion for analysis; it their function in the given circumstances. One more consideration of prepositions serves to exemplify this critical point and then I move to other issues.

Prepositional phrases (PrepP) not only include objects (which are a subclass of NPs) treated as elements but also imply/prompt for mental spaces as mentioned above. The preposition usually implies some kind of direction, movement, source, etc. in relation to its own object. Then, through the agency/existence and motion/action/change supplied by a verb or verb phrase (VP), the entire original phrase becomes potentially connected to other parts of the sentence with its implicit cognitive structure and content. And of course, an entire prepositional phrase itself may be collapsed grammatically to yet another form of noun phrase. Furthermore, as NPs, prepositional phrases may be nested as objects-within-objects of larger prepositional phrases. As a rule, then, prepositional phrases are treated in the coding process as more or less automatic and intact mental spaces.

Structure and content of the mental space prompted for by a preposition provides important specific information which somehow relates to the structure and content of the other mental spaces which can make up a *blend*, if one is to be made. In short, the content and structure of mental spaces is what is put in to the inputs. I needed to determine the content and structure of all mental spaces—from prepositional phrases or not—implied

by a given blend in order to determine when and how each functioned as part of an integrated mental network, the blend.

Other Constructions and Functions

Verbs and verb phrases (VPs) can, via gerundification, be turned into either subjects ("swimming is my favorite sport") or objects ("he disliked having to repeat himself to his inattentive students"). Gerunds may be formed in many ways, but the "–ing" form is most common. Yes, as subjects or objects, VPs can play roles as elements as can NPs and PrepPs.

"To be" verbs are counted as lexicalized verbs when they are not used as auxiliary verbs. Thus, as a lexicalized verb, "to be" is allowed to play a major role in Simplex blends ("Genetics is the study of genes") as well as the prototypical linking verb in identity statements, as we have seen above. And Mirror blends may include even auxiliary uses of "to be" in expressions of transferred energy, action, and motion ("Genes are passed along from parent to child").

An important feature of this treatment of the verb "to be" lies in its "stative" implications. Even in its most basic uses, this state/statement-of-existence verb is considered every bit as robust, active, and evocative as verbs which are usually considered to imply more activity: so-called transitive verbs like run, hit, ski, etc. Thus blends involving "to be" verbs are not only theoretically acceptable but commonplace.

Based on the practices and premises articulated above, I used the following sequence of attention-points on successive readings of the textual data. That is, I first identified nouns and noun phrases as elements, frames, or entire mental spaces (all described in detail elsewhere). I then focused on frame-level words or phrases, including

prepositional phrases, marking them as potential mental spaces. I then looked for verbs and conjunctions to determine the sources and directions of both implied and overt activity and the relationships among the various mental spaces, building and analyzing many graphic models of specific grammatical constructions and their attendant cognitive implications.

To summarize, blends contain or imply at least four mental spaces. Mental spaces contain or imply frames and other elements. Though most elements and frames serve as part of larger mental spaces, they may sometimes bring so much automatic emotional or cultural prompting as to be considered separate mental spaces of their own. The entrenched frames and spaces of memory and culture provide input information during speaking/writing/thinking, but so do situational variables such as context, intent, unfolding events, and any other types of prompts which may present themselves.

The blend analysis I have described is the basis for distilling individual and group information from the pre-and-post instruction open-response statements into data which may be compared with the more traditional quanta garnered from the selected-response results. After all open-responses were analyzed from this core conceptual integration perspective, the rest of the coding processes and data developed more or less as a matter of course along well-established principles in the cognitive modeling of normal discourse/writing. I have used the above-mentioned terms—elements, frames, mental spaces, and blends, and all else—as specifically as possible throughout.

Coding: Special Cases

Identity Statements

One of the most common statement types used by the participants turns out to be not quite a blend, per se. These are identity statements, pairs of linked identity spaces. A blend, remember, is a network of at least four separate mental spaces: a generic, topical space which serves as a starting point for a new blend; at least two inputs spaces, each of which provides unique information to the blend; and the fourth space, the blend itself, combining aspects of the other spaces. Therefore an identity statement such as "chromosomes go through mitosis" cannot be a blend because it only presents two elements linked in an identity/equivalency relationship based on process: that is, chromosomes are defined here by the process of going through mitosis. Linked identity spaces such as provided by the example fall short of being full networks because they do not provide enough detail, content, structure, and dynamic cognitive interrelations to provide the impact, richness, and content of blends.

Identity statements usually involve only two mental spaces. Also, the two spaces are often sparsely developed and may be as simple as single elements such as "Genes are made up of chromosomes." This phrase has but two elements, genes and chromosomes, connected with the verb phrase "are made up of," which is equivalent to a definition (read, "something is something else") using the verb "to be." Thus the definition is based on naming the constitutive parts of the given term. "To be" works very much like an equal sign (=). "To be" often links subjects and predicate nominatives ("he is president") or subjects and predicate adjectives ("she is great"). This linked identity statement form, which prompts for a good deal of important information in its own right, still falls short of inclusion as a blend by itself.

Because they are frequent and foundational to establishing both mastery of domain knowledge, and to reflecting cognitive mechanisms related to conceptual blending, I have counted each instance of identity statement and included those counts as part of both the quantitative and qualitative analyses. This pattern is seen many times in many forms. Other identity statements work by naming a function ("This is what *gives* you eye color…"), a location ("*Within* genes *there are* 46 chromosomes…"), a process ("chromosomes *go through* mitosis"), another equivalent term ("heterozygous …*means* one dominant trait and one recessive trait"), a description, definition, or example ("heredity *is* a person's heritage, their background"), etc. Still other identity statements can work via naming a product, a moment, a relation, a form, analogy and metaphor, constitutive elements, features and attributes, and even by counterexamples. The mental spaces of identity are usually linked by a form of the verb "to be," but there are many other, equivalent forms, as seen above. But linked identity spaces are not blends in and of themselves, and are not counted as such in this analysis.

Double Verb Causatives

Another, much knottier situation arose with the highly conversational language used by participants in their open responses. On the positive side, the language is very natural and unpolished, providing a very real sense of authenticity to the participants' responses. But the analysis of such conversational-style writing forced me to deal with what grammarians call "double raising" or a "double verb causative." It is a common enough linguistic phenomenon--one inner sentence (an independent clause) is couched inside another, often as part of a statement where the subject of what was originally the

inner sentence has been raised—or moved to the left—in relation to its former status as an object of the first or outer sentence.

Thus, I had to untangle the domain-specific language I wanted to analyze from the highly inappropriate trappings of conversational phrases which provided no usable data as demonstrated in the example below.

"I know that traits are passed from parents to children." The outer, first subject, I, has its own verb, "know," and the entire independent clause "that traits are passed from parents to children" is the object of this prototypical Subject-Verb-Object (S-V-O) construction. From the original independent clause, the word "that" is considered in cognitive linguistics a space builder by virtue of its role here as an indicative pronoun; the role of pronoun allows the word "that" to refer to (and subsume) the phrase which follows as a NP unit. This sets up the following core/kernel sentence--"[T]raits are passed from parents to children"--where the object of the first, outer sentence, "traits," becomes the subject of the new sentence, allowing the most important part of the sentence—the domain-specific part— to be used as a mirror blend: $S-V-O_1-O_2$, or, "Traits are passed from parents to children."

The focus of the present analysis is much more targeted on the language the participants use when writing about the given topic, rather than the mere conversational declarations they make in off-topic language. This practice is evident in only some of the response sets; the inclusion of such off-topic responses undoubtedly would result in deeply skewed numeric comparisons of no real value and also to interpretive imbalances. Therefore, in most such cases, my rule has been to analyze only the core/kernel sentences expressed in such constructions. The exceptions are for double verb constructions which

are fully related to the topic. (Example: "The genes tell the chromosomes when to split apart." This is a full mirror blend: S "genes"-V "tell"- O_1 "chromosomes"- O_2 "when to split apart" where the space builder "when" creates a mental space occupied by the gerund phrase-turned NP/element "to split apart.")

Participants presented two further major areas of response-types: noun phrases (NPs) and conceptual metaphors. Both types of constructions are exhibited throughout the response sets; each instance required a separate, ad hoc analysis and decision as to whether or not to include that instance as germane to, or exclude it as peripheral to, the purposes at hand.

Noun Phrases

By itself, without verbs or prepositions to impel, imply, or direct the NP or Pro in relation to something else, the NP/Pro/element may be *part* of a mental space but usually cannot prompt for an *entire* space because there is too little information. Readers will recall that elements which provide a great deal of relative specificity often reflect what cognitive linguists call values. More generic elements reflect what are called roles. When we say "James is the father of Claire" we have a role—Father—and two values in relation to that role--James and Claire. (The implied role of Daughter, though unspoken, but would be used in some cognitive modeling.) Some elements often play generic roles, providing information about kinship (as above), location, products/processes, results, means, activity, or instruments.

There is a wide range of NP possibilities in construction, complexity, and salience. Many NPs are defined and delineated by space builders as described above. Readers will recall that a space builder prompts listeners/readers to construct a mental

space containing a certain amount of certain types of information. This mental space is occupied in part by NPs created by a space builder. This usage is extremely common, especially in unpolished conversation; its use by participants lends to the authenticity and credibility of the data.

Another deceptively simple NP-type of construction is both quite common and quite complex, and requires a good deal of working-out in order to establish where a given instance should be included in analysis. Noun phrases may come in many forms including the three most common two-word nominative compounds: adjective-noun (blue house), noun-noun (eye color), and noun-adjective (duty free). Noun phrases can occur in much longer constructions as well (gerunds/gerund phrases) where a verb, verb phrase, or even an entire noun phrase or prepositional phrase or independent clause may be used as a subject or object of a larger sentence through the syntactical process of double raising described above. These latter, longer noun-phrases are generally much easier to categorize and analyze than the two-word variety, somewhat surprisingly, and thus are not really at issue here. But each two-word NP represents both a potentially deep level of blending and another type of judgment call explained below.

Adjective-noun phrases give us a good chance to appreciate the automaticity, the ubiquity, and the complexity of language-based blending. When we name things and describe them, we have accomplished impressive mental feats. Categorization and memory allow us to name the world and its actions and inhabitants (Lakoff, 1987). Perception and sensation allow us to use context clues as inputs. Imagination and analogy help us understand and use relationships among various elements of our physical and linguistic environment.

For example, a seemingly unambiguous NP such as blue house might evoke very different scenes in the minds of different speakers/listeners. Of course, we must consider that the phrase refers to a house that is painted blue on the outside. Obviously, we would recognize such a place if we were standing right in front of it. But if it is a dark night and the house in question is next to a house of a similar very dark color, we wouldn't be able to tell the difference. Is there a difference if we are unable to perceive it? Or if an interior decorator is working on several sites, perhaps blue house refers to a color scheme for the living room of a particular house which is not necessarily the same blue house as the hypothetical original. The same phrase could correctly refer to more than one house.

Going a bit further, if all the houses on a block were the same non-blue color but only one had a blue door (and the others had doors of other colors), a delivery person would easily discern which house was the blue house regardless of the exterior wall color or interior carpet color. A family who formerly owned such a house might refer to it as the blue house long after it had been sold, repainted, or even demolished. Perhaps an artist's "blue period" was spent at that house. Someone who associated the place with a depressing time or event in her/his life might refer to it as the blue house completely beyond any sense of the color spectrum; that house is blue—in this case—because of its emotional import.

In this construction, the adjective potentially brings its own mapping, frame, content, and other influences to a blend. Considering all such constructions might be a technical possibility, but in some important cases, the issue is resolved before it can be raised, thus excluding a few instances for the following reasons. Any phrase can become so ubiquitous and automatically employed as to lose its novelty (Lakoff & Johnson, 1980;

Linzey, 1997). Often, its elements are then compounded into new vocabulary, e.g., the word "blueprint" (Deutscher, 2005). The upshot here, as elsewhere, is this. If a phrase has become so lexicalized as to be conceptually fused into a single element in a mental space, that phrase is likely to be treated as a unit or an element rather than as an internally dynamic and viable space or blend.

If we turn to noun-noun phrases, the situation is equally difficult. The problem becomes obvious. Somewhere in the course of use, any phrase can be used to the point where the individual words and meanings have long since been blended into a lexicalized unit. The term "heart disease" is a good example. Two nouns, the first turned into a functional adjective, are much less evocative or specific when considered separately; but as a paired set, the words describe in specific and unequivocal medical terminology a single type or at least a single group of related diseases. This and several other highly lexicalized terms have been excluded from blend analysis primarily because of the cognitive and linguistic processes which allow us to use a pair of words to name or describe what we consider to be one thing, in this case a (single) disease. Of course, there are different sub-categories of heart disease which might be accessible to the participant's content domain knowledge. Without further information (input) from the participant, no further prompting can take place; we simply cannot tell, from the information given, if the person knows more. But the difficulties don't stop here.

Another highly typical example from the data presents the noun-noun combination, "eye color." Grammatically, this noun-noun phrase is constructed identically to the previous one, "heart disease." But regardless of identical grammatical construction, the phrases, as simple and similar as they seem on the surface, actually

reflect different cognitive mechanics. Eye color prompts for a different blend than heart

disease: the former is a single scope blend and the latter, at one time a double scope

blend, is now lexicalized through medical terminology to a single noun/element.

Fortunately, the data presented no noun-adjective NPs, which are equally problematic. I

have already shown above how such two-word NPs can prompt for entire blends. Which

is which and what could they mean to this study? (see Chapter V).

<div align="center">Metaphors</div>

Key (Historic, Domain-Specific) and
Overt Metaphors

Many of the minor details of the most automatic, mechanical aspects of the

coding process are noted later in this chapter; however, an early focus during many

perusals of the data was simple and straightforward and dealt with one of the central

issues of this research, metaphor in its many forms. As expected from the pilot test,

participants rarely used overt metaphoric constructions, so they were easy to find in the

texts. In fact, the pretest texts produced a total of only two metaphors, of which one was

indeed a key metaphor. Simple pre-post frequency counts reveal some potentially

noteworthy information, reported in Chapter V.

There is much more to consider here, however. First, because part of the

assessment included direct references to domain-specific metaphors (key metaphors)

used in the past (Marcus, 2004), I was particularly interested to find if any participants

employed any of those specific metaphors. The other interest, one that turned out to be

data-rich and thought-provoking, was in how much of Lakoff and Johnson's (1980) work

on conceptual metaphor would be applicable with this kind of unpolished language data

to study. After all, the topic of metaphor and then conceptual metaphor led to this research in the first place.

Conceptual/Implied Metaphors

Conceptual metaphors must also be addressed here for a number of other reasons. Readers will remember that the wellspring of the conceptual integration movement was the conceptual metaphor revolution. But it is not merely homage to Lakoff and Johnson (1980) to apply their theory here. It is applied not only because its explanatory power still holds in general; for current purposes, conceptual metaphor theory is specifically inherent to conceptual integration practice and the interpretation of metaphor use. It is also appropriate to address conceptual metaphor because it is so obviously at work in the open-response data. I use the term "implied metaphor" here because of the inherently covert, unconscious nature of the usages and constructions; the metaphoric implications are most often covert to both parties in a conversational exchange, not just one or the other. This was a surprising challenge in itself because of their ubiquitous occurrence throughout the data texts. And there was a much more challenging task in determining precisely what to include and exclude.

The myriad examples of implied metaphors have a very real potential to muddy the data. Like the identity statements explained elsewhere, the conceptual metaphors used by the participants are used highly automatically with little or no evident awareness of their metaphoric etymology or cognitive implications. Because these types of statements are in varying degrees of fossilization/lexicalization, varying degrees of metaphoricity are at work, making some analysis rather arbitrary and difficult. But the approach I took was to account first for all the cases of these types of usages in the entire dataset relegated

either to an "active" or "fossilized" group primarily in accordance with Lakoff and Johnson (1980). Then, when given conceptual metaphors arose in particular texts, they were counted accordingly and otherwise analyzed according to conceptual metaphor theory. I present those findings in Chapter V.

Metaphor Mimicry

Using simple frequency counts, I analyzed the open-response data for post-instruction metaphor mimicry. Of the overt metaphors produced after instruction, how many would be copies of metaphors used in the video? Of the unprompted metaphors in either pre-or post instruction data, are any original/creative? Again, the very low counts or overt metaphor use made this all too easy to determine; although there were few surprises, there may be real value in using this data (see Chapter V) to refine our understanding of how educators can make the best use of this cognitive powerhouse (see Chapter VI).

Metaphor Elaboration, Survey, and Creativity

Participants produced three final types of data specifically related to metaphor: metaphor elaboration, creation exercises, and a survey eliciting their opinions about the relative efficacy of the key metaphors. Results from this section of data (Chapter Five) have a real potential to provide valuable insights into some educational practices (Chapter Six).

Blends

In order to deal with the written, open-ended responses to the assessment prompts in a way consistent with the tenets of conceptual integration, I developed a procedure that became, in effect, a blend filter as my primary analytic instrument. In describing how I

developed the instrument and techniques as appropriately as possible regarding conceptual integration theory, I am now afforded the opportunity to offer the reader a final review of conceptual integration theory, especially in the context of the current research.

Readers will recall that a blend is a specific type mental construction—that is, a conceptual integration network— derived from various sources, called inputs. Both the blend and the inputs are examples of mental spaces—"[the] small conceptual packets constructed as we think and talk, for the purposes of local understanding and action" (Fauconnier & Turner, 2002, p. 102). The inputs contribute specific types of information to the blend in terms of content, context, memory, framing structure, etc. The four principle types of blends are identified and differentiated by the way the inputs contribute to, and work in, a given linguistic expression: Simplex, Mirror, Single Scope, and Double Scope networks (Fauconnier & Turner; see Table 2 and Figures 8, 9, 10, and 11) .

In analyzing either written or spoken language, one may unpack a true blend, deriving the relative contributions of inputs to the final blend. Any number of specific cognitive mechanisms—called "vital relations" by Fauconnier and Turner—may be at work in a given blend. The vital relations (analogy, category, cause-effect, change, disanalogy, identity, intentionality, part-whole, property, representation, role/value, similarity, space, time, and uniqueness) work both within and between mental spaces. Examples from the actual data sets to demonstrate each network type and the vital relations at work in each are provided in the coding section which follows. In conceptual integration terms, there are three constituting principles of conceptual integration networks: (a) there is partial cross-space mapping between inputs, (b) there is selective

projection to the blend, and (c) in the blend there will be some kind of emergent structure. Thus, in deciding just what to count as a blend, I looked for evidence of these constituting principles.

Table 2

Inputs and Resulting Blend Types

Network	Inputs	Blend
Simplex	Only one input contains a frame	Blend is structured by the frame
Mirror	Both inputs contain the same frame	Blend is structured by the same frame as inputs
Single Scope	Both inputs contain distinct frames	Blend is structured by only one of the inputs
Double Scope	Both inputs contain distinct frames	Blend is structures by aspects of both input frames

Note. Blends are categorized by the relative contributions of the inputs.
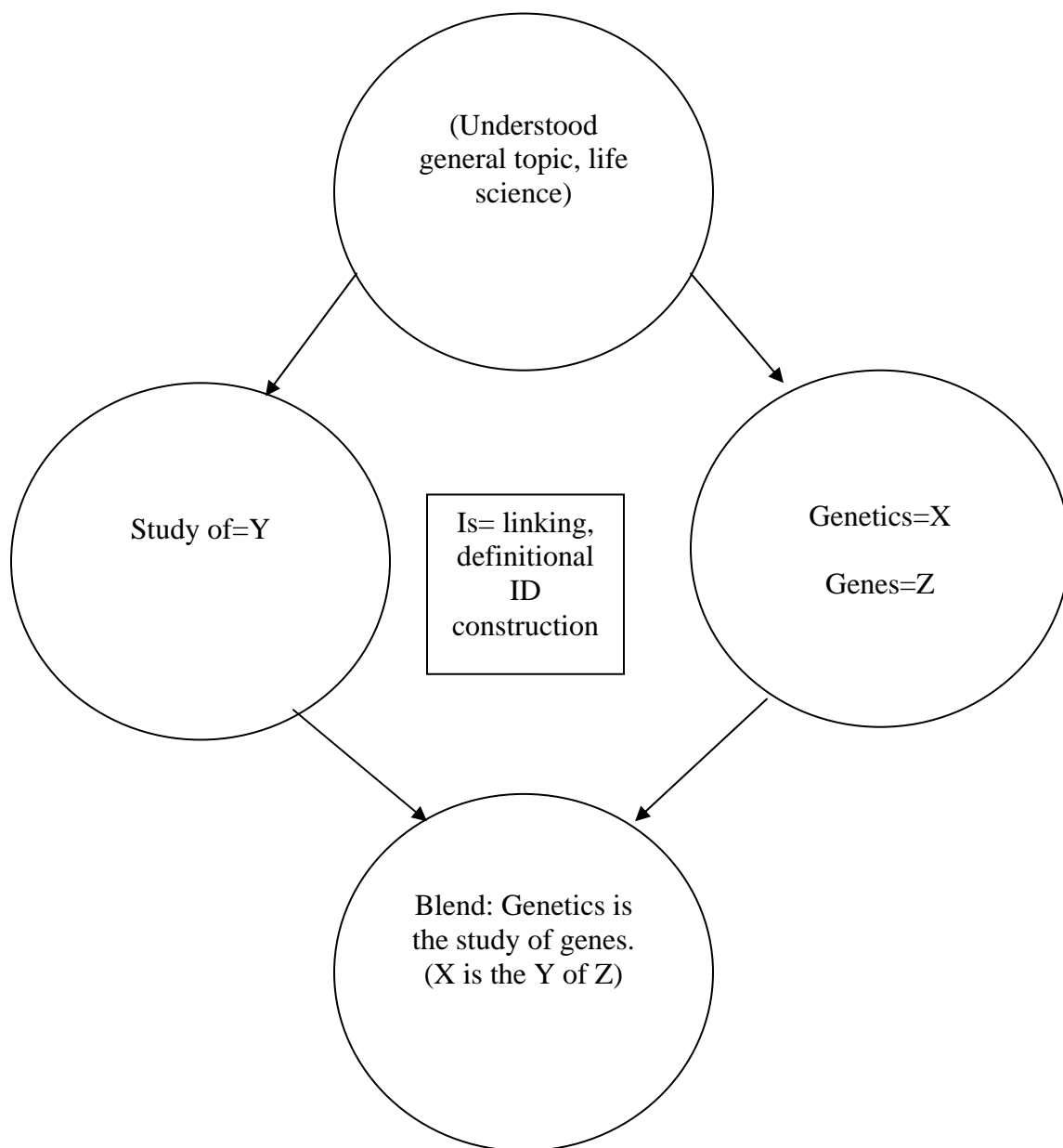
Figure 8. Blend and vital relations analysis of a simplex blend. This is an example of a Simplex blend with XYZ construction of an identity statement, where X is the Y of Z, or "Genetics is the study of genes." Two related but distinct elements, "genetics" and "genes" (X and Y) are linked by their separate relationships to "the study of" in a Simplex blend. The relationship (here, as usual in ID statements) between X and Z is defined by the mental space created by the NP/Prepositional Phrase "of [genes]." "Genes" is the third of the three elements at work in this blend, put into cognitive relationship—in this case, a definitional/functional relationship—with the other two elements.
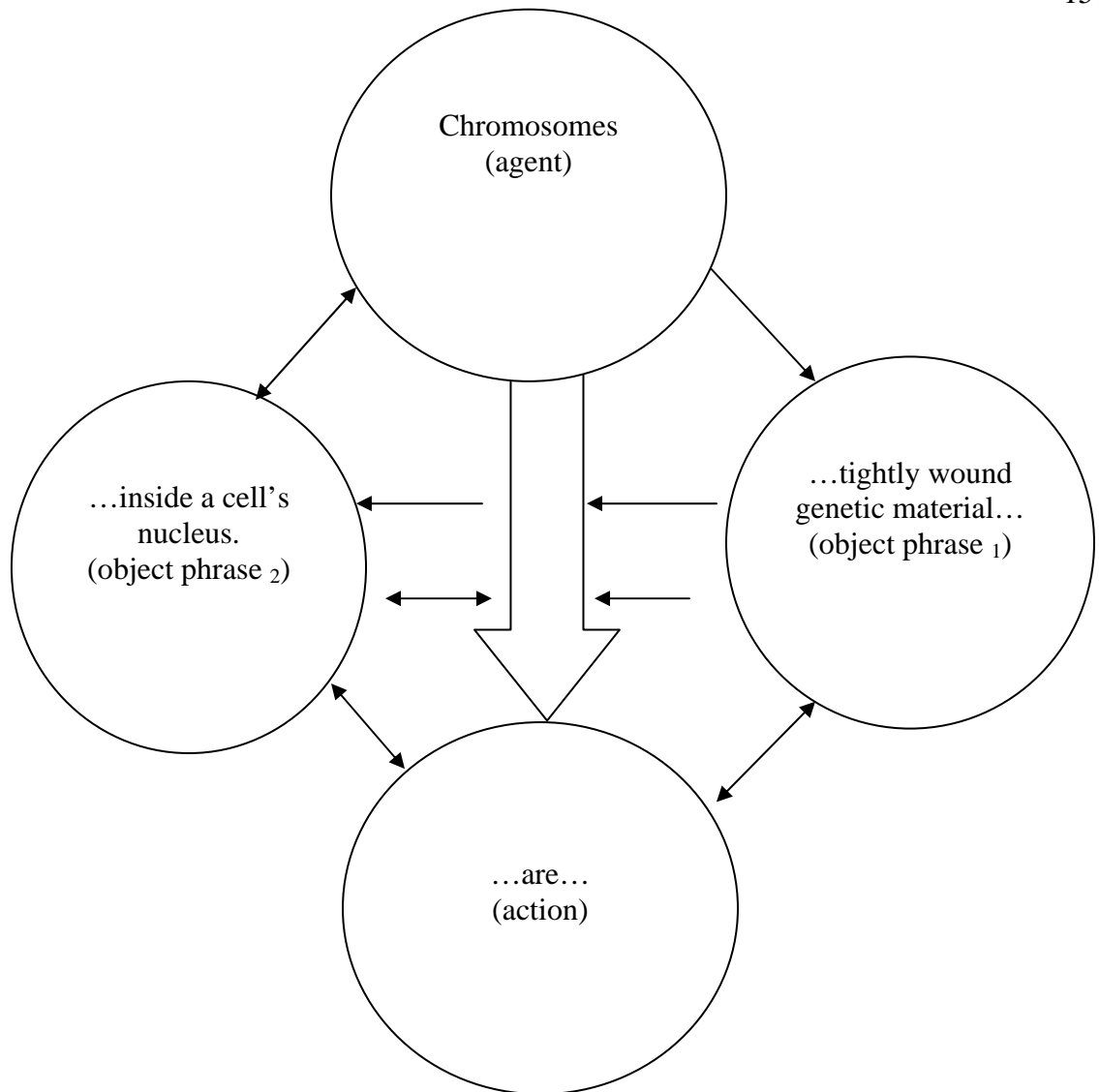
Figure 9. Blend and vital relations analysis of a mirror blend. The agent "Chromosomes" acts, via the lexicalized verb "are," on the object phrase "tightly wound material," which in turn is strongly influential in its relationship to the secondary object phrase "inside a cell's nucleus." This features harmonious, balanced, and deeply shared contributions of spaces, frames, and elements.
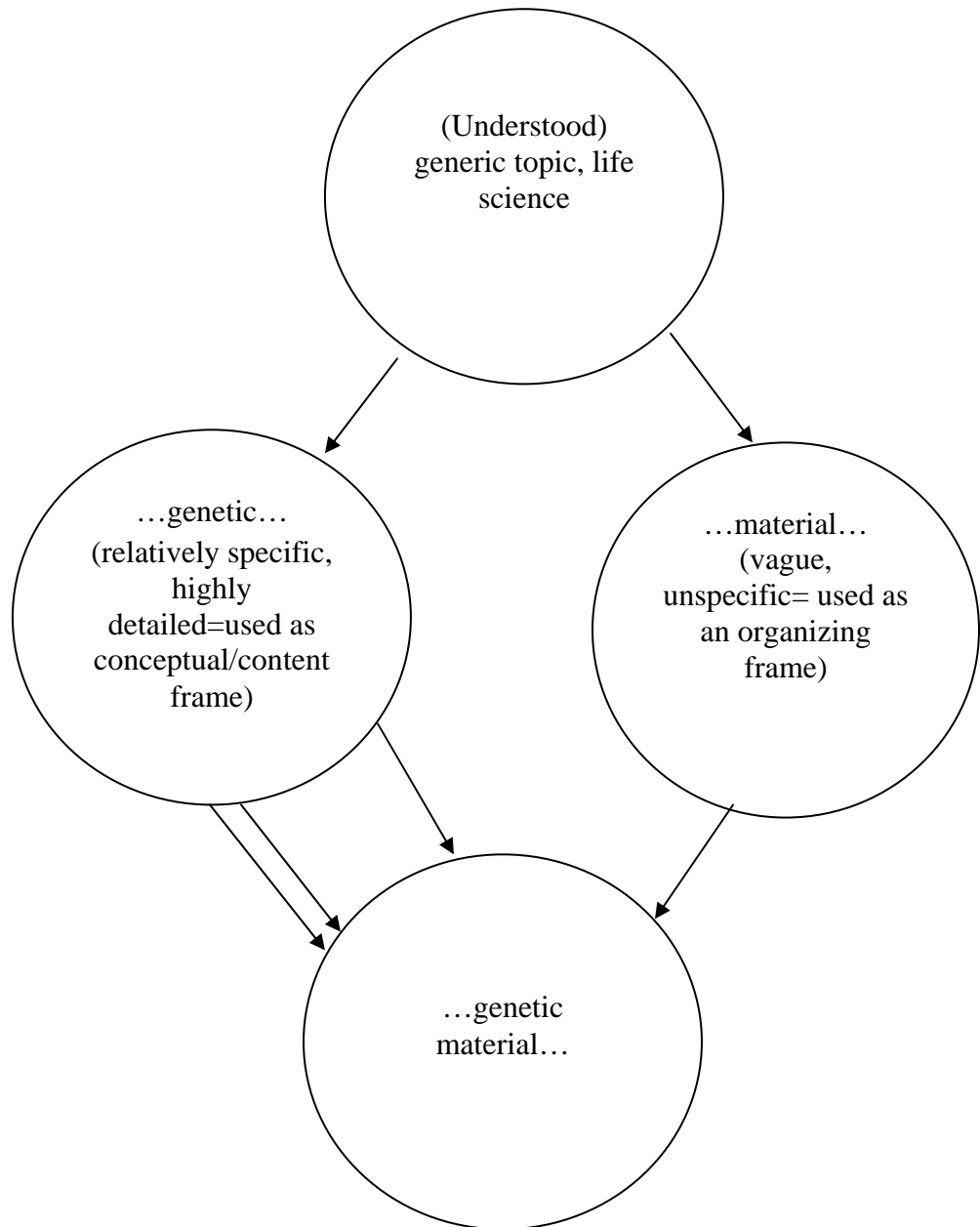
Figure 10. Blend and vital relations analysis for a single scope blend. Asymmetric contributions, but non-clashing elements and frames=single scope.
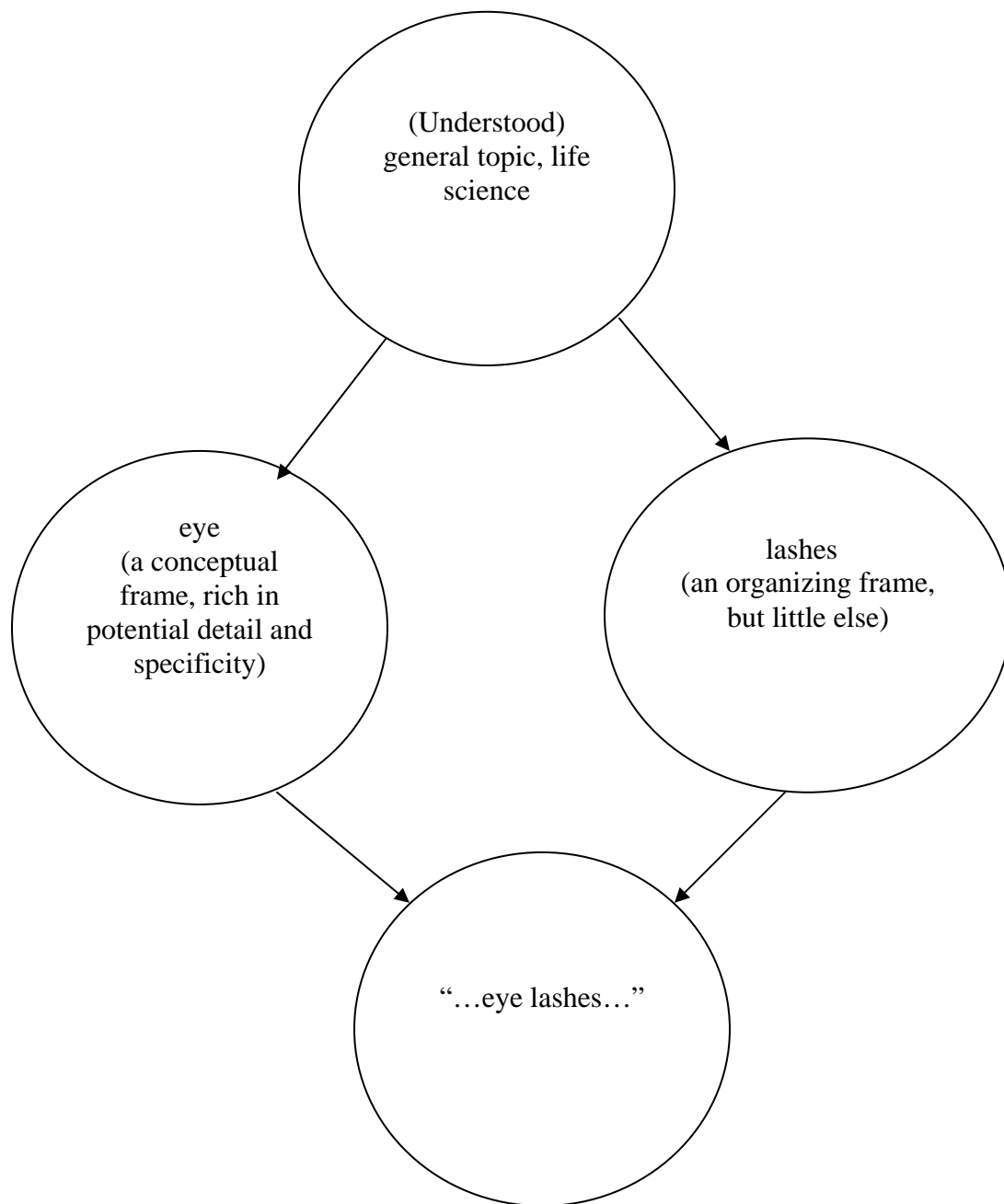
Figure11. Blend and vital relations analysis for a double scope blend. Double scope blends also feature asymmetric input contributions, but with the added dimension of disharmony among some components of the inputs. Here, the first noun "eye" serves as an adjective for the second "lashes," but the second is almost devoid of content. The noun-turned-adjective "eye" is by far the more salient and detailed of the two. The terms clash on details (e.g., major vs. minor body parts, two vs. many) and on larger issues, such as which would be easier to live without, what is one without the other, etc.

Blends develop emergent structure or content or other types of information that are not available in either of the inputs alone. This emergent meaning or understanding is often unique to a situation; blends tend to be quite fleeting in nature due to the cognitive demands of keeping active too many inputs. The cognitive mechanisms of memory games such as trying to remember the names of all the people at a party, for example, would be considered a matter of holding as many thoughts as possible until the demands of memorizing more and more detail overwhelms our ability to store so much information. Blends often change into inputs for succeeding blends and so on. According to conceptual integration theory, this explains many of the basic dynamic processes of human cognition and language-based communication.

I analyzed the sentences written by the participants according to what Fauconnier and Turner (2002) called the governing principles of conceptual integration, described in detail in Chapter II. In presenting and explaining the participant examples below, I use quotes for the first mention only. Small capital letters are used, per convention (Evans & Green 2006), to indicate a mental concept as distinct from a written or uttered word. Readers may also wish to refer to the previously developed sample blends in Chapter II.

Example 1: Simplex, Figure 8:"Genetics is the study of genes." The result is a prototypical XYZ statement, sometimes called a "Y-of" statement where X and Z (Genetics, genes) are values, Y (study) is a role; the mental space for the role Study intersects and interacts with the mental space naming the values Genetics and Genes.

Example 2: Mirror (+ Mega), Figure 9: "Chromosomes are tightly wound genetic material inside a cell's nucleus." Here a subject/agent (NP "Chromosomes") acts

(lexicalized VP "are") upon Object$_1$ (NP "tightly wound genetic material"), which in turn relates itself (O$_1$) to Object $_2$ (NP "inside a cell's nucleus").

Blending is not based on superficial patterns of structure but on deeper, often automatic and unconscious use of cognitive mechanisms. A perfect example is the imbedded single scope blend (NP/AN "genetic material"), the existence of which helps propel the basic mirror blend above into a "mega blend," a combination of blends.

Example 3: Single Scope, Figure 10: "…genetic material…" Looking more closely at this noun phrase in the adjective-noun combination reveals powerful cognitive mechanisms working automatically and effortlessly. Here the model has the generic mental space of the blend as the understood topic: Genes, Genetics, and Heredity. Each input space is inhabited by only one of the two self-named concepts, Genetic and Material.

Consider the different qualities and amounts of information each word contributes to the meaning of the single scope blend. The first concept, genetic, obviously has to do with genes, etc. It is focused and specific in its referential ability. Furthermore, it has a vast potential of prompting for specific references and factoids relating to anything genetic. For example, one could probably name many conditions, traits, etc. somehow associated with genetics. In this case, the adjective part of the NP contributes the great majority of specific information prompted by the two word term; the noun simply provides a very general conceptual framework, meaning, loosely, "stuff," or the "physical, tangible components of a thing," as the cognitive background against which the more evocative adjective is contrasted.

The two words/concepts/inputs play very different roles: in conceptual integration terms, they are said to be highly asymmetric in their relative contributions to the blend but there is nothing inherently "clashing" about what they imply (Figure 10). According to Fauconnier and Turner (2002), when the inputs of a blend do clash, and we still make sense of it, we have achieved a singularity of human cognition--the double scope integration network.

Example 4: Double Scope, Figure 11: "…eye lashes…" This NP with noun-noun construction implies a massive amount of compression, the term used to describe how vital relations work. The generic space (the general topic "genes, genetics, and heredity") relates and informs the basic content of the input spaces, providing the concepts Eye and Lashes. Each provides a measure of potential information; however, the concepts implied by the individual inputs are said to "clash" in the following ways. How many specific details or examples of "eyes" can one imagine? Compare this to the number or quality of specific details one can imagine regarding "lashes." Asymmetry of contribution is a quality of both Single Scope and Double Scope Networks, so the difference between the two cannot lie in that factor. At this point, a considered analysis for each type of blend required a focus on something beyond asymmetry of contribution alone.

The separate terms "clash" on a number of points: one term refers to a specific, obvious, major organ but the other term refers to a high number of small and individually insignificant hairs; "eye" is really used as an adjective here, telling us which lashes to consider. "Eye" creates an organizing frame with essential details,but "lashes" creates a conceptual frame with essential general information. Either term alone might warrant status as an element (see below); together, they rate as a full blend, though the power of

compression. Vital relations have compressed a great deal of information in this blend using category, change, identity, part-whole, space, and uniqueness.

Every time there is a blend, there are different vital relations at work. The final step in coding blends, after I found, graphically modeled, and categorized them by type, was to consider each in isolation, analyzing the language of the given blend for which of the 15 vital relations that must have been at work in the construction and compression of that blend. Therefore, in "unpacking"—that is, analyzing—each blend, I assigned a frequency data point for any of the vital relations at work in activating the blend. For example, in the double scope blend above, I found analogy, category, cause-effect, identity, part-whole, property, representation, role/value, space, time, and uniqueness. I did not find change, disanalogy, intentionality, or similarity at work in this blend. In the scoring matrix I created (Appendix D), the double scope blend category is marked with the numbers 1, 2, 3, 6, 8, 9, 10, 11, 13, 14, and 15, respectively. I performed these analyses on all 340 blends provided by the participants.

To summarize the coding processes described above, the qualitative data were derived from the concurrent application of standard practices and conventions in cognitive linguistics and the theories of conceptual integration. I applied the coding procedures as uniformly and meticulously as possible, trying to account for all responses in as academically principled as manner as possible. Results for all quantitative and qualitative analyses follow.

CHAPTER V

RESULTS

Descriptive results (means and standard deviations) for the quantitative data in

this study are presented in Table 3. Specifically, the selected-response results, the eight

item pretest, the eight item posttest, the four novel item cluster, and the combined 12 item

posttest serve respectively as dependent variables Y1, Y2, Y3, and Y4, providing the

baseline against which the other numeric are compared. All individual selected-response

scores are reported as number correct.

As explained below, no significant group differences were found in either the

selected-response results or the pre-post frequency data; however, the data may still hold

some interest as discussed in Chapter VI. For now, I report the control group scores for

the eight-item pretest, revealing a mean of 3.27 (SD = 1.79), and post test scores showing

a mean of 4.18 (SD = 1.66). Experimental group pre- and post-scores, respectively,

revealed means of 3.57 (SD = 1.40) and 5.71 (SD = 1.59). The remaining sections of this

and the concluding chapters are presented in relation to the research questions.

Research Question 1: How is Learning Reflected
in Changes of Conceptual Integration Patterns?

Reliability Concerns

Reliability calculations revealed the Post 12/Y_4 test to have the highest reliability

(Cronbach's Alpha = .737) of the four sets of selected-response test scores (Pre 8/Y_1 =

Table 3

Whole Group Means and Standard Deviations for Quantitative Variables

Variable	Pre	Post
Selected-Response Data		
8 item quiz	3.40	5.16
(number correct)	(1.528)	(1.795)
	[Y1/QUANT 1]	[Y2/QUANT 2]
4 item post quiz		2.96
(number correct)	n/a	(1.098)
		[Y3/QUANT 3]
12 item (8 + 4)		8.12
post quiz	n/a	(2.603)
(total number correct)		[Y4/QUANT 3]
Open-Response Data		
Accuracy Data		
Number correct	5.56	9.80
	(3.305)	(6.721)
Ratio correct	.9544	1.1696
(Number per sentence)	(.52713)	(.53468)
Metaphor Data		
Overt Metaphors	.08	.64
	(.277)	(.907)
Implied Metaphors	3.04	3.96
	(1.695)	(1.567)
Key Metaphors	.04	.08
	(.200)	(.277)
Blend Data		
Identity Statements	7.16	9.44
	(2.824)	(3.110)
Blends	5.80	7.80
	(3.291)	(3.240)
Productivity Data		
Number of Words	80.0	99.52
	(26.856)	(28.254)
Number of Sentences	5.88	8.00
	(1.764)	(3.1491)

Note. Brackets indicate Design Components; see Table 1.

.405; Post $8/Y_2$ = .597; Post $4/Y_3$ = .600). This allowed us to turn our focus to ways the

quantitative selected-response results (specifically, Post 12 results because of the highest

reliability of the four selected-response quizzes, having the most items, and having the

novel items) may reflect the levels of change, if any, in the patterns of blend use

demonstrated in the accompanying open-response texts.

Significant correlations between the Post 12 results and pre-post blend patterns

(Table 4) arose between the use of simplex blends before instruction and mirror blends

after instruction (r = .536). Pretest mirror networks correlated with pretest single scope

networks (r = .416) and with posttest simplex networks (r = .604). Finally, pretest use of

single scope networks was found to be related to posttest use of simplex networks (r =

.602). These results implied linguistic change in relation to learning, the basis of this

inquiry. Also, T-tests revealed significant differences in the pre- and post-performance of

participants on the use of simplex blends (t = 3.605, .001). Final comments about these

important results are in Chapter VI.

A different kind of reliability tentatively confirmed the interpretation of the blend

data in the open-response sections of the assessment. I enlisted the help of a long time

teaching colleague who took an hour of training from me in the basic coding processes I

developed for this project. I trained him to find identity statements and blends. He then

chose at random 10 different pages of the participants' open responses, circling and

marking given phrases as ID statements or blends.

His choices for identity statements agreed/overlapped with 72% of mine and his

choices for blends agreed/overlapped with 76% of mine. This high degree of inter-rater

agreement was heartening because it demonstrated that other literate people would find

similar levels of evidence to analyze, lending to replicability of the study. Also, my

colleague would have undoubtedly revised his numbers and notions with more in-depth

understanding and re-readings as I did. Further, I know I subsumed some ID statements

into simplex and mirror blends and my colleague had no way of making decisions of that

subtlety without a good deal more training.

Table 4

Correlations Among Post 12, Pre-Post Blend Types

	PreSim	PreMir	PreSing	Pre Dble	Post Sim	Post Mir	Post Sing	Post Dble	Post 12
PreSim									
PreMir	.025								
PreSing	-.175	.416*							
PreDble	.387	.226	.318						
PostSim	-.228	.604**	.602**	.286					
PostMir	.536**	.166	-.029	.079	.034				
PostSing	-.060	-.099	.252	-.031	.186	-.097			
Post Dble	-.125	.013	.074	-.091	-.067	-.207	-.162		
Post 12	.348	.500**	.147	.027	.434**	.356	.043	-.068	

  * Significant at alpha *p* <. 05, 2-tailed
** Significant at alpha *p* < .01, 2-tailed

Conceptual Integration

On visual inspection, the frequencies of blends and vital relations seemed to differ

considerably according to group and Pre-Post performances. In large part, this is

attributable to mimicry for the following reason. In copying and expressing metaphors from the lesson—unconsciously or not—the sheer number of metaphors, and therefore the number of blends, increased substantially. But there was some evidence, via regression calculations, even in this limited sample, that some phrase construction patterns, including blends, were subject to change as a result of learning.

Observation revealed very little change in blend type frequency among control group participants: Simplex statements changed from four to six; Mirror statements went from 30 to 32; Single Scopes went from 32 to 24; Double Scopes went from two to zero. The experimental group seemed to reflect broader changes: from zero to 16 Simplex statements; from 24 to 8 for Mirror blends; from 4 to 16 Single Scopes; from four to zero Double Scopes.

Much more tellingly, regression calculations compared Post 12 results against all metaphor data, blend data, and accuracy data. Posttest Accuracy ratios ($R^2 = .508$) and pretest Identity statements ($R^2 = .631$) accounted for nearly two-thirds of the total variability in test scores.

<div style="text-align:center">

Question 2: Does Metaphorically "Richer" Instructional
Content Lead to Significant Group Differences Either
in Selected-Response Scores or Any
Open-Response Measures?

</div>

Whole group results of the correlations performed between selected-response results and other groups of related variables are presented in Tables 5, 6, and 7. Table 5 displays correlations between all selected–response results as described above and the pair of independent variables referred to hereafter as Accuracy Data. This is the first of four subsets of qualitative pre-post data which completed the datasets described in Table 3. Pretest data are labeled by the variable name in the left hand column; postest data for

that variable are in the right hand column. There are two pre-post accuracy measures. The Accuracy pre-score is a rating on a scale ranging from 0-3, conducted by a subject matter expert, describing the accuracy level for all open-response statements. Higher scores mean the subject matter expert judged the responses as "more accurate." In order to develop that raw score into a potentially more telling form, the initial numeric rating for accuracy was calculated in proportion to the number of sentences in the same response set, yielding an Accuracy Ratio.

Table 5 shows that almost all of the selected-response and accuracy sores were highly intercorrelated. At the .01 significance level, Pre 8 and Post 8 related at $r = .720$. The pretest also related to Post 4 ($r = .606$) and Post 12 ($r = .752$). The eight-item posttest related to the novel four-item mini-cluster (Post 4) at $r = .595$ and to Post 12 at $r = 941$. The mini-cluster also highly related to the Post 12 results at $r = .832$. Post 8 results also highly related to Pre Accuracy ($r = .588$), Post Accuracy ($r = .700$), and the Post Accuracy Ratio ($r = .783$). Post 12 results strongly related to Pre and Post Accuracy at $r = .612$ and $r = .652$, respectively. Post 12 results also related strongly to the Post Accuracy Ratio at $r = .713$. Pre Accuracy statements related at a level of .816 with the Pre Accuracy Ratio and at $r = .577$ with the Post Accuracy Ratio. Post Accuracy ratings related with Post Accuracy Ratios at $r = .781$ and Pre Accuracy ratios related with Post Accuracy ratios at $r = .615$.

At the .05 significance level, Pre 8 related to Post Accuracy at $r = .499$ and the Post Accuracy Ratio at $r = .502$. The Post 8 score related to the pretest accuracy ratio at $r = .466$. The four item post-instruction mini-cluster, Post 4, related to all four accuracy scores as follows: Pre Accuracy statements--$r = .500$, Post Accuracy statement--$r = .400$,

Pre Accuracy Ratio--$r = .405$, and Post Accuracy Ratio--$r = .410$, respectively. Post 12

results related to Pre Accuracy Ratio at $r = .492$. Finally, Pre Accuracy statements related

to Post Accuracy statements at $r = .440$.

Table 5

Correlations Among Selected Response Data and Accuracy Data

	Pre 8 Y_1	Post 8 Y_2	Post 4 Y_3	Post 12 Y_4	Pre Accuracy	Post Accuracy	Pre Accuracy Ratio	Post Accuracy Ratio
Pre 8								
Post 8	.720**							
Post 4	.606**	.595**						
Post 12	.752**	.941**	.832**					
Pre Accuracy	.350	.588**	.500*	.617**				
Post Accuracy	.499*	.700**	.400*	.652**	.440*			
Pre Accuracy Ratio	.272	.466*	.405*	.492*	.816**	.379		
Post Accuracy Ratio	.502*	.783**	.410*	.713**	.577**	.781**	.615*	

 * Significant at alpha $p <.05$, 2-tailed
** Significant at alpha $p <.01$, 2-tailed

Table 6 presents correlations between the selected-response and accuracy data,

now grouped as a kind of domain-specific dataset, and metaphor production data, and

showed few significant relationships. At the .05 level of significance, selected-response

Pre 8 scores were significantly associated with post-instruction use of "Overt" metaphor

at $r = .439$. Greater use of implied metaphors in pre-instruction responses related to both

the Post Accuracy statements ($r = .421$) and the Post Accuracy Ratio ($r = .398$). But these

results are problematic (see Chapter VI).

Table 6

Correlations Among Selected Response/Accuracy Data, Metaphor Data

	Pre 8	Post 8	Post 4	Post 12	Pre Accuracy	Post Accuracy	Pre Accuracy Ratio	Post Accuracy Ratio
Overt	-.079	-.194	-.126	-.187	-.142	-.327	-.191	-.367
(post)	.439*	.293	.236	.301	.265	.131	.235	.108
Implied	.122	.354	.359	.395	.338	.421*	.164	.398*
(post)	.094	.239	.168	.236	-.004	.181	.021	.297
Key	-.055	-.135	.008	-.090	-.035	-.087	.117	-.001
(post)	.118	.141	.148	.160	.222	.099	.322	.171

* Significant at alpha $p <. 05$, 2-tailed
** Significant at alpha $p < .01$, 2-tailed

On the other hand, Table 7 shows several significant correlations between the

selected-response and accuracy data, and the pre- and post data regarding Blends and

Identity Statements. Because both the selected-response and open-response sections of

the assessment overtly prompted for definitional information, it was only to be expected

that there would be strong correlations between identity statements and the selected-

response and accuracy data. This was certainly the case across the board with the one

exception of the selected-response pretest. All variables (except the Pre 8 scores) related

strongly to the Pretest Identity statements: Post 8, $r = .603$; Post 4, $r = .580$; Post 12, $r =$

.660; Pre Accuracy, $r = .695$; Post Accuracy, $r = .478$; Pre Accuracy Ratio, $r = .506$; Post

Accuracy Ratio, $r = .500$. One Post Identity association emerged in connection with Post

Accuracy statements at $r = .668$. Of note though, among the correlations in this table,

were the significant levels of association of both Pre and Post Blends and the mini-cluster

of novel items (Post 4) at $r = .470$ for Pre Blends and $r = .431$ for posttest blends.

Another correlation of note lay between posttest productivity in blends and accuracy

statements at $r = .492$. Pre- and Post-Blends also related to the Post 12 results at $r = .445$

and $r = .428$, respectively.

Table 7

Correlations Among Selected Response/Accuracy Data, Blend Data

	Pre 8	Post 8	Post 4	Post12	Pre Accuracy	Post Accuracy	Pre Accuracy Ratio	Post Accuracy Ratio
IDs	.342	.603**	.580**	.660**	.695**	.478*	.506**	.500**
(post)	.277	.323	.225	.317	.024	.668**	-.140	.217
Blends	.157	.358	.470*	.445*	.344	.322	.236	.343
(post)	.295	.357	.431*	.428*	.264	.492*	.234	.217

  * Significant at alpha $p < .05$, 2-tailed
** Significant at alpha $p < .01$, 2-tailed

The assumptions for MANOVA calculations seemed to be satisfied. Independent

random sampling was at work in the participant pool. Independent variables (IVs) were

categorical and the dependent variables (DVs), as selected-response results, were

continuous variables. The DVs were moderately correlated, there were no missing data,

and there were no extreme outliers in the observations, providing multivariate normality.

Visual inspection of means and standard deviations also indicated normality and homogeneity of variance. Box's $M = 12.703$, $p = .422$, suggesting the covariance matrices were equivalent. Levene's test of Equality of Error Variance, testing homogeneity of variance, revealed F values ranging from 2.72-.002 and p values ranging from .113-.965.

Table 8 displays the pre- and posttest means and standard deviations of phrase construction frequencies by experimental condition. Five MANOVAs were performed to investigate differences between the control group and the experimental group across all groups of variables. First, when using selected response results as dependent variables, no significance was found by group: F $(3, 21) = 1.25$, $p = .318$. A second MANOVA, this time using the pretest scores as a covariate, also showed no significant difference between group performances: $F (4, 19) = .776$, $p = .554$. A third MANOVA was performed on group differences between pre-post word and sentence productivity scores; again, none was found for number of words or number of sentences: $F(4, 20) = .519$, p = .723. The fourth MANOVA, analyzing group differences in pre-post identity statements and blends, also revealed no significant differences: $F(4, 20) = .954$, $p = .454$. Finally, a fifth MANOVA compared group differences in metaphor data (numbers of overt, implied, or key metaphors) for group differences and, again, none was found: $F(6, 18) = .497$, $p = .802$. With no evidence of significant group differences on quiz performance, further analyses focused on pre- and post-differences rather than on experimental condition as a major factor.

Table 8

Means (and SDs) of Pre- and Post- Construction Frequencies by Group/Condition

Dependent Variable		Control	Experimental
Words	Pre	69.8	88
		(20.7)	(29.1)
	Post	92.5	105
		(16.7)	(34.6)
Sentences	Pre	5.2	6.2
		(1.6)	(2.0)
	Post	7.1	8.7
		(1.9)	(3.8)
Words per Sentence	Pre	14	14.7
		(4.64)	(4.46)
	Post	13.7	13.2
		(3.49)	(5.18)
Overt Metaphors	Pre	0.1	0.1
		(.03)	(.03)
	Post	0.5	0.7
		(.09)	(.09)
Implied Metaphors	Pre	2.7	3.29
		(1.19)	(2.02)
	Post	3.73	4.14
		(1.42)	(1.7)
Key Metaphors	Pre	0.1	0
		(0.3)	
	Post	0	0.1
			(.04)
Identity Statements	Pre	6.8	7.4
		(3)	(2.8)
	Post	8.6	10.0
		(1.804)	(3.792)
Blends	Pre	5.5	6.0
		(3.2)	(3.4)
	Post	7.4	8.1
		(3.61)	(3.01)
Mega Blends	Pre	0.4	0.4
		(0.7)	(1.2)
	Post	0.6	0.8
		(0.92)	(1.41)
Accuracy	Pre	4.9	6.1
		(2.88)	(3.63)
	Post	7.6	11.5
		(6.021)	(6.959)
Accuracy Ratio	Pre	1.0	1.0
		(0.6)	(.05)
	Post	0.99	1.3
		(0.58)	(0.47)

Pretest-Posttest Differences

A good deal of other evidence (see Table 9) pointed to significant changes between the pre- and post-performances of the entire group on many variables. In order to investigate these differences, a series of paired *t*-tests was conducted on all the relevant variables and showed significant increases from pretest to posttest on all except the key metaphor data ($p = .574$). Because there were only two key metaphor observations in 347 sentences (one pre-, one post-), this did not present enough data to warrant further inclusion. However, the pre-post effect sizes were significant for the other paired variables, shown as Cohen's *d* values.

Table 9

Paired t-Tests and Cohen's d Values on Pretest-Posttest Data

Variable Pair/Name, Pre-Post	*t*	*df*	Sig. (2-tailed)	Cohen's *d*
Words	4.049	24	.000	.708
Sentences	3.761	24	.001	.612
Overt Metaphors	2.914	24	.008	.835
Implied Metaphors	2.302	24	.030	.564
Key Metaphors	.569	24	.574	N/A
Identity Statements	3.198	24	.004	.768
Blends	2.828	24	.009	.612
Accuracy Statements	3.508	24	.002	.800
Accuracy Ratio	2.311	24	.030	.407
8 Item Selected-Response	6.943	24	.000	1.053

Phrase Construction Frequencies

As far as numeric analysis, one of the first places to start—word and sentence counts–is classic, simple, and sometimes very informative, but not here. Words per sentence ratios are typically used as a tentative indicator of either intellectual ability or complexity of thought. This type of data is calculated as matter of course. In this study, the most interesting thing at first blush was the slightly lower word per sentence rate in posttest performance. Using fewer sentences to convey more information was fine, but of little further use here.

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Research Question 3: To What Extent Does Mimetic
Learning Apply to the Use of Instructional
Metaphors by Participants?

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Key Metaphors, Overt Metaphors,
and Mimicry

As expected, overt metaphors were in very short supply, especially in the pretest responses (i.e., only two observations in 147 sentences). Of those, only one was a domain-specific key metaphor (code). The posttest response sets provided a fairly dramatic contrast in terms of sheer numbers, at least, providing a not-so-grand total of two key metaphors and a very respectable 16 metaphors overall. Potentially more interesting than anything the paltry key metaphor counts demonstrated was other data, which seemed to provide evidence pertaining to the more central question about change in any overt metaphor production, especially as a result of mimicry.

I have to mention group differences at this point. Each group happened to present one (1) metaphor in their combined pre-instruction texts. But Group C, the participants who did not have the enriched instructional condition, only produced six metaphors in their posttest metaphor production, while the experimental group produced 10. When it

came to mimicry, 8 of the 10 posttest metaphors produced by the experimental group were blueprint, recipes, or twisted ladders, all in the video. But the apparent disparity in performance was not between groups, as shown in the MANOVAs, but only between pre-post performances.

Conceptual/Implied Metaphors

Table 10 lists the following items, in order of high-to-low-frequency, as too fossilized/lexicalized to warrant further attention in this study. It was beyond the scope and focus of the present study to analyze the data for group differences on this type of ad hoc measure; however, the terms themselves and the frequencies of their use were instructive on face. Many of these terms clearly confirmed Lakoff and Johnson's pioneering work (1980). Notice how many terms involved concepts of Traits Are Physical Things: Have/has/had, posses, include, get, give, transfer, linking, based on, connected.

Table 10

Conceptual Metaphors: Lexicalized/Fossilized and Excluded from Further Metaphoric Considerations

Lexicalized/Fossilized Metaphors (and Frequencies)	
Have/has/had/posses	23
Find, found/found out, include, get	5 each
Give, transfer, linking, based on	4 each
Wrapped, fields	2 each
Connected, picked, set up (a table)	1 each

Of greater interest were the less-fossilized terms participants used in describing their domain knowledge. Participants used many other terms which may be understood as conceptual metaphors (Table 11) in high-to-low frequency. These terms were specifically included in the data as *implied* metaphors, included in the analyses of the data, and represented in a major portion of statements used to describe the content domain.

Table 11

Implied Metaphor Frequencies

Implied/Conceptual Metaphors (and frequencies)	
Pass along/down/on/through/to	36
Make, make up, made (V)	24
Contain	13
Made up of (AdjPhrase)	9
Make-up (NP)	9
Show	8
Carry, receive	5 each
Decide, determine, go (through), tell	3 each
Built (V/Adj), build-up (V), structure (V)	3 total
Background (N), trace (N), control, hold, play(a role), run (through), says (all VPs)	2 each
Breakthrough (N), code (N), cool things (NP/AN), around (Prep), over (Prep), through (Prep), advance, assign, dictate, flow, (to) further, grow (up), look, put together, stay, store, survive (through), [take] the forefront, turn (out)	1 each

However, regardless of their relatively higher degree of metaphoricity, treating even these less lexicalized terms as true metaphors rather than as conceptual metaphors would be theoretically unprincipled. They served their duty primarily as verbs in the blends they helped create. Whole group frequencies and parts of speech, when germane, are listed parenthetically.

Identity Statements

Identity statements are an important subclass of expressions; they usually lack enough information to become blends in and of themselves. They are often simply a pair of linked elements (in X IS Y form, where object Y either renames the subject or adjective Y describes the subject). Identity statements are not necessarily accurate; nor are they necessarily a sign of improved domain-specific knowledge. It is only when they are played out against some other factors, such as the accuracy data, that one may determine their relative value. This is indeed addressed in the integration of data near the end of Chapter Six.

Mega Blends

Data from this analysis, unlike the conceptual metaphor data, were more straightforward in their quantification. As with key metaphors, not enough data were available to make any other definitive claims about it.

<div align="center">

Research Question 4: Can Participants Develop
Effective Novel Metaphors of Their Own?

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The participant survey prompt provided a list of nine classic metaphors about the topic and asked participants to choose and defend their choices for the most effective metaphor. This prompt had selected-response and open-response elements, providing frequency data in direct connection with highly focused textual responses. As in the pilot

test, respondents selected blueprints, recipes, and codes over the other metaphoric offerings overwhelmingly. Participants provided few truly *novel* metaphors even when prompted; most suggestions--puzzle pieces, maps, building blocks, and yarn--were well-worn.

Some responses were truly novel and exhibited a sense of having been formed ad hoc. Novel metaphors ranged in levels of target and source specificity, and in overall salience from the vanishingly shallow ("Genes are like polar bears because they all look the same unless you look really close") to the surprisingly effective ("Just how are genes like a class of graduating students?"). As mentioned in the previous chapter, the participant who offered this creative metaphor articulated many examples about groups working together--all individuals ("genes") having roles to play depending on their category and group ("cells" and "organs"), a strict timing and sequence to everything, some individuals seem to be "in charge" while others wait or just "go through the motions," etc.

In Chapter VI, I discuss some of the specific and general implications of this study about teaching, learning, and cognition.

CHAPTER VI

DISCUSSION

The various kinds of data elicited in this research have been obtained in order to add to the growing body of literature about conceptual integration in both educational psychology and cognitive linguistics (Evans & Green, 2006; Fauconnier & Turner, 2002; Levitin, 2002; Pinker, 2002). Because blends by definition have emergent structure, the mental act of blending goes beyond the given information of the separate contributing inputs. The practical implication for educational psychologists is clear: blending may be a powerful form of learning and imagination which is only beginning to be understood. One of the most obvious forms of blending in language is the use of metaphor, a classic topic in language studies. The logical and theoretical progression toward much of what is now the entire cognitive linguistics enterprise began as investigations into metaphor. Because metaphor and conceptual integration are so deeply linked, it is only logical that a study of either one would become, in part, a study of the other. Whether metaphors or blends, what ties them together for the current purpose is how they relate to teaching and learning.

The core aim of this research project--from first learning about theory and developing questions to the final design, research, and data collection to interpretation-- had always been to find whether or not Fauconnier and Turner's (2002) ideas about conceptual integration could be used to understand more about the way we think when

we learn. Therefore, the analysis of the focused-text open responses of the participants in accordance with Fauconnier and Turner's theories became the primary focal point of this entire paper. The fact that the participants were expressing their ideas about a common topic allowed for a level of qualitative standardization that could not be achieved if the participants were engaged in unfocused verbal exchanges. This fact was crucially important because only by using a common topic to unify the conversational domain could the participants' written statements be justifiably compared in many of the most probative ways.

In this chapter, I integrate and discuss the findings (Chapter V) with regard to the original research questions. With those elements in place, I continue this chapter with a summary of the work, after which I re-address some of the constraints and limitations of the study in light of the emergent data. I close with a consideration some of the implications of this study for educators, psychologists, and researchers.

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Research Question 1: How is Learning Reflected
in Changes of Conceptual Integration Patterns?

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It is appropriate at this time to discuss issues of reliability and validity, addressed here as fundamental to the proper interpretation of any results relating to the question.

First, readers will remember the pilot test that was used to test the feasibility and refine many aspects of this study as early evidence of my efforts to enhance the reliability of the instruments and processes.

Results of the eight-item pre- and posttests and the novel four-item post test (as well as the combined Post 12) scores were related at relatively high levels (see Table 4), as should be expected. Those within-set correlations lent some confidence as to the selected- response instruments' reliability, leading to further confidence in the possibility

of more valid interpretations about the study's overall implications. There were also data about instrument validity.

Table 5 showed that almost all the selected-response variables and the accuracy data were highly related. More gratifying than surprising, the results lent credence to the assessment's external and internal validity. The premise of the current work rested on the theoretical assumption that language changes as a result of learning. High correlations between the traditional quantitative results and the qualitative results which dealt the most with the same aspect of content domain mastery were a validation that these instruments measured some of the participants' same generalized and commonly accepted cognitive understanding of the domain of genes, genetics, and heredity. This was highly suggestive of positive cognitive links between participants' quantitative selected-response performance and a qualitative open-response performance, suggesting indeed that learning and language change might be reflective of one another in specific and measureable ways.

External validity was implied here, too; the subject matter expert's ratings (Accuracy Data) correlated with each of the most objective measures in the study, the selected-response scores, virtually across the board. This meant that the data from each of these two crucially important variable sets were the least susceptible of all data obtained in this research to whatever subjective rater biases I would bring into the mix. Readers will remember too that I developed still another third-party source of checking for reliability with my own rater-training activity, described elsewhere.

I contend that the combined effects of using the pilot test, many drafts of the instruments, separate third-party accuracy checks of two critical elements of the content

validity of the data, and the process of analyzing the data (as described previously) lent credibility to the entire study.

Table 6 showed a number of high correlations between identity statement and blend production and the accuracy scores, but the language itself probably prompted for identity statements by asking for definitions. Also the video instruction contained many overt definitions. It was possible that a fluke of language seemed to make this set of correlations with ID statements so strong. Identity statements are certainly part of cognitive linguistic research and conceptual integration as well and are often blends in the making with cognitive implications of their own. But this research was about blends all along and some of the associations that emerged here between the production of identity statements, blend production, accuracy, and posttest scores suggested that learning and blending might be significantly related. Their inclusion here reflected their value in conceptual integration analysis and also helped answer the first research question. This was confirmatory of blending theory in general and the premise of the primary research question for this study: how is learning reflected in changes in blend patterns?

Conceptual integration theory suggests that certain, though as yet unspecified, types of linguistic change must be associated with learning, of which blending may be a large and important part. A final set of numeric data reflected some of the linguistic changes participants exhibited in their whole-group pre-post writing performances. Included in this data was a subset of numeric information about participants' use of metaphors, overt and implied, in their open-response answers. Not only were these data worth noting in their own right but they provided a direct tie-in to the more obviously

qualitative data described elsewhere. Basic word and sentence counts revealed highly uniform sentence length, averaging 14 words per sentence in the pretest and 13.4 words per sentence for the posttest. Participants wrote 147 sentences before instruction and 200 after. They used two pretest metaphors and 16 posttest metaphors. This was not surprising, given that participants knew from the sign-up process and the consent form that the research was about metaphor use in learning and teaching and more than half of them saw two slightly elaborated metaphors in the lesson. Basically, there was nothing in the data to suggest anything beyond simple mimicry in this case: they came, they saw, they copied. This was not to say that mimicry is necessarily bad; it was derivative rather than original, perhaps. However, it could provide a Vygotskyan type of initial cognitive scaffold for future behavior and comparisons.

Pre-post implied (i.e., conceptual) metaphors rose from a total of 76 instances to 99. ID statements rose from 179 to 236, but the definitional nature of the exercise probably accounted for most of that apparent gain. The total number of blends, however, also increased substantially from 145 to 195. Did familiarity, confidence, learning, or some other factor make blending more likely simply as a result of any given instruction? It is logically possible, but beyond the scope of this study, leaving another tantalizing question. Also unanswered was this implied question: is more blending a sign of more learning? The theory of conceptual metaphor (Lakoff & Johnson, 1980) is a now a critical sub-component and access point to conceptual integration theory. As seen with overt metaphor and blending, implied (conceptual) metaphor is also deeply tied to blending; the study of one will inevitably involve the study of the other.

With three out of the four correlations shown in Table 4 (Chapter V) involving simplex and mirror networks, evidence started to suggest these kinds of simplex and mirror blends might be connected to the expression of knowledge about these particular domains. Both the correlations and the t-tests pointed to simplex blends as the type of blend participants were most likely to use—and change their use patterns of— when describing their understanding of the topics.

Fauconnier and Turner (2002) claimed that simplex blends prototypically involved statements about human cultural and biological history (X is the Y of Z; e.g., James is the father of Claire). The results might be viewed as tentatively confirmatory of the Fauconnier and Turner claim. Perhaps also the types of questions which led to these types of statements limited the kind of blending required to answer the question. This also fit with the notion that definitional questions lent themselves to simplex type of answers, in part because of their close similarity in form and function to identity statements.

Finally, it should be noted that there was some evidence about changes in the use of some of the different vital relations in the blends expressed by the participants. Identity, the vital relation most associated with naming things, was used much more often in the statements participants made after instruction than before instruction. The two vital relations that were used much less often in post-instruction responses, property and uniqueness, might well be explained by the nature of the prompts: perhaps descriptive adjectives—or even creative metaphors—were somehow cognitively inhibited by the prompts or at least by the participants' inner re-constructions of the prompts.

There was more to the issue than specific changes in blending per se; blending is a vitally important subset of speech behaviors in general, here counted as phrase construction frequencies. The first research question was about changes in conceptual integration patterns due to learning. The effects of instruction on phrase construction frequencies as shown in Table 9 (Chapter V) seemed to be significant, regardless of group, confirming not only what the MANOVAs were indicating about the lack of group differences (discussed below) but also confirming significant whole group change after instruction.

<div style="text-align:center">

Research Question 2: Does Metaphorically Richer
Instructional Content Lead to Significant Group
Differences Either in Selected-Response Scores
or Any Open-Response Measures?

</div>

First, I address the results from the traditional quantitative data-- the matching/selected response exercise. No significant differences were found between the experimental and control groups. This was not surprising since the content of the two videos substantially overlapped. Also, other factors such as instructional or assessment clarity might account for the lack of difference between the two groups' performances. However, considerable and significant differences in whole group means between pre-and-posttest performances suggested two possibilities: (a) the instructional videos had some effect and (b) robust practice or priming effects might be also expected. By the time participants had read and responded in writing to several highly-focused prompts and also watched an overtly instructional video about the same topics, they had been exposed to the material a number of times within mere minutes of the first "cold" assessments. This was simply a limitation of the study I had to accept in light of the overwhelming difficulties of a two-session approach.

The practice effect having been acknowledged, however, it could be accounted for/factored out to some extent. Given the nature of the participants in this study as undergraduate introductory psychology students, their expertise with traditional, classroom-like assessments such as this could be assumed. The first possibility—that the instruction contributed to the participants' subsequent changes in linguistic performance—remained intact.

The relatively robust correlations discussed above allowed me to continue the investigation of data at deeper levels. If remaining quantitative differences were to be found, they would logically be derived from experimental condition, which is where the effects, if any, of the instructional differences would lie. However, MANOVAs showed no significant differences by experimental/instructional condition. Thus, experimental condition is no longer a viable topic in this part of the discussion.

Although the MANOVA operations indicated no significant difference by group condition, it is worthy of note that the changes in the different groups' performances were at least in the expected direction, hinting at some as yet untraced effect. The issue of using different metaphors cannot be counted as "settled"—especially as being settled against enriched metaphor conditions. It is not impossible that significant differences might appear in different research over longer times or with more polished instruments, etc.

Research Question 3: To What Extent Does Mimetic Learning Apply to the Use of Instructional Metaphors by Participants?

Mimicry, though perhaps superficial, may be a first step in constructing understanding. Though as revealed in Chapter V, the result—lots of copying, conscious

or otherwise—was completely unsurprising, mimicry should not be dismissed too quickly as an effective teaching and learning factor. It is clearly a factor in learning many linguistic skills, uses, and behaviors. A Vygotskyan educator would say that mimicry is an early level or stage of internalization which can lead to important learning of skills, ranges of acceptable behaviors in social situations, and, among other things, self-developed and creative uses of what was at first merely mimicked.

The implications of Table 6, showing only a few significant relations between metaphor production data and the selected response and accuracy data, were not of practical use. Logically, change in metaphor use would reflect improved understanding as measured by the selected-response and accuracy data. However, higher selected-response Pre 8 scores were significantly associated with post-instruction use of overt metaphor at r = .439. One possible interpretation here is that prior knowledge, reflected in Pre 8 scores, could lead to higher confidence or comfort in producing or even "merely" mimicking related metaphors. This was the only significant association in the quantitative analyses between any pre-post aspect of overt metaphor production and any selected-response variable. Given the high number of significant correlations among other variables as well as low metaphor productivity, these results may not be usefully interpretable.

But overt metaphor production was not the only aspect of performance under consideration. Greater use of implied (i.e., "conceptual") metaphors in pre-instruction responses related to both the post accuracy statements (r = .421) and the post accuracy ratio (r = .398). One implication here could be that frequency and fluency of conceptual metaphor use could provide a mechanism for linguistic or perhaps domain-specific understanding, mastery, or clarity.

Research Question 4: Can Participants Develop
Effective Novel Metaphors of Their Own?

The metaphor preference survey provided no new information. No doubt, most participants had heard both of the overt instructional metaphors, perhaps many times. It is likely here that familiarity brought comfort and the "genes as blueprints and recipes" metaphors live on, probably because old habits die hard. The survey counted for little for now. Part of the point was to provide a hidden mini-lesson on metaphors in the activity in order for participants to be primed for the more creative activity to follow.

The creative element of the Post-5 prompt displayed an entirely different aspect of the study's participants as discussed below. The participants' choices in developing novel metaphors ranged from mundane to clever. Three chose "puzzles" for a metaphoric source; two each chose "building blocks," "maps," "shoes," and "yarn." These first 11 choices were mostly tried and true, except "shoes." Both respondents made comments about "a good fit" in obvious reference to the great specificity genes must exhibit in their processes. One said she chose "shoes" simply because she liked them. This was not necessarily a flippant answer. If the metaphor fit, if it worked to help a person understand something, it had some kind of personal salience which could not be "canned" and applied without further thought.

For a possibly flippant, but more creative choice, one participant chose "gobstoppers" as a metaphor. Here the sheer silliness might make for a good mnemonic device; a person might have a valuable mental picture of variety, complexity, and yet a kind of harmonious outcome. Complexity, details, and exactitude were elicited by another source: "sheet music." Participants here explained their choices, giving a pretty accurate notion of their levels of understanding by the number and novelty of aspects

they could name or describe. This confirmed evidence of differential metaphor abilities measured by elaboration (Johnson, 1991). My favorite? The "graduating class" metaphor was nicely argued with many parallel roles between the various participants in a graduation ceremony and the genetic participants in the biological processes explained in detailed ways, clearly showing that the metaphor was robustly salient, at least for that participant.

<div align="center">Limitations</div>

Many of the most serious limitations of this study were related to time and logistical factors. Developing and applying the analysis and coding techniques were very time consuming. The administration and organization details were created for this study and had a real chance of overwhelming this single researcher. The "gift" of a larger sample size would create the need for a much more cumbersome organizational effort, including training raters, dealing logistically with large groups of participants, integrating and unifying bureaucratic and data entry protocols, etc.

The untried analysis of open-responses via conceptual integration network types and vital relations represents a new approach to understanding teaching and learning. There are and will continue to be difficulties in making accurate inferences about prior knowledge and bias regarding any particular metaphor because of the inevitable differences in learners' demographic factors (such as poverty levels, linguistic abilities, experiential differences, and in this case, possibly the university majors of the student participants) which could dilute the viability of conclusions that could be derived from the relatively small sample.

Also, the focus of one lesson in one subject area with only a few given metaphors may be difficult to transfer to other teaching and learning situations. Even with some progress in the current endeavor, this concept is still only in its infancy.

Significance

This research implies that teachers may want to rethink their approach to their instructional use of metaphor: just as meaning is not considered by cognitive linguists to be "contained" in a word, neither is meaning contained in a metaphor. The results, therefore, underscored constructivist theories. Our impact as teachers is less a factor of the information we "give" to our students than the factor of student engagement in the cognitive activities they apply to that information. If students construct meaning through hearing a metaphor, conceptual integration theory holds that the students have been prompted to do so through the small packet of information supplied by the metaphor and their own immense neural network designed to make sense through the "vital relations," which construct and compress the information into blends, the way we think.

No quantitative changes were attributable to either of the different conditions of instructional metaphors. The implication of the conceptual integration model is that improved quantitative scores will be reflected in changed qualitative output. This has been born out.

The idea that more metaphors lead automatically to improved learning is on very shaky ground. This work is no death knell for conceptual integration theory. Metaphors are only part of the picture and their use, too, may be improved with an improved understanding of conceptual integration. With further work, limitations of design and

analytical applicability may be overcome to the point where more definitive results will emerge.

Summary

In developing research to reflect and test the techniques and supporting theories which define cognitive integration, I used a traditional pre-post/selected-response assessment to provide a quantitative data set against which the rest of the qualitative data was compared. I performed this research to investigate how changes in learning are reflected in changes in language. The following statements summarize and mark a final interpretation of the findings,

1. Language patterns do seem to change in identifiable ways which reflect learning.

2. Enrichment by mere number of instructional metaphors cannot be as valuable as enrichment by quality and depth of engagement with the metaphors to develop what they can really teach us.

3. Copying will always be with us; perhaps we can use that fact to our advantage.

4. Creativity is not merely related to ability to learn, but can be a rich source of learning in itself.

Implications and Conclusion

Two implications of a conceptual integration approach to education become immediately apparent: (a) conceptual integration could potentially provide measures of content-domain mastery and conceptualization; and (b) conceptual integration could lead to enhanced teacher effectiveness through the more deliberate use and application of

instructional metaphors (as well as other linguistic and cognitive means) and increased sensitivity to specifics of student understanding.

For teachers, the diagnostic possibilities are tantalizing. For example, can conceptual integration teach us to write more effective assessment prompts for the facilitation of more complex, dynamic, deeper, thinking and learning implied by the conceptual integration model and measurable as blends and vital relations? Or perhaps by analyzing student comments from the conceptual integration perspective, a teacher might become aware of information or processes that could be helpful in remediating some learning obstacles.

The reader will remember an example provided in Chapter IV where a participant presented the identity statement, "[h]eredity is your heritage, your background." The writer used geographic/locative terms--"background," "where," "come," and "from"--for a word, heritage, connotative of *cultural* heredity. Remember the lack of direct connection to *biological* processes and products, a common aspect of many simplex blends. This participant's identity statement did not provide enough information even for a simplex blend.

In a classroom, this type of distinction could provide a teacher with more effective and subtle powers of diagnosis and instructional remediation. In this case, for example, a Vygotskyan/constructivist teacher could at first build on the cultural metaphor the participant already has as a frame of reference for this content domain by demonstrating ways the metaphor source (e.g., "background") is accurate (BACKGROUND = "something in historical past"). The teacher would nudge the student to consider "people"—such as grandparents—as part of "something in the historical past," providing a conceptual bridge

from history to biology and from biology to genes, genetics, and heredity. Then over time, the teacher would introduce ("instruct") and help the student develop ("construct") other, more salient, and personally relevant and accurate metaphors.

Further research in conceptual integration will not be limited to education, of course. Here are a few other fields of interest for non-education researchers in conceptual integration: communication, business and advertising, psychology, developmental psychology, forensics, problem-solving, psychopathology, and psychotherapy.

Responsible, responsive teachers, as lifelong learners, will always work on ways to improve their understanding of and practice in the judicious and effective use of any teaching tools, especially those with such powerful potential, such as metaphor. My own teaching will change as a result of this study. I will not expect meaning to be in my metaphors any more than it is in my words. I will take the time to analyze instructional metaphors with students in order to help them realize multiple, even contradictory aspects of topics. Because the meaning students attain is not a matter of what I give them but of what they can mentally construct in the learning environment I try to create for them. I will also regularly ask for and attempt novel metaphors; who knows what I and my students might learn? With the right approach, we can learn much.

Through more accurate diagnosis and more accurate and subtle application of what this could teach educators about their own language use in the classroom, new techniques from conceptual integration theory for measuring changes in an individual's understanding of a concept, psychologists will have another analytical tool at their disposal. The techniques developed in this study could eventually assist test makers in creating more effective, valid, and reliable assessments. Many stakeholders, from

students to educators, to politicians and publishers, could benefit. Additionally, and most

importantly, from the perspective of day to day schooling, the same stakeholders will

benefit from improved classroom instruction as well.

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APPENDIX A

SCRIPTS

Instructional Metaphors in Science
Robert Johnson

Scripts

(An asterisk (*) denotes graphic picture/text support from Power Point presentation of key concepts/ vocabulary provided throughout script. With the exception of the title, capitalized words in the text are to be shown on-screen (as a subtitle or as part of the graphic screen's text) when they are mentioned and are specific answers to selected response (matching) questions in the pre-and post-assessments. Camera and "stage" directions, as per convention, are in italics.)

1. *(Dissolve from title*, *1 Review of Genes, Genetics, and Heredity *to close-up)* Hello. My name is Robert Johnson. Thank you for participating in this research about the psychology of teaching and learning. Today I will be presenting a brief lesson about several closely- related, vitally important, and fascinating topics: Genes, Genetics, and Heredity. As mentioned in the informed consent form you signed just before the pretest phase of this research, this study is designed to test how teacher language is reflected in student language and learning. The different groups to which you have been assigned will be viewing and hearing slightly different versions of an otherwise identical lesson. At no time in the lesson is there any purposeful deception, so you won't need to focus on exact details of accuracy about the topics. The only differences between the lessons will be in the types of metaphors used to describe various aspects of the topics. And remember, in psychology, as distinct from literature, the term "metaphor" refers to <u>any</u> figure

of speech, not only the traditional metaphoric construction of a literature-based metaphor, such as, "Life is a journey."

2. To preview our lesson, I will be discussing a bit about the history of the science of genetics and heredity, what genes are, and where they are found. Then I will explain some of the structures, functions, processes, and products of genes. That is, I will discuss what they look like, how they work, what they do, and what they make. But I will first explain some of the reasons genetics is considered by so many people to be one of the most important fields of science.

3. *(Medium shot, include screen behind presenter)* By learning about how genes work, agricultural scientists having been working to improve crops and livestock. (*2; two farm scenes) Thus in both agricultural science and animal husbandry, genetics holds the promise of providing more food for more people all across the world. But botany and zoology are only two of the major areas of scientific concern dealing with genes, genetics and heredity.

4. A third field with interest in genes, genetics, and heredity is medicine. (*3; medical research) Many medical researchers are finding genetic links to various types of illness and disease. There is a rapid pace of discovery in genetic approaches to birth defects, many types of cancer, many viruses, and diseases such as diabetes, Parkinson's disease, and Alzheimer's disease. By understanding the genetic links to these and other ailments, scientists hope to alleviate the suffering of millions of people.

5. A fourth field of interest and promise lies in the search for genetic engineering applications to environmental issues such as waste management (*4; landfill/ biofuel plant) and fuel production.

6. Even archeologists and historians are using genetic evidence to trace the movements of ancient peoples across the earth in prehistoric times. (*5; world map) With these important possibilities ahead of us, it is no wonder that so much scientific attention is being paid to genes, genetics, and heredity.

7. Today, I will discuss various elements of our topic, but I would like you to listen especially for how genes are defined, what they look like, where they are located, what they do, and what they produce. In short, I will review some of the information about the structures, functions, processes, and products of genes. Over the years, scientists have used <u>many</u> different metaphoric descriptions of genes and genetic processes.

_____

(*Group C-control goes to Paragraph #8 now. Group E-experimental gets both the Blueprint and Recipe metaphors.*)

(*Presenter does quarter turn—cut— to new camera angle for both of the metaphors. At end of recipe metaphor, a quarter turn –cut— back to original camera angle. Presenter continues.*)

_____

Group E (Blueprint):

Some people metaphorically describe genes do as a kind of * blueprint.

(* 6; *blueprint and house*)

That is, just as a blueprint provides information on the building design and structure to a builder with precise graphic descriptions of what needs to be done, with what materials, in what order, and with particular types of uses in mind, genes somehow provide information (in the form of templates, guidelines, or instructions) that determines the structures and functions of the cells of an organism. The information directs what the cells do, using particular molecules, working in a particular sequence, assembling particular chemicals and cellular tissues with one or more particular useful functions/products as a result. (Continue) *Group E (Recipe):*

Some people metaphorically describe the work the genes do as a kind of * recipe.

(* 7; *recipe, cake*)

That is, just as a recipe provides a chef with precise descriptions and directions of what needs to be done, with what ingredients, in what order, and with particular uses in mind, genes determine what the structures of cells will consist of and look like, and what functions the cells of an organism will perform. Genes determine what cells are supposed to do, using molecular ingredients, working in a particular sequence, and with a particular useful function/product as a result.

_____

Group C (No overt metaphoric description; skip directly from paragraph 7 to paragraph 8):

(*Both groups re-enter the lesson's text from here forward.*)

8. (*Return to close-up after presenter's quarter turn; graphics on bottom of screen as mentioned-add and retain all till end of paragraph*) But any metaphoric description, no matter how well it communicates <u>some</u> aspects of what is being described, still falls short of being entirely accurate. With this in mind, let us take a brief look at how our understanding of genes, genetics, and heredity has developed.

For thousands of years, people have wondered about how all living things grow, survive, change, and pass certain characteristics to succeeding generations. As scientific techniques and tools became more precise, many of these ancient questions have begun to be resolved. Over the course of the last 150 years, scientists have discovered that growth, survival, change, and reproduction in all known life are functions of tiny segments of DNA molecules called "genes" (from the Greek word for "birth"). Thus, the study of genes is called "genetics," and the process of how characteristics are passed from one generation to the next is called "HEREDITY." Unlocking the secrets of how these molecules work has been one of the great scientific achievements of all time. And new discoveries in this field are still being made. There is even a new field emerging, called epigenetics, which concerns how multiple generations of an organism respond to changing environmental pressures.

9. (*Return to medium shot, with screen; include graphics at bottom, changing as mentioned*) Now, let's move to just *what* genes are, and *where* they are found. As microscopes were improved over the years, it was discovered that all living things

were made up of one or more cells, (*8; single cell) and that these cells could divide to create more cells. (*9; cell division) Careful observations of cells during division revealed that within the cells were even smaller structures which seemed to control their workings. (*10; cell nuclei) These structures, the "nuclei," had even tinier molecules inside them which came to be called "CHROMOSOMES." (*11; chromosomes) Every species has a particular number of chromosomes; humans, for example have forty six. The chromosomes were found to be very long and very tightly wrapped chains of amino-acid molecules known as DNA.

Genes are specific sets or combinations of molecules along the chains of DNA (*12; DNA), made of four basic chemicals represented by the letters A, T, C, and G. These chains of DNA molecules were found to form a structure now famously known as a double helix, which looks like a very long, tightly coiled or twisted ladder. The basic unit of genetic code is called a "CODON" (*13; codon chart), the smallest functional working part of a string of genetic information –only some combination of three of these molecules, in fact.

10. (*Return to close-up; continue graphics at bottom on mention*) Every living thing has a particular set of genes and DNA unique to its species. Humans, for example, are thought to have about thirty thousand different genes scattered along their forty-six chromosomes. While some of these genes may work independently, many of their functions are the result of partnerships among them. Also, many genes and gene partnerships may have multiple functions. All of this occurs on a very small scale; there are nearly three billion locations for the molecules which

make up gene sets on human chromosomes. Further complicating matters is the fact that many of these specific sets of genes may be hundreds or even thousands of molecules long. Interestingly, particular genes may occur in many different species.

11. (*Medium plus screen, plus graphics*) Having seen what genes are and where they are located, we can now consider some of the processes genes control. Amino acids such as DNA are part of a very large family of complex organic chemicals known as "PROTEINS" (*14; proteins), from the Greek term for "I come first". The origin of this term implies that proteins are the most important chemicals in living things. Indeed, some of the most important products of gene expression are another type of protein known as "ENZYMES," (*15; enzyme) which seem to initiate and regulate a great many gene activities, such as molecular assembly and disassembly, reproduction, growth, and change in an organism. In short, most of the work genes do is primarily involved in producing or constructing proteins of one kind or another, and most of these proteins are enzymes.

12. Basically, the expression of genes controls or regulates two main functions: 1) regulation of growth (through typical cell division-mitosis) and 2) regulation of reproduction (through sexual recombination-meiosis). Thus, every cell in every living organism contains a chemical copy of the set of genes which allow the organism to grow and reproduce. So, regardless of whether an organism is a cow, a cauliflower, an amoeba, a person, or a snail, (*16; composite) that organism contains a genetic code in its DNA which promotes the survival of its species

through growth and reproduction. A closely related sub-category of DNA, RNA,

is a special gene sequence involved in much of a cell's internal growth, structure,

and function.

13. Because RNA is so important, it warrants a brief explanation here. Two forms of

RNA are necessary for the DNA to make copies of itself, which ability is the

basic reason DNA is considered the essential chemical basis of life. (*17; RNA

and DNA) One form, messenger RNA or mRNA, is responsible for preparing a

nucleus and the rest of its cell to be copied by signaling the readiness to do so to

the various bits and pieces of potential new cellular material floating in the

cytoplasm of the cell outside the nucleus. The second form of RNA is transfer

RNA, or tRNA. These tiny components of the nucleus actually travel through the

porous nucleus wall and attach to—or collect— the specific bits of material called

for by the mRNA from the cytoplasm and return them to interior of the nucleus to

start building new DNA. The new DNA is produced by a lengthwise split of the

DNA's ladder-like molecules, which provides exact templates to which the new

molecules, with help of the tRNA, attach. This process of synthesizing matched

copies of original DNA strands is called "REPLICATION."

14. Broadly speaking, the particular DNA sequence, or genetic information for a

given species is called its "GENOTYPE." All of the individuals in a species have

this genotype as a baseline of traits or characteristics such as basic size, shape,

gender, body parts, etc. Depending on the exact application of a given sub-field of

genetics, the term "genotype" may refer to an instinctive behavioral trait, a

physical characteristic, or to an entire species. (*18; composite of different humans) With this genotype as a starting point, environment, experience, and nurturing shape the individual organism during its life, giving each individual a both species-typical body <u>and</u> a unique form, called a "PHENOTYPE."

The <u>genotype</u> may be understood as the particular chemical formula or starting point for the development of traits and characteristics for a given species, but the <u>phenotype</u> may be understood as the resulting physical or behavioral manifestations of the actual physical bodies of individual members of that species. Technically, even the manifest <u>results</u> of genetically induced behavior— <u>beyond or outside of</u> – a species' physical bodies are sometimes considered phenotypes. For example, cities may be considered a phenotype of the human genes which evolved to favor social and cultural cooperation. (*19; city and beaver pond) Another example would be the lakes created by beavers' genetically induced gnawing behavior. The entire typical set of a species' total genetic information is called its "GENOME." In an amazing world-wide effort, scientists have recently "mapped out" the entire three billion gene positions of the human genome.

15. As individuals reproduce and continue the species, certain characteristics or traits are expressed, and certain others are not expressed. These characteristics are called, respectively, dominant and recessive. The genes responsible for passing of these characteristics to given individuals, such as eye color, or blood type, are called "ALLELES." (*20; eyes) Basically, <u>alleles are different forms of the same gene</u>. They will be found in the same location on the same chromosome with the

same length of chemical instructions; however, there will be very slight differences within the chemical sections, accounting for the differences in dominant or recessive characteristics.

16. There is still much to be learned about genes. They seem to be at the center of our ongoing search for how cells copy each other for growth and even for creating new individuals from older ones. Before cells <u>divide</u> for growth through "mitosis," their genes usually control a process where DNA strands duplicate and split apart. When this synthesis of creating new parts is accomplished, the new cells are practically exact copies of the previous "parent" cell, and this process is called cell reproduction.

17. In sexual reproduction, though, the process of "meiosis" provides a different kind of duplication and matching. Here, instead of one donor cell dividing into two daughter cells, there are two donor cells, combining separate contributions of the cells of the parents. Occasionally, the halves of the chromosomes do not find and bind to <u>exact</u> matches, and change occurs. This change process is called "MUTATION," an <u>abrupt heritable change in a single allele, gene or region of a chromosome</u>. Mutation is very typical in any species. Usually, a mutation is <u>not</u> copied any further, and there is no further change in the individual or the species. However, sometimes, the change can be beneficial, and the mutation stays with the organism and the species more or less permanently, as a positive mechanism for survival.

18. Recently, researchers have begun to use cells to copy entire organisms in laboratories without involving typically necessary sexual reproductive processes. This process, called "cloning," has moved from single-cell organisms to plants and animals. Thus a "CLONE" (*21; Dolly) is an organism <u>genetically identical</u> to a single ancestor, <u>produced by asexual reproduction</u>. There is an on-going debate about whether cloning humans is possible or ethically acceptable.

19. This brief lesson about genes, genetics, and heredity has probably been a mere review for most of you, but it is likely that your performance on the upcoming assessment will be much improved over the pretest you took before. I hope you have been able to benefit from this lesson, and that you will use it for accurate and thoughtful responses to the questions in the next part of this research. We will now convene for a posttest similar to the one you took a short while ago. Then we will ask for some final responses about your opinions regarding the content of this lesson. Of course, for the posttest, we hope you will be thorough, thoughtful, and even creative when it comes to the last sections on developing your own metaphoric descriptions regarding the structure, functions, products, and processes involved in genes, genetics, and heredity. Thanks again for your participation.

End

APPENDIX B

ASSESSMENTS

Pre-1
(ID: please write your initials and the last three numbers of your Bear Number- _____ +
___)
(Demographic information: Gender_____; Age_____; Major_____)

<u>INSTRUCTIONS</u>: Please complete and turn in each page in order. Do NOT look or work
ahead.

1. Please describe in the spaces provided below everything you know about GENES,
   GENETICS, HEREDITY and their **functions and processes,** linking the words or
   ideas you remember into <u>*full sentences*</u>.

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Please turn in this sheet before you start the next page.

Pre-2

(ID: please write your initials and the last three numbers of your Bear Number- _____ +
_____)

<u>Matching</u>

Please match the definition below with its term on the right. Mark your choice by writing
the letter of the term in the space at the beginning of its correct definition. No term will
be used more than once.

Definitions   Terms

Definitions	Terms
	a- chromosomes
	b- allele
1 ___ : one or more possible forms of a gene, affecting whether a trait is dominant or recessive.	c- genotype
2 ___ : basic unit of genetic code	d- diploid
3 ___ : genetic information about a <u>species</u>	e- protein
4 ___ : special protein type, which fuels assembly, reproduction, and change in an organism	f- centromere
5 ___ is the study of how traits of an organism are passed from one generation to the next	g- heredity
6 ___ : the primary <u>product</u> of genes	h- codon
7 ___ the specific <u>physical form</u> an individual attains through genes plus experience	i- chromatid
8 ___ Long molecular chains of chemically-coded genetic "instructions" for growth and regulation of cellular functions/activities, structures, and replication, specific and unique to each species	j- enzyme
	k- autosome
	l- phenotype

Please turn in this sheet and await further instructions.

Post-1

(ID: please write your initials and the last three numbers of your Bear Number- _____ + _____)

1. Now please summarize below what you recall of anything you ever knew about GENES, GENETICS, HEREDITY, *especially as a result of the recent video lesson*, linking the words or ideas you remember into full sentences.

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Please turn in this sheet before you go on to the next page.

Post-2

(ID: please write your initials and the last three numbers of your Bear Number- _____ + _____)

Please match the definition below with its term on the right. Mark your choice by writing the letter of the term in the space at the beginning of its definition. No term will be used more than once.

Definitions   Terms

Definitions	Terms
1 ___ : one or more possible forms of a gene, affecting whether a trait is dominant or recessive.	a- chromosomes
2 ___ : basic unit of genetic code	b- allele
3 ___ : genetic information about a *species*	c- genotype
4 ___ : special protein type, which fuels assembly, reproduction, and change in an organism	d- phenotype
5 ___ : is the study of how traits of an organism are passed from one generation to the next	e- proteins
6 ___ : the primary **product** of genes	f- enzyme
7 ___ : the specific **physical form** an individual attains through genetic coding	g- heredity
8 ___ Long molecular chains of chemically-coded genetic "instructions" for growth and regulation of cellular functions/activities, structures, and replication, specific and unique to each species	h- codon
9 ___ : change in a gene	i- replication
10 __ : an organism identical to a single ancestor, produced by asexual reproduction	j- genome
11 ___ : the synthesis of DNA	k- clone
12 ___ : the total genes in the basic set of chromosomes of an organism	l- mutation

Please turn in this sheet before you go on to the next page.

Post-4
(ID: please write your initials and the last three numbers of your Bear Number- _____ +
_____)

Of the following alphabetical list of possible metaphorical descriptors of
genes/genetics/heredity, which three, in order, make the most sense to you, **and why**?

- archives/libraries
- blueprints
- codes
- instruction manuals
- interchangeable parts
- computer programs
- recipes
- switches
- triggers

1st Choice

_____

_____

2nd Choice

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_____

3rd Choice

_____

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Are there any other metaphorical descriptions you can think of which might help you or
other students understand the concepts (especially the *functions and processes*) related to
GENES, GENETICS, HEREDITY? How?

_____

_____

Please turn in this sheet before we close this session with a debriefing page, time for
questions, and information about credit. Thanks again for your participation.

APPENDIX C

CONCEPTUAL INTEGRATION MATRIX:
BLENDS AND VITAL RELATIONS

Conceptual Integration Matrix: Blends and Vital Relations

Blend Type →	Simplex	Mirror	Single Scope	Double Scope
Vital Relations ↓				
1 Analogy				
2 Category				
3 Cause-Effect				
4 Change				
5 Disanalogy				
6 Identity				
7 Intentionality				
8 Part-Whole				
9 Property				
10 Representation				
11 Role				
12 Similarity				
13 Space				
14 Time				
15 Uniqueness				

APPENDIX D

INFORMED CONSENT FOR PARTICIPATION
IN RESEARCH

UNIVERSITY *of*
NORTHERN COLORADO

Project Title: A CONCEPTUAL INTEGRATION ANALYSIS OF INSTRUCTIONAL METAPHORS IN SCIENCE

Researchers: Dr. Kathryn Cochran and Robert Johnson
Contact Information: 970-351-1681; Kathryn.cochran@unco.edu
970-227-3758; robertbjohnson@go.com

This study is designed to test how well certain instructional metaphors help teachers educate students. Teachers use many metaphors in the course of instruction, in order to provide students with relevant examples of different aspects of a given topic.

In psychology, as distinct from literature, the term "metaphor" is used as a general reference to *any* figure of speech. Thus, metaphors per se, and also similes, irony, proverbs, etc. are lumped together as examples of metaphoric descriptions, unless there is a specific need to distinguish one kind from another. My work is designed to help teachers provide more effective metaphors in order to help students learn more information more accurately.

The study will consist of a pretest asking for some full-sentence responses and a brief matching quiz to establish a baseline of information about your current knowledge of genes, genetics, and heredity. Then you will be assigned at random to a smaller group to view an instructional video on the topic. After this brief video, you will be given a posttest involving the same basic information asked for in the pretest plus a few more questions about what you may have learned or recalled about the topic after seeing the video lesson.

Near the end of the posttest, you will be provided with a list of several descriptive metaphors used by science in the past for some of the structures, functions, and processes associated with the study of genes, genetics, and heredity. You will be asked determine and explain your reasoning of the three "best" descriptors. A final question is completely open-ended, asking you to name and explain—if possible—a different descriptor of your own which could help explain the topic.

We appreciate your help with this study. Should you decide to help us, we will proceed in this room right away. Your participation should be no more taxing or strenuous that taking a quiz. We are unaware of any risk of performing these tasks. However, should you choose to participate and find that any part is too distressing, you may quit at any time, for any reason, without penalty. We anticipate that this study will take no more than two hours to complete.

There is no deception in this study, and the test items are not tricks to see if you can find minor inaccuracies in terminology. The terms may, however, be somewhat different in detail than what you may know or recall from your own experience in previous class work. This is simply because we have taken the terminology from several sources; different specialists may have slightly different definitions for given terms, based on the specific uses in their respective fields.

We will also ask some basic questions about yourself (e.g., gender, age, major) to help our understanding of the demographics of your group and to allow us to organize the data effectively. We will make all of your individual data completely anonymous. Other than the researchers, no one will be granted access to your individual data. We will not release any information about you to your professors, other students, etc., and maintain a high standard of protecting your privacy.

After the initial pretest and subsequent grouping, at no time will any individually identifying information be used or disseminated. All reasonable measures and cautions will be taken to provide confidentiality. The proposed research involves no more than minimal risk to any participants.

At no time will you be exposed to any harmful environment or inaccurate information. Results will be reported only on the relative effects of the instructional metaphors on group performance. Upon completion of the study, I will share the results with any professors and students who so desire. Other than a possible improvement in understanding the topic, it is unlikely that your participation will result in any direct benefits to you as an individual. You will already have already received a credit slip for your class by keeping your appointment with us.

By signing below, you are acknowledging that:

1) You understand that participation in this study is only one way to satisfy the research experience for your PSY 120 class and that you may select an alternative assignment to being a research participant.
2) Participation is voluntary. You may decide not to participate in this study and if you begin participation, you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had the opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Sponsored Programs and Academic Research Center, Kepner Hall, University of Northern Colorado, Greeley, CO 80639; 970-351-1907.

Participant Signature: _____ Date: _____

Researcher as Witness: _____ Date: _____

DEBRIEFING

INSTRUCTIONAL METAPHORS IN SCIENCE

<u>WHAT THIS STUDY IS ABOUT</u>:

This study is designed to test how certain types of teacher language in a lecture format affect student learning. To that end, the two groups of participants have been presented with nearly identical instructional videos containing small but very specific differences in the metaphoric language used by the instructor. The common current and most widely used metaphors about the topics—genes, genetics, and heredity—have been presented.

We have provided a format including both quantitative assessment, in the form of a matching quiz, and qualitative assessment in the form of short-answer written responses. We will compare the quantitative results of the different groups to determine if either of the two primary metaphors in question, that is, "blueprints" or "recipes," have any inherent relative strengths or weaknesses. The written answers will be analyzed for more subtle differences in use or understanding.

First we will determine if either group's changes in qualitative scores match observable changes in frequency or elaboration of the metaphors participants use in their written responses. Then we will try to determine how much of any changes in language may be attributable to mimicry of different metaphors used in different lectures. Finally, using a technique specifically designed for this research, we will test whether improved selected-response scores in the posttest reflect improved understanding through the use of a specific, given, metaphor, or if the act of elaborative thinking involved in using metaphors more deeply in itself develops the understanding of the concepts being taught.

In short, we will use the information gathered in this research to help teachers do a better job of explaining sometimes hard-to-understand topics such as genes, genetics, and heredity. Please ask any question you like now or via email: Robert Johnson (Principle Investigator) john5602@bears.unco.edu or Dr. Kathryn Cochran (Faculty Sponsor) Kathryn.cochran@unco.edu.