The Experience of Doing Science with an Artistic Spirit:

A Hermeneutic Phenomenological Study

by

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Abstract

This qualitative research study explored the perceived experiences of doing science with an artistic spirit through the voices of living scientists who also engage in the arts. The purpose was to understand how accomplished scientists who engage in the arts make sense out of their experience of doing science and to gain the scientists' perspectives on the context of their experience. Four highly able scientists (ages 31-61) with expertise in their field who also self-identified as actively engaged in the fine arts were given a voice on the following issues: 1) What are your perceived experiences of doing science? As such, what can we infer about the role of the arts in doing science? 2) Based on personal experiences, are there implications for the integration of the arts and sciences in education? Through hermeneutic phenomenological methodology using thematic analysis, four major themes emerged: 1) Risking Success in a Scientific Vocation; 2) Feeling Healthy through the Arts (Satisfying an Inner Drive; Coping in a Stressful World); 3) Gaining and Giving Different Perspectives through the Arts (Complementary Tools of Perception; Complementary Processes of Perception); 4) Feeling Connected to Something More through the Arts. Each theme alluded to some aspect of aesthetic experience or extracognition, emphasizing the role of the arts in attaining such experiences. Educational implications are discussed in light of aesthetic experience, extracognition, and also interdisciplinary education in today's context of science education.

Table of Contents

Abstract.....	ii
Table of Contents.....	iii
List of Tables.....	vi
List of Figures.....	vii
Preface.....	viii
Acknowledgements.....	x
Dedication.....	xi
 CHAPTER 1 Literature Review.....	 1
1.1 Introduction.....	1
1.2 Definitions.....	2
Science.....	2
Art.....	2
Highly Able.....	3
1.3 Historical Interplay of Science and Art in Highly Able Scientists.....	3
1.4 Conceptualizing an Artistic Spirit Today.....	5
Aesthetic Experience and Extracognition.....	6
Aesthetic Experience.....	6
Extracognition.....	7
Unity in Experience.....	8
Aesthetic Experience.....	8
Intuition and Beauty.....	9
Summary.....	12
The Role of Emotion in Experience.....	13
Aesthetic Experience.....	13
Intuition and Beauty.....	14
Summary.....	15
Summary of Artistic Spirit.....	16
1.5 Practice in Education.....	17
Unity in Experience.....	17
Making Connections Beyond Consciousness.....	17
Holism.....	18
The Role of Emotion in Experience.....	19
Excitement and Motivation.....	19
Moral Goodness.....	20
Summary.....	20
Israel Arts and Science Academy.....	21
Philosophy.....	21
Interplay of Art and Science.....	22
1.6 Literature Review Summary.....	23
 CHAPTER 2 Research Question.....	 24
2.1 Acquiring the Question.....	24
2.2 Specific Aims.....	25

2.3 Questions.....	25
CHAPTER 3 Methodology.....	27
3.1 Research Design.....	27
3.2 Participants.....	29
3.3 Data Collection.....	30
Interviews.....	30
First Interview.....	30
Second Interview.....	32
Third Interview.....	32
Observations.....	33
Field Documents.....	33
3.4 Data Analysis.....	34
Phenomenological Mind-Frame of the Researcher.....	34
Researcher Positionality.....	34
Hermeneutic Mind-Frame of the Researcher.....	36
Description of Thematic Analysis.....	37
Thematic Analysis.....	37
Setting Participants' Contexts.....	37
Individual Thematic Stories.....	38
Merged Thematic Story.....	43
3.5 Strengths and Weaknesses of Methodology.....	48
Strengths.....	48
Weaknesses.....	49
3.6 Ensuring Credibility.....	50
Clarifying Researcher Bias.....	50
Prolonged Engagement and Persistent Observation.....	50
Triangulation.....	51
Thick Description.....	51
Member Checks.....	52
3.7 Ethical Issues.....	52
CHAPTER 4 Results.....	54
4.1 Introduction of Participants.....	54
Setting Participants' Contexts.....	56
Spatial World.....	56
Nina's Spatial World.....	56
David's Spatial World.....	58
Naori's Spatial World.....	61
Kent's Spatial World.....	64
Temporal World.....	66
Nina's Temporal World.....	67
David's Temporal World.....	69
Naori's Temporal World.....	72
Kent's Temporal World.....	74

4.2 Thematic Story.....	76
The Experience of Doing Science with an Artistic Spirit.....	76
Risking Success in a Scientific Vocation.....	76
Feeling Healthy through the Arts.....	79
Satisfying an Inner Drive.....	80
Coping in a Stressful World.....	81
Gaining and Giving Different Perspectives through the Arts.....	84
Complementary Tools of Perception.....	85
Complementary Processes of Perception.....	89
Feeling Connected to Something More through the Arts.....	92
4.3 Summary.....	98
CHAPTER 5 Discussion.....	99
5.1 Recapping the Research Question and Results.....	99
5.2 Reflection on the Literature.....	100
The Role of Emotion in Experience.....	100
Risking Success in a Scientific Vocation.....	101
Gaining and Giving Different Perspectives through the Arts.....	102
Unity in Experience.....	103
Gaining and Giving Different Perspectives through the Arts.....	104
Feeling Connected to Something More through the Arts.....	106
Feeling Healthy through the Arts.....	107
5.3 Educational Implications.....	108
5.4 Limitations of the Study.....	111
5.5 Strengths of the Study.....	113
5.6 Future Directions.....	114
5.7 Impact on the Researcher.....	116
5.8 Impact of the Researcher.....	121
5.9 Conclusion.....	122
CHAPTER 6 Epilogue.....	123
Bibliography.....	125
Appendix A: Letter Requesting Participant Nomination	132
Appendix B: Letter of Initial Contact.....	134
Appendix C: Consent Form.....	136
Appendix D: Background Information Form.....	139
Appendix E: Ethics Approval.....	140
Appendix F: Ethics Amendment.....	142
Appendix G: ‘The Art of Science’ Poster.....	144

List of Tables

Table 3.1. Summary of Themes and Thematic Statements from Individual Accounts.....	41
Table 3.2. Initial Combination of Themes from Individual Thematic Stories	45
Table 3.3. Major Themes Identified by Participants.....	46
Table 3.4. Summary of Major Themes and their Importance to the Experience of Doing Science as an Artist	47
Table 4.1. Participant Demographic Information.....	55

List of Figures

Figure 4.1. Science-Fiction by Nina.....	57
Figure 4.2. Sculptures by David.....	59
Figure 4.3. Chinese Painting by David.....	60
Figure 4.4. Naori's photography of her early work, "Le Jardin de L'Esprit," that she choreographed and directed for the filming done by a film artist. The piece was her first venture into the spiritual realm	61
Figure 4.5. Naori performing in a piece called "The Seed", directed by the leader of Wildfire at the annual Hemp festival.....	62
Figure 4.6. Naori doing improvisational dance in "Manufacturing Zero" – improvisational performance for Petri's Quadrille.....	62
Figure 4.7. Theremin instrument Naori used to alter projection landscapes for multidisciplinary project entitled "Transformation."	63
Figure 4.8. Atomic force microscopy images (5 x 5 μm) of fungal spores (A) and high resolution images (0.5 x 0.5 μm) of the spore surface (B, C). The colour image is a projection landscape of the "soil/fungal" cyberworld. A fellow-collaborator used images of fungal spores (top) to come up with a soil cyberworld (bottom) with which Naori interacted through improvisational dance in "Transformation."	63
Figure 4.9. Paintings by Kent.....	65
Figure 4.10. Nina's temporal world engaging in sciences and arts.....	67
Figure 4.11. David's temporal world engaging in sciences and arts.....	69
Figure 4.12. Naori's temporal world engaging in sciences and arts.....	72
Figure 4.13. Kent's temporal world engaging in sciences and arts.....	74

Preface

My love has always lain in visual art, not for any complicated reason. I simply appreciate its direct qualities of beauty, colour, and physical creation. I enjoy its invitation for openness and expression of self in both the maker and perceiver.

That said, what is the purpose of the arts in life today? I feel that quite often the arts are under-valued in terms of their purpose in daily life, especially in comparison to the sciences. Personally, I have grown up gravitating towards the arts, but never quite doing it because it is a field that offers “no opportunity.” As such, I am always interested in finding reasons for the arts in life and hoping to give them the status I always somehow felt they deserved.

A few things happened that inspired me to do this research. First I met a nuclear physicist who spoke of finding a beautiful formula through playing around with drawings and the visual of a flower. Coincidentally, the next week I read an article about history’s elite scientists who spoke of their experiences in terms of extracognition, which to me sounded very artistic and related to the nuclear physicist’s experience. I have also briefly come in contact with a program for highly able students who gain early admittance to university. I was surprised to hear how science-oriented the program is and saddened to hear a student express her enjoyment of the arts, which it is not well-supported in the program. Finally, in talking to my most inspirational art teacher over the summer, he told me of the stipulations being put on his art classes (which were entirely inspiring to me in grade seven). Again, I was saddened to hear of the arts being pushed to the wayside.

Considering these things, I am using this opportunity to seek understanding of art’s purpose in today’s society against the backdrop of what I feel certainly has purpose in today’s society: science. I feel that if anyone were to speak to the relevance and meaning of the arts

today it would be scientists themselves who have incorporated artistic engagement into their lives. What then are the experiences of scientists who engage in the arts?

Acknowledgements

This thesis would not have been brought to life if it weren't for the four participants who tuned it with their voices. Many thanks for your dedication, insight, and humour during your busy lives. You've made this a fun and rich learning experience for me.

I would also like to acknowledge my supervisor, Dr. Marion Porath, for your unconditional support and faith in this. Thank you for your eagle-eyed editing and most of all for reminding me to get out and enjoy the arts and life in general. This wouldn't have been as complete an experience if you hadn't encouraged me in Life Balance.

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Dedication

Since I don't get to make too many formal dedications,
here's to my close ones...

To my Mom, Helen, and my Dad, Simon, for your endless artistry in setting me on wide-open
paths and your consistent love that always brings me back.
I love you.

To my brother, Mark, for seeing my potential whenever I don't and for pushing me in the nick
of time to come to such a beautiful university and explore beautiful people and beautiful ideas.

To my best friend, Ashika, for balancing every journey of my life since I left home, including
this one. You're my favourite serendipitous discovery.
Kampai!

Chapter 1

Literature Review

“After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well.”

- Albert Einstein (as cited in Kaplan, 2001, p. 37)

1.1 Introduction

The work of eminent educator, Elliot Eisner, and educational work influenced by him advocate for the arts in education (Berghoff, Bixler Borgmann, & Parr, 2003; Descollonges & Eisner, 2003; Eisner, 1991, 2003a, 2003b, 2005; Marquez-Zenkov, 2003) in a society that often marginalizes the arts (Eisner, 2003a; Winner & Cooper, 2000). History, however, shows that eminent scientists also engaged in the arts, such as “Renaissance man” Leonardo da Vinci (Deckert, 2001), not to mention, for example, 400 other cases of famous scientists who also practiced art at a high level (Root-Bernstein, 1989). If not entirely engaged in the arts, highly able scientists throughout history have at least engaged in science with an artistic spirit, a term brought up in the call for participation at Building the Scientific Mind Colloquium (2007). For example, of five correlations between artistic and scientific creativity, one is that scientists and artists use common tools for thinking such as intuition and imaginative processes (Root-Bernstein & Root-Bernstein, 2004). Indeed, the literature shows shared themes amongst concepts of aesthetic experience, extracognition, intuition, and beauty, which will all be considered in light of artistic spirit.

1.2 Definitions

This research focuses on highly able scientists who engage in the arts. As such, the conceptions of science, art, and highly able must be understood. First consider their etymologies and then explanations for the purpose of this study.

Science

Science comes from the Indo-European root “skei-” meaning “to cut” or “to split” (Skei-, 1997). As such it implies a reductionist outlook on investigation and understanding in life. For the purpose of this research, science is understood in terms of an occupational practice belonging to scientists. Scientists are defined as people with expert knowledge of one or more sciences, especially natural or physical sciences (Scientist, 1997). For this study, I define the domain of science as limited to the natural or physical sciences as opposed to the social sciences. This definition complies with the participants’ expertise.

Art

Art comes from the Indo-European root “ar-” meaning “to fit together” (Ar-, 1997). As such it implies a holistic outlook on investigation and understanding in life. When we think of art, it is often in terms of its final product, but for the purpose of this research, art is understood as both product and process (Dewey, 1934) whereby quality of the product is not necessarily the only measure of artistic engagement and composition, but also the process of getting there in which artistic imagination is used and holistic understanding might be accomplished. In other words, scientists who engage in art are not only meant to be understood as composing a final product of art, but are understood as composing it with artistic and aesthetic processes, which will be outlined more in depth in the section on conceptualizing an artistic spirit today.

Highly Able

“Able” comes from the Indo-European root “ghabh-” meaning “to give or receive” from which “gift” is also derived (Ghabh-, 1997). It is defined as having sufficient ability and being capable or talented (Able, 1997). For the purpose of this research the highly able are generally understood as those who have given and received much in their field of science. Typically there are two models of thought that capture what giftedness and ability are. Ericsson, Nandagopal, and Roring (2005) cite Galton’s view as being the first on giftedness; it argued for innate ability in attaining eminent achievement. Ericsson et al., however, cite much literature that now recognizes heritable talent as a constraint on achieving expert performance. This perspective speaks more to a developmental model of high ability than an innate model. Because this research focused on highly able scientists, based on attaining a certain level of education, “highly able” is primarily viewed in light of a developmental perspective, and more specifically an expert-performance perspective (Ericsson et al.), where high ability might be assumed after gradual engagement and deliberate practice in the field. Identifying highly able scientists based on level of education implies time enough spent to have “given and received” in their field of study and to become experts as is suggested by the definition of “Scientist” (Scientist, 1997). It is important to note, however, that this study was certainly open to other perspectives on high ability, but it was felt that the expert-performance perspective best captured the way participants were identified.

1.3 Historical Interplay of Science and Art in Highly Able Scientists

Literature shows that often highly able scientists also engaged in the arts to a high degree (Potter, 2006; Root-Bernstein, 1987; Root-Bernstein & Root-Bernstein, 2004). Perhaps the most obvious historical figure who captures the interplay of science and art is Leonardo da Vinci

(1452-1519). In his work, art and science supported one another harmoniously (Potter, 2006). He was not only a renowned artist of the Renaissance, but also a scientist of many facets such as botany, civil engineering, hydrology (Potter, 2006), and anatomy (Nicholl, 2004; Zwijnenberg, 1999). Just as Leonardo da Vinci demonstrated both scientific and artistic spirit in his life attainments, a myriad of other eminent individuals expressed the same spirit. In particular, Root-Bernstein (1989) found 400 instances in which famous scientists also considered artistic careers and were highly able in art as adults. One example of many is Roger Guillemin (1924-present), Nobel laureate who isolated the first peptide hormones, and a painter and professional computer artist (Root-Bernstein & Root-Bernstein, 2004).

In reflecting on eminent scientists throughout history, it appears as though the skills, abilities, and perspectives in the arts complement those of discovery in the sciences. Root-Bernstein (1987) notes that engagement with music, the arts, poetry, and literature shapes our personalities and it is from our personalities that grand ideas arise. While Root-Bernstein (1987) shows that the arts have shaped the kinds of personalities that meaningfully contribute to the biomedical arena, other scientific arenas such as engineering and physics are also shaped by artistic personalities, as exemplified in Leonardo da Vinci.

To further illustrate the point that scientists find the integration of an artistic spirit important, consider their inspiring quotes. Physicist and Nobel laureate, Allan Cormack, says “The abstractions [I do in mathematics] are just as beautiful [as in art] and I find them more satisfactory” (as cited in Shavinina & Seeratan, 2004, p. 85). Furthermore, Max Planck, father of quantum theory, proposed that pioneering scientists “must have a vivid intuitive imagination, for new ideas are not generated by deduction, but by an artistically creative imagination” (as cited in Shavinina & Seeratan, p. 90). Einstein furthermore sums up the interplay of science and art by

saying, “After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well”

(Kaplan, 2001, p. 37). Finally, Phenix, author of *Realms of Meaning*, states that “as between science and art, the priority developmentally seems to rest with art, this being the more immediate and intuitive ground from which the rationalistic and generalizing scientific meanings subsequently develop” (as cited in Innamorato, 1998, p. 58). It is clear that great minds of our times have considered the interplay between the arts and the sciences to be of great importance as evident in their artistic spirit in doing science.

1.4 Conceptualizing an Artistic Spirit Today

The aforementioned scientists speak to high ability in science in light of an “artistic spirit.” What is that “artistic spirit”? Upon investigating the creative processes of gifted scientists, artistic spirit might best speak to the notions of *aesthetic experience* (Dewey, 1934) and *extracognition* (Shavinina & Ferrari, 2004). Shavinina and Ferrari reveal “extracognition” as a new concept in the development of high ability, especially in the sciences. Many facets of extracognition indeed, however, seem to have aesthetic qualities that resonate with the arts as described by Dewey’s (1934) theory of art as an experience. The aim of this section is to extract some common themes of aesthetic experience and extracognition, in terms of two of four aspects of extracognition: a) intuition and b) specific feelings like that of beauty. For the purpose of this research, the other two aspects of extracognition - “specific beliefs” and “preferences and values” will be excluded. While all aspects of extracognition are nonetheless related, the main reason for the exclusion of these last two is that in using such search terms in the electronic database PsycINFO, too many ambiguous articles resulted in which these concepts were not central to the paper. As such, in keeping focus on intuition and feelings of beauty, the themes that arose and resonated with aesthetic experience are: a) unity in experience, and b) the role of emotion in

experience. These two themes will be explored in detail after first briefly exploring aesthetic experience and extracognition separately.

Aesthetic Experience and Extracognition

The theory of aesthetic experience primarily addresses engagement with the arts (Dewey, 1934), while studies on extracognition primarily address highly able engagement with the sciences (Shavinina, 2004). While Dewey's theory of aesthetic experience is slightly older, Shavinina's of extracognition is relatively new.

Aesthetic Experience

Aesthetic experience comes from Dewey's (1934) *Philosophy of Art*. He wrote a major philosophical work entitled, "Art as Experience," that speaks to the formal structures and effects of all the arts, such as painting, music, and literature, on life. This work has credence in the world of education, philosophy, and psychology.

What then is aesthetic experience all about? Dewey (1934) considers art itself to be real, complete, fulfilling, and thereby an aesthetic experience. As such, art must be properly defined. Art is both product and process according to Dewey. While the term "artistic" refers to the product and "aesthetic" refers to the process of perception and enjoyment, true art of human nature combines the two. For example, consider a chef who is cooking a meal. The artistic product is the meal; the artist is the chef; and the aesthetic perception and enjoyment is a customer's consumption of the meal. While it appears that the art of making a meal lies in its final product, Dewey states that true craftsmanship must be "loving" and care deeply for the product during process. Machines can produce items of pure artistic nature without the aesthetic experience, but humans who engage in art must engage in both the artistic and aesthetic nature of art for it to be complete and meaningful. As such, art and making art is defined not only as mere

artistic production, but also aesthetic experience of perception and enjoyment. Reflecting on the whole aesthetic experience, it encompasses realness, completion, and fulfillment.

Extracognition

Extracognition is a relatively new concept particular to the study of high ability (Shavinina & Ferrari, 2004) and seemingly resounds with the philosophical ideas of aesthetic experience (Dewey, 1934). A review of the literature on PsycINFO reveals that few articles other than those used in Shavinina and Ferrari's (2004) book entitled *Beyond Knowledge: Extracognitive Aspects of Developing High Ability* use this terminology.

What then does extracognition mean? According to Shavinina (2004), extracognition, particularly in Nobel laureates, includes the following aspects that contribute to high ability, especially in the sciences: a) intuitive processes; b) specific feelings of direction, harmony, beauty, and style; c) specific preferences and values in terms of a chosen field; and d) specific beliefs. Overall, extracognition refers to all things that are not cognitive and all contributions that do not come from basic cognitive influences (Runco, 2004).

What role does extracognition play in the creativity of highly able scientists? Shavinina and Seeratan (2004) did a comprehensive study looking at autobiographical and biographical findings on scientific geniuses and also qualitative interviews with gifted 15 and 16-year-old students of physics and mathematics. From the autobiographical and biographical accounts of past scientists, they came up with the four aspects of extracognition and even found similar findings in gifted adolescents, namely: a) feelings of direction; b) specific beliefs such as the feeling of truth and faith in the power of ideas; and c) specific preferences like an aspiration towards harmony and beauty.

Unity in Experience

Aesthetic experience and extracognition (in terms of intuition and beauty) will now be explored as merged under the theme of unity in experience. Aesthetic experience will focus more on the philosophical grounds of unity, while intuition and beauty will be more detailed in reference to the current literature.

Aesthetic Experience

Dewey (1934) explicitly speaks of “unity in experience” as a key description of having an aesthetic experience. He describes such experiences as continuous flow where there are no holes but constant movement. In other words, there is a single quality about the experience despite the variation of its parts. In its purest form, the immediate action of unity in experience is not emotional, practical, or intellectual. Only by *talking about* an experience and reflecting on it can we assign such characteristics according to Dewey. *Having* an aesthetic experience in the moment involves a pure process of unity, flow, and movement. In concurrence with this notion is Csikszentmihalyi’s (1997) concept of flow whereby all our conscious experiences are in harmony with one another.

In terms of art, this unity in experience seems to touch primarily on process. Nevertheless, Dewey (1934) combines it with the notion of art as a product. In addressing the issue of art as product or final conclusion, Dewey describes “conclusion” as no separate thing but as “the consummation of a movement” (p. 38). In other words, the culminating product of art carries with it the unity of movement that went into it. Furthermore, there is that human quality in its conclusion that came from the flow and interaction of a living being with the environment (Dewey) that gives us a relationship with the whole world (Csikszentmihalyi, 1997).

Intuition and Beauty

A more extensive literature review was done on the extracognitive concepts of intuition and beauty. While these two concepts are different, they are both included as components of extracognition, and share similar themes which indeed resonate with aesthetic experience. Detailed extractions on the theme of “unity in experience” are: a) making connections beyond consciousness, and b) holism. It is assumed that these ideas speak to the concept of unity.

Making connections beyond consciousness. Making connections beyond consciousness may be the most difficult to understand and also may be somewhat of a stretch in likening it to both intuition and beauty. To clarify, intuition taps neurological ideas of making unconscious connections between ideas and patterns. Beauty, on the other hand, taps a more humanistic idea of making spontaneous connections between oneself and the world. Both, however, speak to a transforming experience whereby intuition may result in new ideas and beauty may result in new perspectives on the world on a larger level.

In their extensive literature review, Sinclair and Ashkanasy (2005) found that one running theme of intuition is that it is derived from somewhere beyond consciousness. As such, intuition occurs as a gut feeling or an unknown realization that might be described as: a) pattern recognition (Anderson, 2003; Frantz, 2003; Sinclair & Ashkanasy, 2005; Volz & von Cramon, 2006; Welling, 2005) or b) flat activation (Gabora, 2002). In particular, pattern recognition is an unconscious process whereby we recognize pieces of missing information that should be there and consequently make connections (Welling, 2003). In turn, the notion of non-verbalism is related. Welling (2003) cites Schooler and Melcher who stated that insight in innovative tasks follows more of a nonverbal trajectory because verbalization interferes with achieving insight. For example, a painting holds a thousand words all of which can be understood at the same time, as opposed to the linear understanding of a novel. As such,

connections between non-verbal patterns can be made, transforming the given ideas to an enlightened perception of new ideas.

Another way, in terms of intuition, to explain the unconscious connectivity between ideas is through the cognitive perspective of flat activation (Gabora, 2002) and neurological evidence of intuitive spontaneous thought (Christoff, 2007). Specifically, in terms of flat activation, the human mind has a variety of memory locations that are filled with experiences and things we know (Gabora). When we brainstorm, we loosen up our usual neural connections from one idea to the next and we let new insights come. This happens through “flat activation” (Gabora). It is like defocused attention. It is as though every memory location is stimulated almost equally so that none takes precedence over the other. Gabora uses the example of “snowman.” “Snow” and “man” are not usually connected in our minds, but during flat activation they are given almost equal attention and so have the opportunity of melting together and combining to form the creative new concept of “snowman.” In addition, Christoff’s neurological research on intuitive spontaneous thought suggests something similar in that when our brains are at rest, they are more highly activated than when involved in a task. This suggests that when we are not involved in tasks, we are engaging in rich ideas be they through intuitive and spontaneous thought processes. This research gives a whole new perspective on human thought and where creative thoughts may come from. Flat activation and neurological evidence allude to the notion that a wide range of ideas and indirect activation of those ideas might foster creativity and new discoveries by way of making connections beyond consciousness.

The notion of beauty more clearly speaks to the theory of aesthetic understanding, but similar to intuition, shares the idea of making connections. In particular, the experience of beauty is a unified experience of the inner and outer (Hagman, 2002) where aesthetic understanding involves making connections between the self and the world and in that respect is

transforming (Girod, Rau, & Schepige, 2003). In other words, the way in which we understand our world by making connections to it will transform us to a new consciousness. In this sense, interaction with the world culminates in a unique ending perhaps similar to the transformative “aha” of pattern recognition as discussed in relation to intuition. For example, in teaching 4th-graders about geology in an aesthetic way, one student transformed her perspective on rocks and how they are situated in the world by seeing them as each having a unique story. Furthermore, she changed her perspective on the world in seeing everything as having its own unique story, even in terms of concepts such as the number 2 (Girod et al.). In comparison to intuition whereby pattern recognition and non-verbal reflection provoke a new way of knowing information, Girod et al. state that aesthetic understanding transforms the individual into a new way of seeing the world as a whole, and not just ideas in themselves.

Holism. The concept of holism resounds with Dewey’s (1934) concept of having unity in experience whereby there is a single quality to a “real” experience despite the variation of its parts. While intuition and beauty can both be understood in light of holism, distinctions can nevertheless be made. Holism speaks to intuition on the grounds that information and ideas are processed holistically. It focuses on the way in which ideas are formed and unified. On the other hand, holism speaks to beauty on the grounds that the person is made whole with ideas and the universe. This theme is somewhat similar to the first theme’s aspect of making connections.

During intuition, information is processed in a holistic way (Sinclair & Ashkanasy, 2005). In other words, information is processed non-sequentially. A current way to understand this non-sequential processing is in light of what Mintzberg would describe as synthesizing “unconnected memory fragments into a new information structure” (as cited in Sinclair & Ashkanasy, p. 357). This perspective plays on the idea that ideas in and of themselves are unified. An older way, however, of looking at information as processed non-sequentially is in

placing it in line with the big picture where ideas are unified with historical and cultural contexts. This idea comes from Jung and certainly depth psychology, which is a psychology that embraces the physical, psychological, and the spiritual (Reynolds & Piirto, 2005), might best speak to it. As such, ideas might resonate with historical and cultural patterns. Whether ideas are connected amongst themselves or to the larger picture, the common denominator is that they are formed based on non-sequential information processing.

A similar theme that Girod et al. (2003) find in aesthetic understanding is that beauty is unifying, thus speaking whole-heartedly to Dewey's (1934) theory of aesthetic experience. Here, unity somewhat reflects the feelings of connection between the self and the universe as exemplified in depth psychology (Reynolds & Piirto, 2005). Rather than simply focusing on the unity of ideas, however, beauty aspires to building connections with others, with the earth, and also then with valuable ideas (Girod et al.). Girod et al. go on further to explain that aesthetic understanding unifies the past with the future and unifies parts, ideas, and concepts that result in a beautiful whole. For example, upon understanding each part of the periodic table, one can see the unified beauty in the structure of chemistry. Hagman (2002) echo the notion that having that sense of beauty in seeing the wholeness of an object can also integrate a fragmented self. While intuition speaks more specifically to the holistic processing of information, beauty complementarily speaks broadly to the holistic integration of the self with information, other people, and the world as a whole.

Summary

In reflection on Dewey's theory of aesthetic experience in part, it is evident that the newer concept of extracognition (at least in terms of intuition and beauty) resounds thematically on the grounds of "unity in experience." In particular, however, intuition and beauty speak more specifically to: a) making connections beyond consciousness, and b) holism. It is important to

recognize that while this literature review is grouping concepts into broadly shared themes, there is inevitably room for differences as well.

The Role of Emotion in Experience

Following the idea of unity in experience, emotion plays an integral role as well for both the aesthetic experience and in terms of documentation of the extracognitive concepts of intuition and beauty. While an exploration of aesthetic experience yields philosophical grounds for the role of emotion in experience, investigations of intuition and beauty are grounded more in the current literature.

Aesthetic Experience

Dewey (1934) speaks directly to the role of emotion in aesthetic experience. In fact, he states that no experience is *an* experience, an aesthetic experience, without emotion. Furthermore, it is emotion that threads together dissimilar parts of an experience to a unified whole (Dewey).

In terms of art, emotion is the force involved in both process and product (Dewey, 1934). It guides the accomplishment of a process. Dewey gives the example of two men who meet where one is an applicant for a position and the other decides whether he gets hired. Here, emotion plays a role during the process of the interview whereby it might begin with the applicant feeling hope or despair and conclude with the feeling of joy or disappointment. As such, these emotions give unity to the experience; they are woven throughout the entire interview making it complete. Furthermore, during the interview, interacting emotions of the applicant and interviewer guide the conclusion whereby a joyous conclusion is gained through harmonious interaction between the applicant and interviewer and a disappointing conclusion results through inharmonious interaction. Similarly, an artist goes through a process whereby he or she can emotionally connect parts of an experience into a unified and harmonious whole.

Emotion is the thread throughout the process that integrates the parts into a meaningful product or conclusion.

Intuition and Beauty

Emotion is also an important theme in both extracognitive concepts of intuition and beauty. While the literature reviewed on intuition focused on the neurological connection between intuition and emotion, the literature reviewed on beauty spoke more to the personal emotion evoked from beauty resulting in excitement and moral goodness.

Neurological evidence. In their review on the concept of intuition, Sinclair and Ashkanasy (2005) found that indeed intuitive perceptions often go hand in hand with emotion. Other authors agree (Greene & Haidt, 2002; Sadler & Zeidler, 2005; Volz & von Cramon, 2006). Neuroscientific literature shows that specific neurological structures and neurons involved in emotional and affective behaviour are also involved in intuitive decision-making (Allman, Watson, Tetreault, & Hakeem, 2005; Volz & von Cramon). More specifically, Volz and von Cramon cite Bechara, Tranal, and Damasio's work showing that damage to the ventromedial prefrontal cortex results in poor decision-making that lacks emotional integration. Furthermore, Allman et al. hypothesize that specific types of neurons play a role in both intuition and emotion whereby their irregular development may contribute to autism and its characteristic social-emotional disabilities, which results from faulty intuition. Finally, Greene and Haidt (2002) take a moral perspective on the role of intuition and emotion in decision-making. They note studies such as Anderson, Bechara, and Damasio's work whereby patients with damage to the ventral, medial, and polar aspects of the prefrontal cortex are immoral and lack emotionally intuitive decision-making capabilities. Overall, neuroscience tells us that intuition and emotion are indeed tied together at the micro-level and result in socially appropriate and moral decision-making.

Excitement. Fittingly, the final theme in Girod et al.'s (2003) study similarly states that aesthetic understanding of beauty involves emotion in which understanding is compelling and dramatic. It was found that emotion from beauty can be tied to excitement and moral goodness. In their study of 4th-graders who were taught about geology in an aesthetic way, they found that for those students who gained aesthetic understanding, emotion was involved such that the object, rocks, took on a whole new meaning that actually got them excited.

Moral goodness. While beauty can evoke emotional excitement, the understanding of it can also evoke moral goodness (Diessner, Rust, Solom, Frost, & Parsons, 2006; Winston, 2006). Beauty is often viewed as lacking in utility, yet Winston suggests that it promotes social justice. Perhaps the term “humanity” can be used to describe the effect of feelings of beauty. In using the rock example, a moral sensitivity towards rocks is gained in which one girl feels she can no longer throw rocks into the water because it is like throwing away stories. Another example where beauty breeds humanity for social justice is found in a community arts project for preschool children and their parents (Winston). While some doubted the usefulness of such an event, it nevertheless was described numerous as beautiful by parents and workers who saw the production. Winston describes this beauty as morally appealing in that the beauty of the project's plot directly dealt with altruism whereby children were encouraged to engage in the act of sharing with homeless creatures. While intuition speaks more clearly to neurological connections with emotion, beauty connects with emotion in terms of excitement and moral goodness.

Summary

In reflecting on Dewey's (1934) theory of aesthetic experience in terms of the “role of emotion,” it is evident that extracognition's aspects of intuition and beauty resound. In particular, however, intuition speaks more specifically to a neurological connection with

emotion, and beauty speaks more specifically to emotion as involved in excitement and moral goodness.

Summary of Artistic Spirit

In an attempt to ultimately better understand the experience of doing science with an artistic spirit, this part of the review has taken a deep look at concepts involved in an artistic spirit. The reason why concepts were explored deeply is because notions like extracognition are new (Shavinina & Ferrari, 2004) and there is much to gain in understanding them. First, artistic spirit was considered in terms of aesthetic experience (Dewey, 1934) for a philosophical grounding. Second, artistic spirit was considered in terms of extracognition with particular reference to intuition and beauty for a newer perspective on the experiences of highly able scientists (Shavinina, 2004; Shavinina & Seeratan, 2004). What ensued were shared themes between what highly able scientists experience and what Dewey philosophizes as experiences inherent in the arts. These themes were: a) unity in experience, and b) the role of emotion in experience. While these themes speak directly to Dewey's theory of aesthetic experience, a review of the literature on intuition and beauty suggests a more detailed account. Namely, "unity in experience" refers to making connections beyond consciousness and the idea of holism. "The role of emotion in experience" refers to its neurological underpinnings in terms of intuition and excitement and moral goodness in terms of beauty. In tying the theme of emotion to that of unity, it seems evident that emotional responses of awe, interest, and excitement will transpire upon the realization of unity. Ultimately, in synthesizing these themes between the role of intuition and beauty as aesthetic experiences, we might better understand the grounds on which art and science can interact and evolve into a high state of creativity.

1.5 Practice in Education

In taking the concepts of aesthetic experience and extracognition to a practical level, Girod et al. (2003) state, “If we are to truly educate our children, we must develop both the scientist and the artist within them” (p. 577). How then can we develop both the scientist and artist within? Are the aforementioned themes of “unity in experience” and “the role of emotion in experience” a part of the answer? A collection of work speaks specifically to science education in light of these themes in an artistic spirit (Alexenberg, 2005; Battles & Rhoades Hudak, 2005; Charyton, 2006; Girod et al., 2003; Girod & Wong, 2002; Innamorato, 1998; Wickman, 2006). This section is meant to specifically address science education.

Unity in Experience

Making Connections Beyond Consciousness

Making connections beyond consciousness is significant for fostering scientific discovery in two ways: a) pairing art and science as subjects enables creative connections, and b) the realization of creative connections transforms the individual. First, in pairing art and science, unforeseen connections might be made, as discussed from the cognitive perspective of flat activation (Gabora, 2002). This raises the question of whether or not an integrated curriculum of art and science would facilitate creative thinking. It certainly seems that if artistic and scientific experiences fill up our memory locations, brainstorming will yield fascinating combinations of concepts integrating both art and science. It is important to note, however, that human creativity is largely non-random (Hummel, 2002) and people need clear relationships between content for optimal learning (Geake & Cooper, 2003). As such, Battles and Rhoades Hudak (2005) describe an interdisciplinary course in art and geology whereby the disciplines are meaningfully paired. Class activities centre on topics that illustrate interconnections of geology and art. For instance,

the medium of metalwork and jewellery might foster discussion around the properties of minerals, while the medium of sculpture might afford us the opportunity to investigate different rock types and consider how differing material will affect the characteristics of the sculpted piece. As such, creative connections and new discoveries might be made.

Second, the realization of creative connections brings the student to a whole new level of consciousness which is important in seeing the world in a new way and making further connections. Girod et al. (2003) and Girod and Wong (2002) might say that creating these connections is a transforming process whereby the individual actually changes alongside the insightfully creative idea. For example, a student might stare at a flower for a while and suddenly realize its systematic patterns. Upon this realization she might see patterns in all forms of nature and so through her sudden realization of connections she sees the world differently and is also, herself, transformed. Another example can be seen in how a student sees astronomy in a whole new way, talking about it on a deeper level upon the true realization that everything is moving (Girod et al.). He is overcome with a new relationship to the universe. All in all, science can benefit from seeing concepts, things, and “facts” in a non-rational, sub-conscious, and artistic way in order to evoke new connections and transform the way in which we see the world.

Holism

Holism is probably the most obvious perspective to take in learning science with an artistic spirit. Holism provides the grounds on which: a) science can be seen in an artistic way, and b) students themselves can become whole, embracing the interaction of two different disciplines. First, while Girod et al. (2003) and Girod and Wong (2002) do not speak to the direct integration of art per se in the science classroom, they do speak to the importance of incorporating aesthetic understanding of unity in the science classroom in order simply to unify

the elements of science. For example, once students see the relationships between individual elements on the periodic table, it becomes unified, beautiful, and whole.

Second, in considering science in light of art and aesthetic understanding, scientific subject matter becomes whole and so do the students. In particular, engaging less with the traditional linear approach of science and more with a holistic approach, students can see and appreciate ideas in a personally significant way, thus building on their own journey and self-fulfillment in life (Innamorato, 1998). For example, science students resist knowledge if it has no means for personal fulfillment (Galbraith as cited in Innamorato). Innamorato thus suggests the importance of integrated curriculum that focuses on personal meaning or artistic abilities. Furthermore, Eisner (2005), who advocates strongly for arts in education, recognizes that we need to pay attention to the whole child in educating them. In so doing, he notes that indeed the arts can promote this holistic development whereby artistic forms of cognition in a variety of activities, including science, represent the most complete form of integration (Eisner).

The Role of Emotion in Experience

Excitement and Motivation

Bridging connections between science and art and seeing things in holistic ways result in an emotional response of joy and wonder (Alexenberg, 2005). These emotional responses can be linked to: a) excitement and motivation and b) moral goodness in the science classroom. First, it is natural that this excitement in seeing connections evokes motivation to engage the learner further (Charyton, 2006) and to foster further investigation in science (Girod et al., 2003; Girod & Wong, 2002). For example, in their study where the teacher combined the study of geology with an artistic sense of “telling rock stories,” Girod et al. found that even a poorly behaved fourth-grade student engaged in the activity with energy and interest. Furthermore, students in general might respond excitedly by wanting to tell others about what they have learned and by

wanting to learn more (Girod & Wong), thus enabling greater motivation in school and in science. Motivation in science stemming from an artistic spirit also has implications for engaging more girls, a population less engaged with the sciences (Charyton; Innamorato, 1998).

Moral Goodness

Second, alongside the excitement to further investigate scientific concepts, it is hoped that moral goodness accompanies the investigation. Many scientific ideas, such as human genetic engineering, require ethical considerations (Sadler & Zeidler, 2005). While no research was found stating a direct relation between the arts fostering moral goodness in a science classroom, literature does show that beauty is often associated with an awareness of moral goodness (Diessner et al., 2006; Winston, 2006) and the arts themselves hold the quality of beauty (Winston). Perhaps investigations need to be done on the question of whether or not art integration in the science classroom might evoke moral goodness in scientific decision-making.

Summary

Educational practice can develop both the scientist and artist within in order to foster integrative and holistic minds. Based on Dewey's (1934) theory of aesthetic experience and the extracognitive aspects of intuition and beauty (Shavinina, 2004), two interrelated themes are derived from which science classrooms can integrate an artistic spirit. First, fostering a science classroom where there is unity in experience can yield positive results. In particular, connections can be made beyond consciousness to: a) allow the combination of art and science to enable creative connections and b) allow the realization of these creative connections to transform the individual's perspective on and connection with the world. Furthermore, a holistic approach in science provides the grounds on which: a) science is seen in an artistic way and b) students themselves can become whole. Second, fostering emotion in the experience of science promotes: a) excitement and motivation to learn more, and suggests b) moral goodness in decision-making.

All themes considered are linked to aesthetic experience and the extracognitive facets of intuition and beauty, which seem to be inherent in eminent scientists of artistic spirit. As such, extracognition in reflection of aesthetic experience is hoped to be relevant into the current day of science education whereby subjects are taught in an interdisciplinary way.

Israel Arts and Science Academy

A concrete example of a school that integrates the arts and sciences in the spirit of creativity, holism, and moral goodness is the Israel Arts and Science Academy (IASA). IASA is a national, residential senior high school established in 1990 that incorporates creativity through arts, discipline through sciences, and values and ethics through community work. It is open to all high school students across the country but is ultimately limited to those of high ability (Donoghue, 1999; Erez, 2001; IASA, n.d.; Passow, 1992).

Philosophy

Passow (1992) describes the program's design in terms of a circle of four rings. The first and innermost ring is the field of specialization. In the second ring around that are general core studies and interdisciplinary studies. The third ring is the school/community relationship. Finally, in the fourth and outermost ring are the broad values devoted to a humanistic orientation and commitment to the country and its people.

With a focus on the second ring of interdisciplinary studies, the overlap of science and art becomes evident. Science and art work together at IASA to complement one another's opposing dispositions. IASA follows the Greek ideal of "Truth, Beauty, and Goodness" where science seeks truth and art seeks beauty and perhaps truth as well (Erez, 2001). Art and science further complement one another in the opposing mental processes of analysis and synthesis where art is primarily about synthesis and science about analysis (Erez, 2001). Furthermore, while high school science chiefly focuses on justification, art focuses on discovery. The philosophy behind

IASA is to have art and science work together in complementary ways, always in the context of values and morality (Erez, 2001).

Interplay of Art and Science

IASA is interesting for its interdisciplinary nature on two levels. On one level, students are exposed to a wide array of passions and interests simply by living with one another, it being a residential school (Erez, 2004). The hope is that science students who may not have an interest in art or vice versa might gain some interest or curiosity simply by living with someone who does (Erez, 2004). As such, the arts and sciences intermingle in an informal and friendly way.

On another level, IASA provides a range of courses to help students perceive connections amongst various fields while concentrating on their own (Donoghue, 1999; Erez, 2004). It is as though the sciences and arts mix in a context whereby science students are allowed to engage in innovative art projects and art students are allowed to engage in innovative science projects. For example, one week, called the Gildor Project Week, gives students the space and time to experiment with new approaches in their own field or to explore a subject other than their own field of study (IASA, n.d.). IASA endorses creative excellence in its students, recognizing that scientific creativity is often difficult at the high school level while creativity in art is the name of the game (Erez). By pairing the arts and sciences in an interdisciplinary manner, it is hoped that the creative mentality of art will transfer to science where to dare is rewarding (Erez). By overlapping the discovery process of art with science in order to promote new ideas, the integration of art and science can be seen as credible (Erez, 2001).

1.6 Literature Review Summary

The purpose of this literature review was to investigate the relevance that art might have in education by exploring scientific creativity in light of an artistic spirit. As such, a look at history's eminent scientists reveals that indeed there is an artistic component to scientific creativity at the highest levels. I have looked at that component as being aesthetic experience and extracognition with particular reference to intuition and beauty. Through a systematic review of the literature, three shared themes of intuition and beauty were derived. These are: a) making connections beyond consciousness, b) holism, and c) emotion. In reflection on Dewey's (1934) theory of aesthetic experience, the first two themes resonate with his notion of "unity in experience" and the third theme resonates with "the role of emotion in experience." The interconnections between these themes give solid grounding to the relatedness of aesthetic experience as may be felt in artists to extracognitive experience as felt in past scientists, suggesting a commonality between engagement with the arts and sciences. The themes were then explored on an applied level in light of science education. Israel Arts and Science Academy was touched on as a relevant example particularly in terms of holism, creativity, and moral goodness.

Chapter 2

Research Question

2.1 Acquiring the Question

In generating a research question that was important to me I went through a number of methodical steps and random occurrences. As explained in the preface, I first had an interesting conversation with a nuclear physicist who also engages in piano and spoke to the ideas of beauty and intuition in his work as a physicist. Second, the notion of extracognition was brought up in class the next week in a discussion of Shavinina and Seeratan (2004), which addresses the phenomena of intuition and feelings of beauty particularly in highly able scientists of the past. Third, a systematic review of the literature was done on the concepts of intuition and beauty and what was derived from that were shared themes that resonated with Dewey's (1934) theory of art as an experience: a) unity in experience, and b) the role of emotion in experience. Above all, I am curious about a purpose for the arts in life.

From the interconnecting themes amongst concepts of interest (intuition, beauty, and aesthetic experience) which spoke to both the arts and sciences, I realized that if there is anyone today who might give a new layer of credence to the arts as advocated by Elliot Eisner, it would be scientists who have an understanding in them. While Shavinina and Seeratan (2004) speak to the idea of an artistic spirit in scientists, their work is largely limited to scientists no longer living and who were not directly interviewed about the artistic aspects of science. The question then became whether or not living scientists who are artists have spoken to the topic. Thus, a content analysis was done on the electronic databases ERIC and PsycINFO using the search terms "polymath," "scientist," "artist," "interview," "qualitative," and "phenomen*" in order to find whether or not any qualitative or phenomenological interviews had been done with scientists who also engage in the arts. Only one book, to date, includes interviews with artists and

scientists on their experiences with creativity (Rosner & Abt, 1970). It, however, does not identify and interview scientists who also engage in the arts. Furthermore, no peer-reviewed studies qualitatively investigate living scientists in the hard sciences who engage in the arts in order to directly give voice to the science-art connection, whether there is one at all, and the extent to which art might be important in education. The aim then is to do just that.

2.2 Specific Aims

This study aimed to: a) obtain descriptions of the experience of doing science by living scientists who also engage in the arts; b) analyze and present these descriptions using thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006; Cohen, Kahn, & Steeves, 2000); c) discuss implications for recognizing the relevancy or not of a shared spirit in art and science in the school curriculum.

2.3 Questions

Based on the historical perspective of eminent scientists who also excelled in the arts and the present day movement towards arts integration as exemplified by IASA, the research question became, “How do scientists who engage in the arts interpret their experience of doing science?” A set of questions to address this issue was devised as a guide. In order to address the perceived experience of doing science in light of an artistic spirit, the flow of the interview was facilitated by the following general questions to be outlined in detail in Chapter 3: 1. “What are the perceived experiences of doing science by scientists who engage in the arts?” As it follows, what might we infer about the role of the arts in doing science? 2. “Based on personal experiences, are there implications for the integration of the arts and sciences in education?” Note that while participants were given a voice to speak directly to the second question, analysis

was beyond the scope of this research, time not permitting. Instead, educational implications are discussed based on results from question one in Chapter 5.

Chapter 3

Methodology

“I am very astonished that the scientific picture of the real world around me is deficient. It gives a lot of factual information, puts all our experience in a magnificently consistent order, but it is ghastly silent about all and sundry that is really near to our heart, that really matters to us”
(Erwin Schrödinger, 1954).

3.1 Research Design

Hermeneutic phenomenology was used as the appropriate research design, which is based on phenomenological philosophy (Cohen, 2000). While phenomenology in general is concerned with the structure of an experience, hermeneutic phenomenology is interested in how people go about understanding their world whereby the structure of the phenomena is not important, but rather how the phenomena are interpreted (Cohen), focusing on the lived experiences of people (Van Manen, 1990). Ricoeur’s (1981) theory of interpretation, from which hermeneutics stems, is connected tightly to the concept of *text*. He stresses that articulating the experience of being through language does not change it into something else, but makes the experience become itself. As such, by studying participants’ words and my own chosen words closely, it is hoped to give voice to the inner matters of the way in which the real world is pictured as urged by physicist Erwin Schrödinger (1954).

It follows that hermeneutic phenomenology is appropriate for three reasons. First, hermeneutic phenomenology recognizes the inevitability of interpretation. In other words, the findings do not claim to extend to all scientists, but more so to similar scientists in a similar context and within the confines of this piece of writing. It recognizes a) context, b) participants’ interpretations, and c) the researcher’s interpretation as factors that sit contrary to finding the essence across all human experience in time. Hein and Austin (2001) nicely state that hermeneutic phenomenology “involves a process of contextualization and amplification rather

than of structural essentialization” (p. 9). The recognition that findings do not speak to all human experience is crucial for this study because the research question aims to amplify the experiences of a particular population, that being highly able scientists with engagement in the arts, in the context of their time and place.

Another distinctive aspect of hermeneutic phenomenology is that it recognizes the importance of language, whatever the form, and the interpretation that goes with that. Words are paid special attention to in their context (Ricoeur, 1981) and we must recognize the embeddedness in text (Van Manen, 1990). In other words, any theorizing in this research study cannot be separated from the writing in which it is portrayed (Van Manen). Furthermore, Hein and Austin (2001) explain that it treats human experience as a textual structure whereby the actual words used by participants may be explored in great detail even down to the etymology. Von Eckartsberg (1998) moreover describes that “the hermeneutical-phenomenological approach to research investigates human experience as it becomes expressed in spontaneous productions of speech, of writing, or of art” (p. 49). As such, it recognizes the importance of interpreting language and concrete expressions, whatever their form, in order to consciously understand actual experiences. This approach fit the exploration of the perceived experiences of doing science by scientists who engage in the arts for two reasons: a) it encouraged the use of artifacts such as artistic modes of scientific exploration as a vehicle for experience and b) the spontaneity of the approach allowed experiences that are not easily visible to the participants to be discovered through my deeper investigation of language and its amplification. The hope, therefore, was to further understand the experience of doing science in an artistic spirit perhaps even beyond what the scientists are currently aware of, thus opening the floor to notions like aesthetic experience and extracognition.

Finally, using hermeneutic phenomenology is important in the context of education. While Van Manen (1990) focuses on the importance of attending to the lived experiences of children for the sake of pedagogy, I propose that it is also important to attend to the lived experiences of educators.

3.2 Participants

Participant recruitment was first attempted through purposive selection as recommended by Steeves (2000) for hermeneutic phenomenological research, specifically through a process of nomination. When no responses were gained through a process of nomination, participants were recruited purposively through networked introductions. Purposive selection is primarily concerned with carefully selecting participants who have rich enough data to bring clarity to understanding of the phenomenon of interest (Polkinghorne, 2005), that being the experience of doing science in an artistic spirit. More specifically, Steeves explains that a principle of hermeneutic phenomenology is to view participants not in terms of meeting certain characteristics, but rather as people who can illustrate what it is like to be themselves as they make sense of an experience. As such, demographics are not so much a concern as is simply finding highly able scientists who also engage in the arts. Participant selection remained fairly wide-open, focusing on elements described by Polkinghorne (2005) such as: a) experience with science at a high level and self-perceived engagement with the arts, b) willingness to describe that experience to a researcher, and c) ability to sufficiently reflect on and verbally describe their experiences to an English-speaking researcher.

In order to recruit participants who were highly able scientists who engage in the arts, Department Heads in a variety of UBC's Departments of Science were sent a letter by e-mail from the researcher requesting nominations for appropriate and potential participants (see Appendix A). When no affirmative responses were gained, participants were recruited through

word of mouth and networked introductions through other students or faculty members who knew of people fitting the requirement. Participants were then contacted personally, requesting their participation (see Appendix B).

Sample size was determined by the intensity of anticipated contact needed to gather sufficient data on the phenomenon (Steeves, 2000). In anticipation of three interviews each, field notes on the interviews, and the use of field documents, a total of 4 participants were recruited. This number appeared to allow for a sufficiently deep understanding of doing science with an artistic spirit.

3.3 Data Collection

Interviews

Interviews are the most common way of producing qualitative data in which we get a first-person account of an experience (Polkinghorne, 2005). Before the interview began, participants were asked to sign a consent form (see Appendix C) and to fill out a background information sheet (see Appendix D). Interviews were relaxed with no strict agenda to follow and lasted for about one to two hours each, being audio-recorded with permission (Polkinghorne). Polkinghorne cites Seidman as suggesting three dyadic interviews for each participant. In compliance with a basic principle of hermeneutic phenomenology that the driving force of human consciousness is to make sense out of one's experiences (Kahn, 2000), three interviews gave ample room to ponder, reflect, share, and clarify the experience of doing science with an artistic spirit.

First Interview

The first interview consisted of getting acquainted and informing the participant of the basic interest in his or her experience of doing science. After informing the participant of the

study's general interest in the experience of doing science with an artistic spirit, I used this opportunity to get acquainted in particular with the participants' background in order to situate their experiences and meanings within a context that is unique to them, typical of hermeneutic research (Hein & Austin, 2001). This was used to set the context. The conversation opened with a question like, "Tell me a bit about how you came to where you are today in terms of being a scientist and an artist. You can start perhaps at when you were a child." During the first interview, the scientist was also asked to bring one or two of her own self-perceived artistic compositions for the next interview, and was given a small list of questions to review and consider for next time. Because there was time to consider more questions in the first interview of participant one, the rest of the participants were asked to bring their own self-perceived artistic compositions to the first interview and were given all questions before the first interview. Participants were given enough time to consider their position before going in-depth (Polkinghorne, 2005). In turn, the first interview was used to get into the exploration of their experiences with doing science as artists.

In order to elicit narrative data, typical of hermeneutic phenomenological research, the interviews were kept quite conversational (Kahn, 2000). The first question dictated the flow of the remaining interview, and questions varied between each participant (Rubin & Rubin, 1995). In this way, the questions were tailored for each participant, making it most relevant to their personal experience and, therefore, accessing the greatest depth and insight that each participant had to offer. Nevertheless, these general questions guided the interview: 1. "Tell me how doing science is part of your life." 2. Tell me about how engaging with the arts is part of your life." 3. "Can you describe a time when your experience in doing science had what you perceive as an artistic element to it? If so, what was that like? The process? The product? Feelings?" 4. "Can you describe a time when your experience in doing science had what you perceive as *no* artistic

elements to it? What was that like?” 5. “Can you describe your experience of composing one of your works of art that you’ve brought? Try to describe it as vividly as possible. Do you feel that it or the process of it fostered any scientific investigations?” 6. “What do these experiences mean to you personally? What do they mean to you in terms of doing science? In terms of the scientific method?” 7. “Think back to a significant scientific investigation that gave you the most pleasure and satisfaction. What might you say made that success possible?” 8. “In your experience, do you feel it was important to literally engage in the arts?” 9. “What do you think about arts-integration with the sciences?”

Second Interview

The second interview consisted of a more focused, in-depth exploration of their experience with doing science as artists. From the first interview, I made a summary consisting of their personal context and sought clarification. Next, I asked any remaining questions from the interview script that were not yet addressed in the first interview. Finally, we discussed some themes that I felt spoke pertinently to their unique experiences of doing science as artists. From those themes I aimed to ask a) Can you describe a time when [theme] occurred? b) Can you describe as vividly as possible how it felt (before/during/after)? c) How do you make sense of that experience? Why or how would that happen?

Third Interview

The final interview with each participant consisted of verifying my interpretations of their unique stories. In particular, verifications of their experiences with doing science in an artistic spirit, filling in missing pieces, clarifying, and adding information if it arose took place (Polkinghorne, 2005). To this interview, I took a write up of their personal context describing how they got to where they are today as scientists and artists. I also took a final formulation of themes and resounding quotes that I felt spoke most pertinently to each participant in light of

their unique experiences. I did not consider other participants' experiences at this point. I received final verification from each participant on whether it was an accurate depiction of themes that spoke to their unique experiences of doing science as artists.

Observations

The participant and setting were observed during the interview. Kahn (2000) notes five key purposes of keeping field notes after observation. First, they were meant to allow me to reconstruct the physical environment in which the participants spend most of their time. As such and when possible, the interviews took place in the primary setting of doing science for each participant. Unfortunately, this did not work out for all interviews. The hope, nevertheless, when possible, was to allow a richer account of the experience by lending itself also to the contextual setting. Second, field notes brought to awareness aspects of the interview that could not be captured on audio, such as body language, dress style, environmental distractions, and tone of voice. Third, field notes brought to life any conversation that took place after the interview had been recorded. Fourth, they gave me an opportunity to reflect and self-evaluate which was important in recognizing personal bias. Finally, field notes allowed me to record any hunches or ideas in regards to content and theory. I also recorded what was confusing because all initial observations are also important as a part of data analysis (Kahn). These items were all important in deepening the context of the interviews for better understanding in later analysis.

Field Documents

Field documents are anything in permanent form that can be viewed any amount of times (Kahn, 2000). In this case, the scientists' artistic compositions were captured in a photograph when feasible or e-mailed by the participants. First, however, the artistic compositions were talked about in detail by the scientists themselves, as previously discussed.

3.4 Data Analysis

Data were analyzed through thematic analysis (Braun & Clarke, 2006; Cohen et al., 2000). First, however, it is important to consider the proper mind-frame of the researcher that was attempted as an on-going process of data analysis even during data collection (Taylor & Bogdan, 1998).

Phenomenological Mind-Frame of the Researcher

There are two phenomenological practices to consider: a) epoché and b) phenomenological reduction. Epoché required me to “bracket”, or put aside, any preconceived notions surrounding the subject, or phenomenon, being studied (Patton, 1990). Epoché was ongoing and occurred throughout the entire analysis in the best of attempts. While hermeneutic phenomenology recognizes the researcher cannot entirely do this, the effort was important in ensuring that the outcomes were not unconsciously clouded by my own experiences and perceptions. See “Researcher Positionality” below for my own experiences and perceptions. Another significant aspect of phenomenological analysis is “phenomenological reduction” (Giorgi & Giorgi, 2003). Through phenomenological reduction, I was aware that things may present themselves differently to different individuals. For example, not everybody “sees”, “hears” or “feels” the world the same way. Indeed, this made it difficult to reconcile themes adequately at times.

Researcher Positionality

In recognition of Patton’s (1990) suggestion to bracket any preconceived notions of the experience of doing science with an artistic spirit, I have reflected on my own account in order to bring to awareness the inevitably interlaced interpretation that went into this human science research. This is meant to make the reader aware of any biases or assumptions that may have

shaped the study. Stating my position complies with Creswell's (1998) suggestion to clarify researcher bias.

Where am I in terms of art and science? I must admit that I am in very few ways formally informed by the hard sciences, which made this a somewhat intimidating study to step into. I was turned off from science in grade 9 chemistry when I simply could not see the meaning behind the content and lab work. Furthermore, I felt it had nothing to do with me and so it was hard to invest my interest in it. In turn, I will have to liken my scientific engagement to human science research in the fields of Psychology and now Special Education. On the other hand, I have always leaned more towards the arts, participating in painting, pencil portraiture, photography, and poetry.

Through my own experiences, I have felt art to be a great benefactor in my happiness and health during my engagement with human sciences. I have also found art to be an outlet that allows me deeper understanding of myself and the world around me, often times making sense of the artwork after its completion and its relation to myself and the world. As such, participating in the arts has always held a greater purpose for me than what seems mere product and frivolity. It contributes to my happiness and to my own way of deeply understanding myself and the world.

Why then, have I not pursued the fine arts whole-heartedly? Although I do not like it, I am of the world-view that we live in a fast-paced world where I must limit my time to the space that art provides for pondering, playing, and freely creating. It is my bias that we live in a science-driven society where value seems to be placed more on science and technology. Based on my love for the arts and their felt lack of purpose next to the hard sciences, I am likely to bias this research in light of finding the positive things about the arts in the lives of scientists more than looking for any negative experiences.

In order to experience as actively as possible in the phenomenon of doing science as an artist, I deliberately engaged more thoughtfully in art during the entire year of writing this thesis. I took an art class and several photography classes, and wrote poetry. The largest impact that living this way had on me was attaining a sense of well-being and happiness. “Forcing” myself to take the time to sit still and let my mind turn from rigorous thoughts to those that travel around and come back to silence helped me to feel mentally well and simply happy. Every time I gave up artistic engagement to focus on this thesis, I became stressed and seemingly less motivated. It became more of a duty than a pleasure; more of pulling teeth than running with momentum. My experience may be similar to participants or may indeed bring about bias.

Hermeneutic Mind-Frame of the Researcher

Having considered the phenomenological mind-frame of the researcher and the researcher positionality that adheres to its philosophy, let us now consider the hermeneutic mind-frame of the researcher. In terms of a hermeneutic phenomenological mind-frame, there were a number of aspects to consider, going into the analysis. First consider the etymology of hermeneutics. The name comes from Hermes, the interpreter of the gods’ messages. In this way, hermeneutics is “the science and methodology of interpretation” (Hermeneutics, 1997, p. 636) thereby making the role of the researcher an interpreter of participants’ meanings. Next consider the idea of lifescape (Von Eckartsberg, 1998) or life-world (Wertz, 2005). This notion is embedded in the centrality of contextual experience (Von Eckartsberg; Wertz). In this sense, I tried to be aware of the socio-historical surroundings of the interview and continuously assessed myself in the context and assessed the context itself, thus making observations of the interview. In keeping these notions in mind, a description of thematic analysis and the analysis itself follows.

Description of Thematic Analysis

Interviews were qualitatively analyzed through the general form of thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006; Cohen et al., 2000.) Thematic analysis is a method used in qualitative research to identify, analyze, and report patterns or themes within data (Braun & Clarke). It was used in concurrence with the theoretical position, broadly speaking, of contextualist method (Braun & Clarke). A contextualist approach resonated with hermeneutic phenomenology's focus on situating the experience in the context (Hein & Austin, 2001). This position resonated with the spirit of art's holistic intent (Eisner, 2005), aiming to reflect on the individual's historical, personal context to set the stage for their personal experiences and understandings of doing science as a scientist who engages in the arts today.

Thematic Analysis

This section delineates the steps taken for the two parts of the results section in Chapter 4. First, a brief rationale for how participants are introduced through their context is explored. Second, the particular steps taken in the thematic analysis of individual accounts are outlined. Third, the particular steps taken in the thematic analysis across participants are outlined.

Setting Participants' Contexts

Each participant's narrative was first looked at in the context of their life, as it resounds with hermeneutic phenomenology's intent to situate the experience in the context (Hein & Austin, 2001). I used a combination of interview data and field notes for this section. In particular, the participant's Lifeworld was explored in order to deepen the context (Van Manen, 1990). Van Manen describes the Lifeworld as being both source and object of hermeneutic phenomenology. From it, I anticipated orienting myself more strongly to the question of the meaning of doing science as an artist. This consisted of exploring first Lived Space or what I

call Spatial World, which is the way in which the space we are in makes us feel and allows us to be (Van Manen). Here I explored the participant's science profession, arts interests, and also background in terms of belief system, which unexpectedly came up in the interviews as an interesting aspect in participants' lives of doing science as an artist. Next I explored the participant's Lived Time or Temporal World, which is subjective time rather than clock time. I found it useful in this section to first identify the participant's general series of events in the form of a plot-line, which spoke to the storied occurrence of their lives as engaged in science and art. These concepts will be explained more thoroughly in Chapter 4.

Individual Thematic Stories

This section outlines the steps of thematic analysis used first in analyzing individual thematic stories, which I had done in order to attend specifically and specially to each individual, ensuring their own unique experiences. I hoped that this would allow a richer and more accurate analysis when putting all texts together. Because analysis was an ongoing process (Kahn, 2000; Taylor & Bogdan, 1998) in which I was actively thinking about the content of the interviews throughout (Cohen, et al., 2000), I also make note of which step was carried out during the three interviews for each participant.

General steps in analysis. In general, I was actively thinking about the content of the interviews once they were completed (Cohen, et al., 2000). This led to more questions of clarification, which come out in the next interviews. As such, I used field notes to document ideas gained from the interviews and then took those ideas back to the participant for clarification the next time.

Second, I always became familiar with the data in a number of ways. In particular, upon completion of each interview, they were transcribed, read and re-read, and notes of initial ideas were taken (Braun & Clarke, 2006). Transcribing was a huge part of and great opportunity in

becoming most familiar with the text. This involved a word for word copy of the audio-recorded interview.

After the first interview. In addition to the above two steps, the third step was to read through the data several times in order to get a general sense of possible themes (Cohen et al., 2000; Taylor & Bogdan, 1998). I wrote up a summary of two parts: a) personal context and b) possible themes. I took these items to the next interview where further conversation was evoked. Refer back to “Second Interview” in the Data Collection section.

After the second interview. After the second interview, all the above steps were carried out yet again, but a number of other steps were then engaged in. The fourth step was to, with a more careful eye, engage in data reduction (Cohen et al.). This step involved combining interview one and two then eliminating digressions, reorganizing pieces of the interviews by grouping similar topics together, and getting rid of unnecessary vocabulary such as “you know” without losing the character of the participant. Data were organized according to major sections of: a) participant’s context, b) what it is like to do science as an artist, and c) input on educational applications.

Fifth, data were initially coded according to blocks of text that spoke to themes in the context of doing science as an artist. The theme was numbered and put in brackets after each block of text. This coding depended in part on the intent of the study. Of the three different approaches described by Boyatzis (1998) - theory-driven, prior-research driven, and data-driven - this study had a data-driven intent because of its inductive nature in exploring the new topic of the experience of high level investigative science by scientists who engage in the arts. It was hoped that this open approach would result in insights that currently are not supported by research. In this way, coding first considered as many potential themes as possible, while keeping relevant surrounding data. Single extracts of text were approached with the possibility

of being not coded, coded once, or coded many times, giving opportunity to fit into future themes (Braun & Clarke, 2006).

Sixth, once the raw data were all coded, I re-focused to identify broader themes across the whole text. In other words, different codes were combined to form an overarching theme that had to do with the experience of doing science as an artist. Information was not yet discarded, but an attempt was made to map it alongside other themes (Braun & Clarke, 2006). I found this to be a difficult step and must admit to the high level of subjectivity involved in it. Identifying overarching themes became clearer as more participants were interviewed.

The seventh stage involved reviewing the themes. This step involved weeding out, breaking down, adding, and refining themes developed in step five. I further reassessed, “Does this quote and theme have to do with the experience of doing science as an artist?” I was surprised to find how I could cut more the more I read it. At the same time, I highlighted the key sentence of the section that spoke to the theme. Essentially, at this step I asked myself: a) “What does this statement have to do with doing science (as an artist)?” b) “What does this statement have to do with the theme at hand?” c) “Is it a lived experience or is it the participant’s way of interpreting or making sense of the experience?”

Eighth, the themes were defined and named. In other words, I identified what each theme was about and what aspect of the data each theme captured (Braun & Clarke, 2006). Specifically, once all the quotes were under the overarching themes, I thought of thematic formulations (Van Manen, 1990) in order to define the boundaries of what that theme meant. Here, I had to rearrange or delete quotes or make new categories. From the themes and thematic statements I put together a coherent story that spoke to the individual participant’s experience of doing science as an artist. Table 3.1 summarizes the themes from each participant.

Table 3.1. *Summary of Themes and Thematic Statements from Individual Accounts*

Kent	Understanding Intuitively	
		Engaging in art during incubation fosters intuitive understanding in science.
		Hands-on aspects of the arts foster intuitive understanding.
	Well-Being	
		Engaging in the arts as a scientist makes for a balanced life.
		The mechanical process of engaging in the arts breaks the cycle of depression.
	Being Successful	
		Scientists with a love for the arts have chosen science to make a living.
		Scientists who engage in the arts may not be as successful in today's "market-place" paradigm, but are brave in their ambitions.
David	Money	
		Scientists with a love for the arts have chosen science to make a living
		Scientists who engage in the arts may not be as successful in today's "market-place" paradigm, but are brave in their ambitions.
	Having Different Perspectives	
		Using art as a tool in science
		Using science as a tool in art
	Being Open	
		Doing science as an artist involves openness to serendipity.
		Doing science as an artist involves patience.
	Being Able to See	
		Doing science involves the capacity to see beauty.
		The capacity to see involves stillness and connection with something greater.
	Well-Being	
		Scientists experience emotional well-being from engaging in the arts.
Nina	From Within	
		Heart: The heart is central in doing science from which the artist springs.
		Motivation: From the heart comes motivation for science.
		Emotion: Emotion is tied in with heart and motivation.
		Balance: Balancing between the masculine and

		feminine parts of her.
	From Within to With Everything	
		Expression: Art is important in doing science because it is process and the expression.
		Intuition: Intuition is involved in the expression.
		(In) Tune (In): Doing science involves tuning in to the heart and being in tune with the universe. Through Music Through Hardship
		Serendipity: Serendipity occurs from being in tune and tuned in to the universe and beyond.
	The Unexplainable	
		God: Tuning in allows a connection with higher powers like God found both inside and outside of oneself.
Nina 2^a	Balancing Artistic and Scientific Engagement	
		Scientists who engage in the arts may lean more to a feminine approach in their work.
		Scientists who engage in the arts strive to balance the masculine and feminine in their work.
	Inner Motives/Having Different Perspectives	
		Scientists who engage in the arts may use science concepts to motivate their art.
		Scientists who engage in the arts may use artistic processes to motivate their science.
	Outer Connection with Something More	
		The arts can be used to connect oneself with something more.
		The arts can be used to connect others with something more.
Naori	Fragmentation	
		Scientists who engage in the arts experience <i>inner</i> conflict in reconciling their two worlds.
		Scientists who engage in the arts experience <i>outward</i> conflict in reconciling their two worlds.
	The Merging of Worlds	
		When scientists and artists collaborate with one another new perspectives and greater understanding are achieved.
		When science and art collaborate as disciplines, analogies can be drawn in a) process and b) concepts, to achieve new perspectives and greater understanding.

		When science and art collaborate as disciplines, they can also act as tools for one another to achieve new perspectives and greater understanding.
	Connecting to Something More	
		Scientists may use the arts to get in tune with something greater.
		Scientists may use spirituality to get in tune with something greater.
	Balancing Science with Arts for Well-Being	

^a Nina was the first to be interviewed. As such, themes emerged more clearly after a couple more participants were interviewed. I have done her analysis twice. The second analysis was not verified due to her unavailability, but quotes from the first analysis were all considered and reworked along with others.

Each individual account was then taken back to the participant for a third interview that involved verification of their individual account in doing science as an artist.

After the third interview. After the third interview, themes were reworked if needed, but more rigorous analysis was carried out in merging the thematic stories into one. This section follows.

Merged Thematic Stories

In merging the individual thematic stories into one that spoke to the experience of doing science with an artistic spirit, I went through a number of individual steps. I took all individually finalized thematic stories, which were verified with participants in light of highlighting what was crucial to their unique experiences of doing science as an artist. I copied and pasted their overarching themes and thematic formulations (Van Manen, 1990) from Table 3.1 above into one document, changing to unique fonts for each participant for organization.

Next, I printed and cut up each quote from the individual thematic stories into the thematic formulations, writing the main theme by it to keep track of where it came from. The reason I put the formulations at the forefront rather than simply the themes is because, depending on the participant, certain formulations were better highlighted by different themes. My hunch

was that I could mix the formulations up amongst participants and find the ultimate theme to speak to all.

Next, I colour-coded the quotes of thematic formulations according to overarching themes that emerged:

- a. Well-Being (green)
- b. Money/Success (purple)
- c. Connecting to Something More (red)
- d. Disciplinary Links (blue)

I went through each highlighted pile and wrote further thematic formulations that considered all participants. After sorting these new thematic formulations into piles, it was made clear which ones were most pertinent in speaking to all participants' experiences (Table 3.2). Note again that themes are in reference to individualized thematic stories, which were verified by participants for accuracy in speaking to their story as a whole. As such, there may be more quotes that spoke to the topic at hand in the discarded text. I have gone back to gather some quotes when I felt there was a strong pull amongst most, but not all, participants towards a particular theme, and when I could find a quote that fit with the rest of the participants though it was previously discarded on account of not being pertinent to the individual's experience of doing science as an artist.

Table 3.2. *Initial Combination of Themes from Individual Thematic Stories*

Approach to Science as a Vocation
Holistic Appreciation of Science
Commitment to Values, Not Money
Artist in the Closet
Well-Being
Satisfying an Innate Drive / Finding Wholeness of Self
Coping in a Stressful World/Environment (Through Physicality of the Arts)
Coping in a Stressful World/Environment (Through Spirituality of the Arts)
Disciplinary Links
Using Artistic Processes to Guide/Initiate/Motivate the Doing of Science
Using Art as a Tool in Doing Science
Using Art Concepts to Describe Science Concepts
Using Scientific Investigation to Guide/Initiate/Motivate Artistic Work
Connecting to Something More
Description of the Raw Feeling
Using the Arts to Connect to Something More
Being Open to Connect to Something More
Collaborating to Come to Something More

Next, these themes and sub-themes were reworked to encompass quotes from all participants since some only pertained to three or fewer participants. Furthermore, they were renamed to better capture the lived experience of what it is like to do science as an artist. In general, if quotes did not form a coherent pattern under the themes the theme was reworked, created anew, or discarded from analysis (Braun & Clarke, 2006). This was a messy process in

general that involved moving quotes around amongst themes, reworking themes, and discarding quotes. The following summary ensued, which will be storied in detail in Chapter 4:

Table 3.3. *Major Themes Identified by Participants*

Risking Success in a Scientific Vocation
Feeling Healthy through the Arts
Satisfying an Innate Drive
Coping in a Stressful World
Gaining and Giving Different Perspectives through the Arts
Complementary Tools of Perception
Complementary Processes of Perception
Feeling Connected to Something More through the Arts

Next, I verified whether or not each participant indeed touched on each major theme. I printed out Table 3.1 and Table 3.2. I highlighted sections on Table 3.1 according to colours outlined on Table 3.2. By doing this it became evident which former themes and thematic formulations were used for the ultimate four themes. It was confirmed that each participant touched on each major theme.

Next, I paraphrased the content of the data extracts under each theme, identified their importance, and identified why they are important (Table 3.4) (Braun & Clark, 2006).

Table 3.4. *Summary of Major Themes and their Importance to the Experience of Doing Science as an Artist*

Major Theme	Paraphrase	Why It Is Important
Risking Success in a Scientific Vocation	This theme refers to the way in which science is approached as a vocation. It includes how scientists make sense of their vocations in a way that ignores the importance of money and reveres the importance of authentic self-propelled motives in their love for science.	This theme is important to the experience of doing science as an artist because it speaks to the struggle that scientists might have in speaking out authentically in their science vocation when a market-place paradigm is emphasized. Note, conclusions cannot be made on whether or not arts engagement has any causal impact. This is an observational link made between the dialogue engaged in and the fact that these participants engage in the arts.
Feeling Healthy through the Arts	This theme refers to various aspects of well-being, particularly what seems to be emotional well-being of scientists who balance their lives with the arts. It includes the experiences of satisfying an inner artistic drive and then using artistic engagement to cope in a stressful world.	This theme is important to the experience of doing science as an artist because it speaks to the experience of healthy lifestyle and self-care for scientists who are often in stressful or competitive environments.
Gaining and Giving Different Perspectives through the Arts	This theme refers to art and science as disciplines that aid one another in investigation and output through complementary perspectives. It considers art and science as complementary tools or complementary processes of perception in coming to one another's understandings.	This theme is important to the experience of doing science as an artist because it speaks directly to the impact that engagement with the arts can have on one's work as a scientist in terms of discovery and output and the excitement that goes with that.
Feeling Connected to Something More through the Arts	This theme refers to reaching a state that is beyond cognitive functioning. That state includes experiences of intuition, serendipity, or spirituality.	This theme is important to the experience of doing science as an artist because it illustrates the impact that the arts can have on one's work as a scientist in light of reaching a state where creative ideas flow.

Finally, the merged thematic story was produced. The goal in this step was to tell the intricate story of the data in a way that convinces readers of the credibility of the analysis. I moved from a comparison of themes to a logical picture of the whole (Cohen, 2000). This process involved writing and re-writing as new understandings emerged.

Contact with participants continued via e-mail to get verification on this final thematic story in which all participants' themes were considered together and merged into a final outcome. I asked participants: a) Do you see yourself in this story? b) Is there anything I am missing that is core to your experience? Each participant verified its accuracy and provided feedback when needed. One participant noted that although she felt it represented her accurately, I am likely missing something core to her experience, especially if I speak to her in a month. This brings up a good point that the analysis revealed is only verified for this moment in time and is highly interpretive not only amongst participants as a whole but within a participant's own movement through time.

3.5 Strengths and Weaknesses of Methodology

Strengths

Qualitative research and in particular, hermeneutic phenomenology, had a number of strengths for this study's purpose. First, qualitative methods overall were beneficial in finding out about others' experiences, about which there was no previous insight (Rubin & Rubin, 1995), that being the experience of doing science as an artist. As such, making no a priori hypotheses proved a strength in coming to unique understandings. Second, hermeneutic phenomenology allowed participants to understand the world and their own experiences through their own interpretations (Cohen, 2000). The open format of this method seemed beneficial in gaining unique and rich data. Through open discussion, it uncovered a contemporary first person

perspective that resounded in certain ways with that of historically great scientists. It also allowed an illustration of new and current ways to reflect on the arts in a science environment. Getting a first person account allows further investigation in new areas like the experience of doing science as an artist, which can give insight into science education. Finally, the way in which the study was conducted, interviewing participants three times each as suggested by Kahn (2000), proved a great strength to this study in order to allow ample time to reflect, ask more questions, and verify repeatedly my interpretations of an area that is on the cusp of my own understanding and a broad and new area to probe. Overall, qualitative methods allow groups (like artists) to be understood from their own first-person narrative.

Weaknesses

Naturally, it follows that there are a number of weaknesses with qualitative methodology depending on how you look at it: a) Generalizing the results and insights to a large group is not possible from such a small number of participants (Patton, 1990) nor is it possible to state empirical facts (Van Manen, 1990); b) It does not provide a means of coming to causal conclusions and as such cannot problem solve because of its orientation towards finding pure meaning (Van Manen, 1990); c) High subjectivity can be viewed as a weakness, in that it is not seen as lending possibly objective truth. Although these may be seen as weaknesses, there are reasons for arguing otherwise. For example, the goal of qualitative research is not to generalize the results, but to gain local knowledge that is highly specific and usable for a more 'close to home' context (Marecek, 2003), where in phenomenological approaches found meaning is the point of interest (Van Manen, 1990). Furthermore, in reference to subjectivity as a hindrance to finding truth, objectivity does not necessarily lead to absolute truth either. For instance, objective standardized measures assume that aspects of human mental life are the same across

different settings, times, and groups (Marecek, 2003). In sum, for every methodological weakness there can be found a strength, and for every strength a weakness.

3.6 Ensuring Credibility

Because qualitative research seeks to illuminate understanding, I tried to ensure that indeed the study was believable, accurate, and “right” (Creswell, 1998). Creswell suggests using the term “verification” instead of validity. A number of procedures that he has specified in regards to verification were satisfied in this hermeneutic phenomenological study.

Clarifying Researcher Bias

Subjectivity is especially prevalent in qualitative research. In order to account for it, it was important to recognize that I, the researcher, was a co-constructor of meaning (Morrow, 2005), making the findings anything but an absolute truth. In compliance with Creswell’s (1998) suggestion to clarify researcher bias, I stated my position under “Researcher Positionality” at the beginning in order to make the reader aware of any biases or assumptions that may have shaped the study. Furthermore, Rubin and Rubin (1995) state the importance of transparency which involves making oneself credible for the basic processes of data collection not just at the outset, but throughout the study. Journaling ensured that I kept track of my ongoing thoughts, feelings, impressions, and processes. It is hoped that this was reflected to some degree in the data analysis. In this way, I aimed to gain a self-awareness that goes with Morrow’s requirement of reflexivity.

Prolonged Engagement and Persistent Observation

Qualitative research involves a lot of time spent in the setting and with the participants. In order to satisfy this criterion, I used multiple sources of data in order to enhance the interpretive status of the evidence (Morrow, 2005), meaning that my interpretations were left

less to my own discretion, but more to the evidence at hand based on a thorough understanding of the context and a genuinely good relationship with participants (Creswell, 1998; Morrow). Furthermore, I demonstrated persistence, which complements what Rubin and Rubin (1995) call “consistency” by questioning the inconsistencies within the interview such as contradictory statements. The goal was not to get rid of inconsistencies, but instead to persistently understand why they were there (Rubin & Rubin). When this was an issue, it was cleared up in the subsequent interviews.

Triangulation

Triangulation involves using multiple sources to shed light on a theme or perspective (Creswell, 1998). Multiple data sources (interviews, observations, field documents) were used in order to achieve adequate variety in kinds of evidence (Morrow, 2005). It was hoped that the richness of data collected from these multiple sources pointed towards the same findings regarding themes around the experience of doing science in accomplished scientists who also engage in the arts. Field documents and observations confirmed the themes, although they were not analyzed in depth like the interviews, which were the primary source for data analysis.

Thick Description

Creswell (1998) points out that a rich description of the participants and setting will allow readers the opportunity to transfer the information to other settings. As such, I used all data sources - the interviews, observations, and field documents – in the case of hermeneutic phenomenology. See Results in Chapter 4. It is hoped that with rich descriptions of the participants’ Lifeworlds (Van Manen, 1990; Wertz, 2005), the reader can understand the participant so vividly that he or she is afforded the opportunity to transfer the findings to recognizably similar cases.

Member Checks

This form of credibility involved taking data, analyses, interpretations, and conclusions back to the participants for verification. Member checking complements Rubin and Rubin's (1995) criteria of "communicability." Communicability is about the realness of the way that I convey data to participants and readers. This realness came particularly from the third interview when participants were given the opportunity in person to add, delete, or change anything that I had interpreted in their individual thematic stories. For one participant, the final interview was done over the telephone. Realness also came after participants were given the same opportunity to verify the merged thematic story, but over e-mail. When questions arose after the interviews were complete, participants were still contacted for verification (Cohen et al., 2000).

3.7 Ethical Issues

First, this study was approved by the University of British Columbia Behavioural Research Ethics Board (Appendix E). In qualitative research, the relationship between the researcher and participants is a much closer one than in quantitative research. Thus, the underlying aspect for ethical consideration is this relationship or interaction between the researcher and participants (Haverkamp, 2005). Haverkamp highlights ethics in light of trustworthiness in that participants must be recognized as vulnerable; the researcher is thus responsible to promote their well-being and to protect against harm. It was up to me to make ethical decisions in the end.

With Haverkamp's (2005) relational focus at the forefront, the ethical principles of CPA's Canadian Code of Ethics for Psychologists (2000) were more specifically followed. Principle 1 demands respect for the dignity of all persons. Specifically, participants were given informed consent and the data were treated with confidentiality. Based on two participants

choosing their real names instead of pseudonyms, an amendment to the consent form was made (Appendix F). Through informed consent, participants were forewarned of any possible risks, namely that unstructured interviews may become personal with unanticipated questions (Havercamp). Once consent was obtained, collaborative work as researcher and participant was expected although it was made known that withdrawal from the study was permitted. In terms of confidentiality, the participants' identities were kept anonymous unless their first name was chosen to be made public. I did not share any of the data collected in process before it was verified by the participant. Furthermore, any third parties mentioned in participants' interviews were not disclosed (Havercamp) except by pseudonym.

Principle 2 demands responsible caring. The main point to address here is the risk/benefit analysis in which the probable benefit of the study should be greater than the risk. Possible benefits were giving voice to scientists who engage in the arts in sharing their experiences and their possible contribution to the field of holistic education and arts-integration as advocated by Eisner (1991, 2003a, 2003b, 2005), if appropriate to their experience. No risks were foreseen other than the possibility of addressing personal experiences and unforeseen questions.

Principle 3 demands integrity in relationships. In particular, I was honest in describing what the study was about. Furthermore, although objectivity is an ethical standard (CPA, 2000), qualitative research in general is subjective and can only allow the reader and participant to be aware of the researcher's background. Indeed, I have flavoured this thesis with my own position and was also open to discussing with participants my own views on topics when they asked me.

Finally, Principle 4 demands responsibility to society. In particular, this study sought to develop knowledge for the field of scientific creativity in light of an artistic spirit and to enlighten educators on how to foster the holistic growth of students (Eisner, 2005). This is discussed in Chapter 5's Educational Implications.

Chapter 4

Results

Based on the way the data were organized into sections of a) participant context, b) what it is like to do science as an artist, and c) input on educational implications, these are the results that follow. First the participants will be introduced in light of their contexts to acquaint the reader personally with the voices that sing these stories. Next, the thematic story on the experience of doing science with an artistic spirit will be sung. Note that analysis of participants' input on educational implications for arts-integration was beyond the scope of this research, time not permitting. Instead, educational implications will be discussed in Chapter 5 based on the overall results in this chapter.

4.1 Introduction of Participants

First I will introduce the participants individually with relevant demographic information (Table 4.1). Next I will set their unique contexts reflecting on how they got to where they are today as both scientists and artists. Meet Nina, David, Naori, and Kent.

Table 4.1. *Participant Demographic Information*

Pseudonym^b	Nina	David	Naori	Kent
Age	53	61	40	31
Sex	Female	Male	Female	Male
Ethnicity	German/Romanian	White	Caucasian	Anglo-Saxon
Marital Status	Married	Married	Partnered	Married
Highest Level of Education Completed	M.Sc.	Ph.D.	Ph.D. / PDF	Ph.D.
Type(s) of Engagement with the Sciences (most dominant one stated 1st)	Field: Environmental Science 1. Environmental Consulting and Writing Reports 2. Post-Secondary Teaching 3. Researcher	Field: Pathology and Laboratory Medicine 1. Associate Professor 2. Graduate Advisor 3. Researcher	Field: Chemistry/ Biophysics / Biochemistry 1. Principal Investigator 2. Professor	Field: Computer Science 1. Researcher 2. Teacher
Length of Time in the Field of Science	25+ years	44 years	22 years	14 years
Type(s) of Engagement with the Arts (most dominant one stated 1st)	1. Fiction Writing 2. Non-Fiction Writing 3. Photography 4. Cartooning	1. Sculpting 2. Chinese Painting 3. Oils	1. Dance / Performance Art 2. Vocal Performance / Music 3. Mask and Voice / Fitzmaurice / Acting	1. Music 2. Painting 3. Poetry
Length of Time Engaging with the Arts	47 years	Forever	28 years	29 years
Accomplishments	1. Published novels and short stories 2. Published non-fiction works 3. Published scientific papers	1. Refereed Publications 2. Nominated for Killam Award 3. Showed at 8 sculpture exhibitions	1. CSC Research Award / Journal Publications 2. Reviewer for National Science Foundation (USA) 3. Helped establish a Regional Centre of Expertise on Education for Sustainable Development 4. First full performance as an emerging artist	1. Self-satisfaction
Self-Perceived Degree that Artistic Engagement Plays in Life as a Scientist

^b Nina and David chose to use their real names, Naori chose her pseudonym, and Kent was assigned one.

Setting Participants' Contexts

In order to lay a backdrop for the intertwined thematic stories and perspectives told by Nina, David, Naori, and Kent on their lives being lived with a heart for science and art, meet their own unique Lifeworlds (Van Manen, 1990; Wertz, 2005). Van Manen describes the Lifeworld as the lived world as it is experienced in daily situations and relations. It has four existential themes (Lived Time, Lived Space, Lived Body, and Lived Other) that belong to the way all humans experience the world, be it in different modalities. Van Manen recommends these themes as guides to reflection. I am using Lived Space (or Spatial World) and Lived Time (or Temporal World) as descriptions of each participant's personal context. "Other" (or Relational World) will be reflected on in terms of impact of the participants on the researcher in Chapter 5. "Body" (or Corporeal World) will be alluded to in this section where relevant.

Spatial World

Van Manen (1990) describes lived space as felt space. It is not the mathematical space in which we reside, but rather the way in which the space we are in makes us feel and allows us to be. It is relevant to explore profession, interests, background, and place of residence (Van Manen). As such, participants' science professions, arts interests, and background in terms of belief systems were explored. Note that background is explored in terms of beliefs because it was an unanticipated topic that came up and seemed to give a backdrop to their feelings towards science and art.

Nina's Spatial World

Science profession and arts interests. After having taught the sciences in universities and colleges, Nina is currently an environmental consultant. As a consultant she sees herself as bridging those that need a service with rules and regulators such as in the

government. “As a consultant, I am a bridge.” Nina studies the ecology of aquatic systems and effects of human activities and prescribes recommendations for management and mitigation. At the forefront, Nina is an internationally published Science Fiction writer. She also publishes non-fiction writing and photography in magazines, and enjoys cartooning. Just as she sees herself as a bridge in her science profession, she also sees herself as a bridge in her profession as a writer by bridging art and science into science fiction. “As a writer, I’m a bridge.” Below are images of some of Nina’s novel publications.

Nina
Darwin’s Paradox
Photo used with permission

Nina
Collision with Paradise
Photo used with permission

Nina
The Cypol
Photo used with permission

Figure 4.1. Science-Fiction by Nina.

Belief system. In terms of her beliefs, which do indeed flavour her way of making sense of the world and her experiences, Nina currently attributes everything to God and the idea of there being “something more.” In terms of her journey in beliefs she explained:

I’m spiritual. I’m sort of Christian... I did go through a stage where I was an agnostic, but I needed to do that. Even deep down then, I knew I was still a believer. I just needed to figure out *how* I believed and where my faith came from.... I *do* write, nowadays, completely *of* God, *to* God, and *for* God.

Furthermore, she feels that God, religion, or spirituality “is an overlying blanket of process, network, if you want to use a metaphor, that drives everything, *including* science. And

art.” Nina is also excited about science’s explanations for finding that there is “something more” to believe in: “There’s more to it... science is starting to explain that. Chaos theory makes some attempt at putting all that together.”

David’s Spatial World

Science profession and arts interests. David is a professor in the Department of Pathology and Laboratory Medicine. His background is in Zoology and Botany and he is ultimately a morphologist, studying the relationship between structure and function. His primary interest is studying the lung and white blood cell migration. David is also a sculptor whose work has been displayed around Vancouver. He also partakes in Chinese Painting and Oils. These engagements are primarily hobbies. The images below are of his sculpting and Chinese painting, about which he talked most.

David
Bust of Nefertiti
Photo included with permission

David
Egyptian Princess
Photo included with permission

David
Golgi Apparatus
Photo included with permission

Figure 4.2. Sculptures by David.

David
Bamboo in the Wind
Photo included with permission

Figure 4.3. Chinese Painting by David.

Belief system. David calls himself a Panentheist. Through a series of different times in his life, he has come to understand the world through a belief in something more. He explained:

For the last almost 40 years, I've been running around and studying the architecture of life. I started out as an atheist then I became an agnostic when I had children... And now after all this time, I'm what you call a Panentheist. Pan means everything. Entheism means the divine is in everything. And I actually believe that everything that *is*, *is* of the divine. Good, evil, inanimate, animate. All of it. It's *all* the divine. The *antithesis* of that is nothingness. So everything is sacred.

Naori's Spatial World

Science profession and arts interests. Naori is a professor in the Department of Chemistry and Biochemistry. She is also an emerging artist of improvisational dance, not to mention a variety of other art forms such as acting, music, and mask and voice. She is currently bringing the two worlds of science and dance together by using her science in her art; fusing her basic research interests in science into performance through technology. She collaborates as an artist and/or a scientist with other artists and/or scientists.

Naori
Le Jardin de L'Esprit
Photo included with permission

Figure 4.4. Naori's photography of her early work, "Le Jardin de L'Esprit," that she choreographed and directed for the filming done by a film artist. The piece was her first venture into the spiritual realm.

Naori
The Seed
Photo included with permission

Figure 4.5. Naori performing in a piece called "The Seed", directed by the leader of Wildfire at the annual Hemp festival.

Naori
Manufacturing Zero
Photo included with permission

Figure 4.6. Naori doing improvisational dance in "Manufacturing Zero" – improvisational performance for Petri's Quadrille.

Figure 4.7. Theremin instrument Naori used to alter projection landscapes for multidisciplinary project entitled “Transformation.”

Transforming Spaces, Transformation
Photo included with permission

Transforming Spaces, Transformation
Photo included with permission

Figure 4.8. Atomic force microscopy images ($5 \times 5 \mu\text{m}$) of fungal spores (A) and high resolution images ($0.5 \times 0.5 \mu\text{m}$) of the spore surface (B, C). The colour image is a projection landscape of the “soil/fungal” cyberworld. A fellow-collaborator used images of fungal spores (top) to come up with a soil cyberworld (bottom) with which Naori interacted through improvisational dance in “Transformation.”

Belief system. Since Naori was in high school she has believed in a higher power but did not have any specific religion. Currently she draws on her own gut instincts for making

sense out of life and as such relates most to Buddhism and First Nations spiritual values. Dance and concepts behind dance play a role as well in how to reach that higher power, for example, through breath-work. Ultimately she relies on her own inner knowing.

Kent's Spatial World

Science profession and arts interests. Kent is a professor in the Department of Computer Science. He collaborates with film companies' visual effect studios. As a computer scientist his "personal ambition is to understand physics and the related math behind it at an intuitive level and convert that intuition into numerical algorithms so [he] can run computer simulations on it." This work ultimately ties up with the arts and film in that his scientific work provides the building tools for artists to make films. While Kent works closely with the arts as a scientist in regards to film and animation, he engages with the arts more directly and independently through singing, learning the viola, painting, and writing poetry. This engagement is primarily a hobby. Because he considers painting to have most connection with his work as a scientist, it is his paintings that are displayed here.

Kent
Title N/A
Photo used with permission

Kent
Title N/A
Photo used with permission

Kent
Title N/A
Photo used with permission

Figure 4.9. Paintings by Kent.

Belief system. Kent has a pragmatic outlook on life. He seems to understand it in terms of chance and probability. He explained:

There's been a few times in my life where I thought there would be a deeper reason, but I'm fairly skeptical for the most part. I think if I went back in time, lived my life again, the chances are I'd end up on a completely different path. But I would guess that the same number of interestingly significant coincidences would've happened – they'd just be completely different ones.

He explained:

I'd say I'm very much pragmatic and willing to re-evaluate beliefs. And I don't think there's any deeper meaning or high power or anything like that. But I don't think that implies any negative connotations like nihilism or anything like that... I think one of the themes in *War and Peace* is the notion of whether or not you're happy or leading a good life has much more to do with you than external circumstance... I don't have to live a certain way or achieve something and if I fail to do that it's going to be a waste... I think whatever comes up, there'll be a way for it to be great.

Temporal World

Van Manen (1990) describes lived time as subjective time rather than clock time. The participants' recollections of their engagement in art and science throughout life up to this point form their temporal world. While it follows a logical flow of time throughout life, it is subjective in the sense that it is based on recollection of degree of engagement in the arts and sciences during particular life segments in reference to education.

Figures 4.10 to 4.13 are simplified ways of looking at how the participants came to where they are today in terms of being both scientist and artist. There are two items to note in these figures:

- 1) Triangular shape: Because the participants are in a somewhat later stage of their lives, having expertise in their scientific field, these diagrams seek to highlight a climactic point where art became a sure part of their lives as scientists. The point on the time-line illustrates this. The following decline is not a matter of regression, but rather of resolution in being both scientist and artist.
- 2) Shades of grey: In light of honouring the contradictory meanings of art and science, explored through their etymologies, engagement in science is represented as white and engagement in the arts is represented as black, with no meaning attached to black and white other than that they are etymologically contrary. It is important to note that these are not precise calculations of quality and quantity of time spent in either art or science, as that would have involved extensive recounting of events throughout life, which is not the focus of this research. This is an approximate idea for setting the context of each participant's life development as both scientist and artist.

The figure is followed with a more detailed description of each participants' engagement in the arts and/or sciences through the temporal stages.

Nina's Temporal World

Note: Gray shades are the result of various combinations in quality and quantity of time engaging in art (black) and science (white) during this time period.

Figure 4.10. Nina's temporal world engaging in sciences and arts.

As a child, Nina and her sister shared imaginative science fiction stories. "I had the writing bug ever since I was a kid, and my sister and I used to share stories, like crazy stories, wild stories, but even those were somehow related to science... with zooming around planets, and finding things, and different environments..." She certainly had talent and was pushed towards the arts. "I was really good with drawing, and my parents and teachers were incredibly supportive. They sort of pushed me that way."

In high school, she grew to care deeply for the environment. She explained, "Somewhere in high school I discovered a commitment to the environment. I don't know what triggered it." As such, she wanted to save the world and change things. Through her art she started to bring awareness about environmental concerns. "I used my art to make posters. I got very fervent about this. I would put up posters all over the hallway... exhorting people to do something about the environment, about the world... still using my art."

At the end of high school, Nina had big decisions to make about taking the arts or sciences path. She was accepted into a fine arts school, but still felt compelled by the sciences. She recounted:

I was still going to go into fine arts and on registration day was when I changed my mind into going into science.... I'm going to save the world! I'm going to change things. So I went into biology. Haven't looked back since, although the two have always been with me.

Nina succeeded in completing her Bachelors and Masters of Science in Biology still with an interest in the arts:

I went through the whole biology program and ended up getting Masters too in the end. But as I was going through the biology program, thinking of a career in biology, all my extra courses were always in the arts... writing or cosmology or heaven knows! Something totally different.

Once her education was completed, she went into the work force teaching in universities and colleges, followed by consulting. This was a pivotal point for her in deciding to dedicate more time towards the arts. She explained:

I went into consulting. And that was all very science-based.... I was in the business for several years when I felt something was missing. I needed to open another door and do what I was doing another way. Still committed to this planet, to the environment, to this world, to people, but I knew I had another way to go... so I went back to writing.

Nina seems to currently be in the resolution stage of engaging with the arts as a scientist by being an environmental scientist and consultant and an internationally published Science Fiction writer.

David's Temporal World

Note: Gray shades are the result of various combinations in quality and quantity of time engaging in art (black) and science (white) during this time period.

Figure 4.11. David's temporal world engaging in sciences and arts.

Throughout David's life he has been drawing and painting while developing himself as a scientist. He explained:

I've done art all my life... Looking back it's the way it's been. I've had to do something. I can sort of tell you things that I was doing at different times that were art in parallel to becoming a scientist."

To start out with, ever since David was a child he was happily engaged in the arts, such as drawing, clay, and painting:

I have drawings I did when I was 2 years old. I would sit in my father's lap and draw for him and tell him what I was drawing and he would write down in the margins what it was supposed to be.

In high school, although David still took Ceramics class for fun, he geared his focus more towards the sciences for money practicalities and helping the world. Recounting his days in high school, he explained:

Both of my parents had been through the Depression, so the message was, 'Well, that's lovely that you enjoy doing art, but what are you going to do for a living?' So I drifted in the direction of biological sciences.

Furthermore, he noted:

I've also drifted towards the biomedical thing because when I was 16 my mother was diagnosed with Bronchiectasis... At that time they told her, 'You have ten years to live.' That was kind of traumatic. So for a long time I thought I wanted to be an MD.

Although it seems he drifted to the sciences for practical reasons, he found the excitement of art in zoology and biology: "In those days we had to do dissections and drawings. And I *loved* that. Biology played right into my art.... It was an outlet. It was a cross-over." David proceeded to do an undergraduate degree in Zoology, which directed his later studies into Marine Botany.

To avoid being drafted after his undergrad degree, David became a teacher of grade 8 and 9 general science in a Los Angeles ghetto school. David was mostly doing drawing and a little pen and ink during this time. He particularly used drawing as a way of teaching these difficult students. Through drawings and storytelling, David's teaching was like a work of art itself. He explained:

They had a horrible time getting teachers into the ghetto schools in LA so I signed up for this teacher training program.... They were short of teachers too. Substitutes refused to come down and teach where I was teaching.... And I used art there to stay alive. I realized that they were really into random violence because that's the kind of environment that they lived in. I'd come in to cover a class with no teacher... things would be wild. Things were flying across the room. There'd be a fight going on over here or there. So what I would do is just go up to the front of the class, get a piece of chalk, and start drawing a big shark on the blackboard.... And it would get very *quiet*. I didn't say anything to them. And then I would start telling them stories from the research I'd done on shark attacks and shark behaviour... I actually taught them some biology too.

After teaching David went back to school to get his B.A. in Botany from which he proceeded onwards to doing a Masters in Marine Botany and a Ph.D. in Botany. During his graduate work, David took up six years of Chinese painting, inspired by a Swiss clock painter

with whom he interacted during a free class. Finally, upon completion of his doctorate, he reached a pivotal point in dedicating more focus towards the arts. The wake up call arose out of the death of his friend. He recounted:

During the course of doing my masters I came up with this idea for doing a brush and ink painting. I had the idea since I finished my Masters in 1972... and I had a friend die at 41 years of age of prostate cancer... he had always *complained* about how he wanted to paint and never had time to paint because he was working as an architect. Next thing we knew he was dying of prostate cancer and he never got to paint. That was a pivotal point for me. I decided, 'I want to paint? I'm gonna paint.'

David is currently in the resolution stage of engaging with the arts as a scientist by being a professor who also engages in Sculpting and Chinese Painting. He is organizing events for graduate students in his department to showcase their own artistic works. Balancing the science with art in his life has resulted in an increased sense of his own well-being. "When I don't get to go sculpting then I'm less tolerant of [what goes on] during the week. It's a matter of well-being."

Naori's Temporal World

Note: Gray shades are the result of various combinations in quality and quantity of time engaging in art (black) and science (white) during this time period.

Figure 4.12. Naori's temporal world engaging in sciences and arts.

Reflecting on childhood, Naori felt that her life track towards science might have begun due to personal experiences with illness. She explained, "I was often sick as a child and was frequently on antibiotics, so I wanted to know about the chemistry of the body and how drugs function." During her childhood she also did dance and pursued piano training. In high school, while Naori learned both dance and science, she did not yet consider herself practicing. When the time came to choose what to practice, Naori decided to go with science during her final year: "I always say that it was a choice between art and dance, but really I made the clear decision in grade 13 that I was going to go more towards science." She went on further to explain what tweaked her interest:

At the end of chemistry in grade 13 we took something that [the teacher] *called* biochemistry [although it was organic chemistry]. This introduction piqued my interest, and on some level I must have understood that this might be a way to understand the body, and how drugs worked.

During her undergrad then, Naori did a double major in biology and chemistry while also participating in dance classes throughout. During this time she explained that she “kept dance and science throughout *on* my work terms *and* during my schools terms.” Specifically, she “found out that [her] undergraduate institution had a dance program that was connected to the National Ballet... and for no additional fee (above a full course load) I could take dance class and gain credit for those classes.”

After taking nearly a year off from science and dance after undergrad, Naori came back during her Ph.D. to dedicating a large amount of her schedule to both. She recounted taking “four dance classes a week in a pre-professional program. Sometimes more, perhaps 5 in addition to any... professional workshops that were offered. At the time, I was pursuing my doctoral studies including teaching, research, and taking classes.” Naori embarked on her postdoctoral research while continuing to dance intensely:

[I] came back to Canada and pursued postdoctoral research for 8 months... in a *different* area. I hooked up with a dance collective, consisting largely of professional dancers, and there danced and took classes probably 6 nights a week.

Finally Naori hit a pivotal point in which she decided to merge her two worlds of science and dance, which have been with her throughout her life:

In the past, I would do my dance, do my science but totally separate. Two years ago... I went to a contact improvisation workshop in the States and realized that I have to put these two parts of my life together, or I will go crazy.

Naori seems to currently be in the resolution stage of engaging with the arts as a scientist by being a professor and an emerging artist who uses her science to inform her art and vice versa.

Kent's Temporal World

Note: Gray shades are the result of various combinations in quality and quantity of time engaging in art (black) and science (white) during this time period.

Figure 4.13. Kent's temporal world engaging in sciences and arts.

Kent engages in two primary types of arts: visual art and music. Kent has been engaging in visual art at different periods of time while developing himself as a scientist. Constantly throughout, however, he has been engaging in music, be it singing or playing viola. It is important to note, however, that he does not feel music has any direct connection to his work as a scientist. For this reason, it will be kept out of focus. "On the one hand, probably the most artistic thing I do most of the time is really music... But I wouldn't say that has any sort of direct connection with anything I do scientifically. I also paint."

When Kent was a child he was primarily interested in the arts, but found more recognition in the sciences:

I was *very* good at math at school. I was on the International Math Olympiad team for Canada way back. So in some sense it was kind of obvious and simple to keep studying math. But I hadn't set out with that in mind, back in elementary school. I was probably more interested in art back then.

During high school, visual arts started fading out of his life:

Art sort of tailed off in high school... I took art classes but that's kind of where I left off. I don't think I had really done anything particularly artistically interesting until much more recently. It was much more playing around with technical skills.

Having chosen to pursue the sciences by doing a B.Math and M.Math, Kent did not partake in many artistic pursuits, other than music the whole time through as a hobby. "For my undergrad, apart from music, which has kind of been a hobby throughout, I didn't really do anything artistic...I just didn't have the time for it." During his Ph.D., however, which was an interdisciplinary program, Kent rediscovered the arts through an animation course:

[In grad school] I wasn't really doing much artistic. Until I actually took an animation course. It was *technically* in the computer science department but it had almost nothing at all to do with computers. It was really just an art course... That was a fantastic course and I was doing all this drawing and sketching. Even clay modeling and so on.

After Kent completed his Ph.D. he reached a pivotal point, dedicating more focus towards the arts in order to balance out his life and to suit his interests. Kent first talked about balancing his life with engagement in the arts:

Grad school is just incredibly intense. Or at least it can be depending on how into it you are. By the time I took on this job [as a professor], it was like, 'Okay, I can't actually function at that level of intensity for the next thirty years in order to be able to survive' so there was a lot of feeling around and pushing back and trying to figure out how do I actually make this into a sustainable career. So eventually I came back to painting and other stuff.

Kent also talked about coming back to painting to suit his own interests outside of expectations and guidelines:

I think what started the ball rolling was just getting a big white office... so that was the impetus... Probably the other key thing that happened at the same time was, I'm not sure how you'd describe it – not exactly courage, but deciding I'm grown up enough that I can do whatever I want with paint and also that... having the ability to go to the art store and not feeling terribly guilty about buying 10 tubes of paint... and not feeling like I had to master some technique before I could do this.

Kent appears to be currently in the resolution stage of engaging with the arts as a scientist by being a professor in the computer science department and collaborating with film companies while also engaging in painting, singing, learning the viola, and poetry. He describes his life currently as “a little see-saw. But I’d say now, I’ve kind of figured out a good middle ground.”

4.2 Thematic Story

The Experience of Doing Science with an Artistic Spirit

Data analysis revealed four major themes that attempted to capture the experience of doing science with an artistic spirit: risking success in a scientific vocation, feeling healthy through the arts, gaining and giving different perspectives through the arts, and feeling connected to something more through the arts (Table 3.3). From the etymologies of science [“splitting” (skei-, 1997)] and art [“fitting” (ar-, 1997)], the following stories take apart and interweave participants’ voices.

Risking Success in a Scientific Vocation

All participants have chosen science as their vocation. *Vocation* has to do with one’s calling (Vocation, 1997); the word is derived from the Indo-European root *wek^w-*, meaning “to speak” (*wek^w-*, 1997). This is a story about how scientists who engage in the arts speak to or give voice to their vocation in what seems today to be a market-place paradigm. These scientists make sense of their vocations in a way that ignores the importance of money and reveres the importance of authentic self-propelled motives in their love for science. This theme is important to the experience of doing science as an artist because it speaks to the struggle that scientists might have in speaking out authentically in their science vocation when a market-place paradigm is emphasized.

For instance, scientists may grapple with the way they do granting based on beliefs about the importance of the research at hand. Naori talked about how dancing is crucial to her basic knowledge in science:

[Dance] is *crucial* to my grounding... it is a holistic approach towards understanding the body. Sometimes I find that I'm at odds with science because of the desire to describe systems in a holistic manner, but at the same time this enriches my science.

As such, her approach to science changes even if it means resigning from a study:

I don't buy into the idea of doing a study so that you can make pharmaceutical drugs... I've actually discontinued one of my collaborations that used drug testing as the impetus for grant writing... So it changes the way I do granting. I remember writing a grant earlier on in my career that used those ideas, and once it was submitted, I couldn't sleep. Even though I thought, 'Nobody's going to ever read my grant a hundred years from now,' I felt terrible since it is a reflection of me and I signed my name to it.

As Naori struggled to speak out against collaborating on a grant, which she did not feel meshed with her values, David too spoke out against granting in order to emphasize how he is trying to enrich his life with the arts more now. He explained that he feels there is more cost than benefit in spending months of his time writing grants as opposed to doing the things he enjoys:

It's getting to a point where what I have to pay in terms of commitment to my life to do the kinds of things I like to do – the balance is shifting where I'm not really willing to pay the price anymore. I'm not going to write any more grants.

David interpreted himself as perhaps not the most successful in his scientific vocation:

I think I do decent science, but I'm not a good salesperson. I don't have a big lab and all that so I would fall into the category of unsuccessful scientists in a way. In this world, what I've been able to do though, is find a niche in an organization that *is* successful where I can do some science and contribute without being a ringleader. That has its drawbacks, but it's allowed me to do science for 30 years.

Kent also has a smaller lab, and in his work he aims to come up with novel ideas and a novel voice in the scientific community at the cost of numerous publications:

It may sound a bit spiteful, but there are people who a large part of their career is taking one idea and applying it over and over and over. And in terms of the ratio of ideas to papers, they're kind of low. Where I like to have a very high ratio if possible...

Certainly, it can be frustrating to plug away at scientific pursuits without getting the rewards that one hoped for and thought a vocation promised, but it is the risk taken for giving science a novel voice and truly “speaking” or “vocationing.” David’s discovery on white blood cell trafficking took “ten years of work.” He described his struggle to make it a public success:

I had a horrible time publishing that... [but] for me it was totally amazing. That is the stuff of why I do science or why I have done science. You come to a point where you actually believe you understand something. Or you see things in a new way.¹

Kent recalled the same struggle of making his work into a public success in order to give voice to science in a new way:

There’s this, I thought beautiful little paper that I’d done years ago... and it got ignored, which I was a little upset about... I thought it was very beautiful, the connection I had made. And it just finally came back that it was the perfect solution to this issue that the film studio was having.²

Through the struggles of “speaking” in today’s vocations in science, the above stories reflect patience, perseverance, and standing one’s ground at the expense of either resigning from

¹ This paper is about shaking up the idea that tight junctions go all the way around the cell. He looked at tri-cellular corners (the corner that is formed when three cells meet) and he described how the junctions behaved in those corners, predicting that it would be a logical place for cells to cross. Eventually he found cells crossing at the tri-cellular corner, which jived with his prediction in the Scanning Electron Microscope.

² This paper is in reference to a purely mathematical problem. Paraphrased from Kent’s explanation, there had been a class of algorithms for solving linear equations and there had been rules of thumb that results were fairly good if you matched certain algorithms together. The problem was that there was no explanation for why this was the case. Kent, therefore, came up with a plausible explanation to describe why this was happening, which could let others apply it to other problems. This explanation revolved around making a connection to the whole application of global impact, where physically changing something has an influence all throughout space. In reference to explaining the algorithms, he said:

Some classes of algorithms have the property that they were *making* an approximation where if you change something, it only had a local impact. And that fundamentally meant you couldn’t get to the solution except by doing this over and over again until the impact spread. Whereas if you built it in just a slightly different way you could arrange it so that things had a global impact. It might not be the *right* global impact, but at least it *was* global so you had the chance of solving the problem fast.

According to Kent this is particularly relevant because the classic way for solving only worked well if there was a similar processor on the computer. But as computers change, the classic way did not formulate as well, thus making his analogy to global impact more relevant today when tasks are done in parallel with multiple processors.

studies, as was Naori's case, or having people ignore your studies as happened to David and Kent. While Nina did not reflect on a personal experience as such, she likened herself to recognized scientists who also spoke out in a unique way to the field of science. First, she reflected on her favourite scientist, Lynn Margulis, who also struggled in her persistence to give science a new voice on the evolution of eukaryotic cells through cooperation rather than competition. Furthermore, Nina reflected on Brian Josephson, a Nobel Prize winner for his theoretical work on superconductivity who was later ignored for his efforts in investigating paranormal phenomena. When asked if her own experience of doing science involved similar struggles and ridicule in order to give science a fresh voice, she felt: "I'm definitely in that area. I'm thinking that way. I'm asking the questions. And I will continue to do so."

In summary, giving voice and meaning to the field of science seems to involve a struggle to be heard and a risk in speaking out. Participants' experiences illustrate how money and success can be a risk taken on these grounds, to stick to their "calling" and "speak" new meaning into science.

Feeling Healthy through the Arts

Health or well-being was another theme that emerged, reflecting upon what it is like to live as a scientist who balances life with the arts. The meaning of *health* is a state of optimal well-being and is derived from the Indo-European root *kailo-*, which means "whole, uninjured, and of good omen" (kailo-, 1997). This is a story of finding health and wholeness through the arts. It might be said that wholeness is found by first satisfying an inner artistic drive. Health is further found by using artistic engagement to cope in a stressful world. This theme is important to the experience of doing science as an artist because it speaks to healthy lifestyle and self-care for scientists who are often in stressful or competitive environments.

Satisfying an Inner Drive

Having all loved being artists as children, participants talked about a need to go back to, or commit more time to, engaging in the arts. Nina and Naori described it primarily as an intense urge to bring this part of their lives into full swing in order to express themselves. Naori reflected:

There were times when I thought ‘I’m not going to do [dance] anymore,’ and when I did that I’d feel ‘off.’ I couldn’t figure out what was wrong and then I realized I need to express myself in some way. Especially when you’re studying science, you’re not getting to express yourself in an intuitive manner.

Nina recounted a similar experience in feeling that a part of her personal expression was missing:

I went into consulting.... I was in the business for several years when I felt something was missing.... I needed to open another door and do what I was doing another way. Still committed to this planet, to the environment, to this world, to people, but I knew I had another way to go... and so I went back to writing.

Furthermore, Naori needed to blend her disciplines of science and dance even more closely to satisfy her inner drive: She explained that she “did [dance and science] in a really focused way but had two separate lives and felt a little schizophrenic.” Expressed another way, she described her inner drive to integrate dance and science:

In the past, I would do my dance, do my science but totally separate. Two years ago... I went to a contact improvisation workshop in the States and realized that I have to put these two parts of my life together, or I will go crazy.

While Naori and Nina were reconciling art with their work as scientists to quench an inner drive, Kent also recounted a few times in which he felt an inner drive to engage in painting. Kent is different, however, in that his inner drive seemed cooler and seemed to stem more from a technical perspective rather than the need to express himself. He recounted his reasons for doing the middle painting in Figure 4.9: “The first impetus was I wanted to do something – big. Originally the idea was [the department] ha[s] all those blank concrete walls outside, so

I was hoping to start filling them up with interesting things....” In a similar experience, Kent recounted: “I think what started the ball rolling was just getting a big white office... so that was the impetus [to start painting]....” As such, health and wholeness do not necessarily mean satisfying an inner artistic drive to express oneself meaningfully, but also to satisfy an inner artistic drive to literally “go and just *do* things” as Kent said. When asked if his artistic production means anything more to him upon completion he replied, “I think the connection is more in the process of making it. And after it’s done, I’m happy with it but I’m kind of bored with it eventually.”

Whether it is an inner drive to express oneself or an inner drive to physically do something different, general statements about the need and natural drive to engage in the arts for personal well-being and health were made. David summed it up by saying, “To me, it’s like I couldn’t not be. That’s just the way I am.” He went on further to explain:

It really has been [a natural part of me]. There were times when I would’ve denied that. But looking back it’s the way it has been. I’ve had to do something. I can sort of tell you things that I was doing at different times that were art in parallel to becoming a scientist.

Others might agree with David that engaging in the arts is a “congenital problem.” Certainly, Naori echoed him as she recounted, “I was always maintaining dance as I went along.” Nina also chimed in, “I think deep down, unconsciously I was always driven by the artistic side of me... it has always been there. Always, always been there.” Nurturing the inner artist seems to be a relevant experience to living a “whole” and healthy life as a scientist.

Coping in a Stressful World

For these scientists in today’s Western culture, health means engaging in the arts in order to cope in a stressful world. Specifically, Kent spoke to the experience of using the arts to break the cycle of distress often caused in his scientific work.

By the time I took on this job, it was like, 'Okay, I can't actually function at that level of intensity for the next thirty years in order to be able to survive' so there was a lot of feeling around and pushing back and trying to figure out how do I actually make this into a sustainable career. So eventually I came back to painting and other stuff.

More specifically, Kent made sense out of the coping and healing process by attributing it to the mechanical processes of the arts:

You can launch yourself into [mathematical work] and try to solve a problem. But in some sense, either you solve it or you don't. And then you can end up feeling very frustrated. Whereas with painting, if you start squirting paint on a canvas and move around with a brush, you're going to produce something, whether or not it's a masterpiece.... Whereas in math, if you try, you might just fail.... Or you just don't know where to start, and there isn't a mechanical thing you can do to help it start.

In order to emphasize what the mechanical processes of the arts meant to Kent's experiences with coping in the stressful world in which he lives, he recounted his engagement in music during a time of depression:

In my experience viola lessons were fantastic for [overcoming the spiral of depression]. There's a lot of mechanically working on skills. There's a lot of instrument playing that's all about posture or just mechanics of making your arms and fingers and everything work right. Whereas listening to music can very easily feed into depression.

Kent summed up by saying: "With art... once you get into it, you stop thinking about how you're feeling and any kind of self-analysis and that is a way to break that cycle."

While David is also a visual artist who produces tactile works, coping and keeping healthy in a stressful world do not necessarily mean the mechanical processes of engaging in the arts. Rather, healthiness means making space and taking time out for the arts in his busy life.

He talked about his weekly ritual to go sculpting on Saturdays:

I've found it necessary to do art on the side... For me, Saturday mornings are a sacred time. When I don't get to go sculpting then I'm less tolerant of [what goes on] during the week. It's a matter of well-being.

To bolster David's experience about taking the time for the arts in life, Nina described what it is like to be under the stress of *not* taking time and rather doing things too fast: "When I'm disconnected I'm usually under stress. And that's what disconnects me. I'm doing things too fast. I don't feel a true sense of purpose usually when I'm disconnected."

Finally, to Naori, health means physical and spiritual well-being that she gains from dance to keep her fulfilled during her busy work as a scientist:

I can substitute [dance] with something really physical like rowing, and that will exhaust me, but it does not fulfill me in any particular way. It certainly helps my well-being, by doing exercise... but misses the spiritual component of dance.

That said, it is interesting to note that in Nina's and Naori's experiences of engaging in the arts professionally rather than as a hobby, there is also the chance of having to cope with the stress of the arts world. In the throes of just releasing her new book, Nina said:

The ambition to have the book do really well is definitely there and that puts stress on me. And then I just flip the coin and there's the other part of me that goes 'Let it be.' It's only part of something bigger. And what will happen will happen. People will like it.

Naori agreed that the professional world of the arts has caused her fear and stress despite her intense love for it. She talked specifically about combining her worlds of dance and science:

Two years ago was an emotional experience for me. Just recognizing 'Okay, I'm going to do this' took away the possibility of having two worlds. With two worlds, you can fail in one and still leave the other intact, giving purpose to the separation. But then if I combine [science and dance] and then fail, it seems there is so much to lose... So it is partly fear.... because you are also doing something relatively radical.

In summary, whether or not participants perceived both their scientific or artistic worlds as stressful, engaging with the arts ultimately gives meaning to a balanced life of health. Health means gaining wholeness through satisfying an inner artistic drive and using the arts to cope in a stressful world. Scientists achieved health through the mechanical processes of the arts, making time for the arts, or the physical and spiritual components of the arts.

Gaining and Giving Different Perspectives through the Arts

When scientists engage in the arts during their scientific work they may find new meaning in their science, and likewise new meaning in their art. It can be an exciting feeling of discovery having both scientific and artistic perspectives off which to bounce ideas. From Latin, *perspective* means “to inspect” or “to look” (Perspective, 1997) and is derived from the Indo-European root *spek-*, which means “to observe” (spek-, 1997). This is a story about how, when science and art provide lenses through which one can observe the other, new meanings can be made. David reflected, “If all I did was science, and I didn’t look at the world any other way, I think life would be terrible.” To illustrate this point of having the disciplines look at one another, Nina excitedly gave an anecdote about an arts student who was in her undergrad science class:

[There was a] very intelligent fellow, but obviously coming at things from a different angle. We got to discussing what we were going to do [for main projects as graduate students]... so I turned to him and asked him ‘Well what are *you* going to do?’ and he said, ‘My intention - is to make – algae – sing.’ And I went – ‘Sure!’ ...But there was something to that. Obviously he was getting at something else. ...That has sat with me. What it did was it made me realize what I’m doing. ...Not so much make algae sing, but... to bring a new perspective to science. Perhaps that more than anything else.

Each participant revealed experiences whereby art and science as disciplines reciprocally offered meaning to the other’s investigation and output. They reflected on art and science as a) complementary tools of perception or as b) complementary processes of perception. This theme is important to the experience of doing science as an artist because it speaks directly to the impact that engagement with the arts can have on one’s work as a scientist in terms of discovery and output and the excitement that goes with that.

Complementary Tools of Perception

Using art as a tool can concretely give a new perspective and meaning to scientific investigation. Recall David's discovery on white blood cell trafficking:

I'd been looking in the lungs for how white blood cells get out of blood vessels. I came up with an idea that just from doing scanning [electron microscopy], that maybe where they'd like to cross the endothelium to get out of the blood vessel is actually at *corners*... First of all, I had to figure out what the tight junctions or structures that zippered the cells together are doing there. And to *do* that... I had built clay models of each of the corners that I have freeze-fracture images from. Because the way the cells are organized the fracture plane never shows you the whole thing. You can never see it all at once... And then with making the clay models it came together like 'Aha!'... Without my art background, there's no way I could've figured out the organization of the junctions. I had to play with clay....

Just as David gained greater meaning by using art as a way to “look at” or “observe” in doing science, Naori has also found greater meaning in her science by looking at it through her own practical knowledge base in the arts:

[Proteins] are now often described in terms of their motion, for example, breathing... And for me... dance directly translates into that... dance is a lot about breath... So understanding that motion, and then starting to think a bit in terms of how the protein itself would move, function and react, and how motion is crucial to its actual function can lend great insight... I think just that simple and practical understanding of movement and motion helped me understand proteins with greater depth.

Reflecting on David's experience with using art as a concrete tool to make new meaning in science, Naori recounted a similarly exciting experience in which she made meaning in science based on looking at it through artistic tools that lent different perspectives. This, however, is slightly different from David's experience because it relies on collaborating with other people, like professional artists, rather than just the artistic and scientific parts of one's own self. Naori made clear that in collaborating with others across disciplines, different perspectives and tools can be used to inform her science and art, but most important is the experience of then coming to a greater understanding, just as the tools in David's investigation allowed him to. Collaboration is an important aspect of her work as a scientist and artist. She

acknowledged that “somebody else will always look at your ideas differently” and she gave several examples that spoke to the experience of coming to a greater understanding:

A visual artist wanted to print my images onto wax paper and other materials, and she was blowing them up.... All of a sudden, I was looking at this enlarged image, which I would normally look at [on a smaller scale] and I said ‘Oh my God, what are these little features here?’ The features turn out to be scientifically relevant. Here is a concrete example of art contributing to my science.³

Another time when Naori collaborated with others across disciplines to gain new perspectives on her science was for a performance piece in which she made public statements about science and technology.⁴ Because this was a multidisciplinary project in which she was both scientist and dancer, artistic works gave meaning to her science at the same time as her scientific work gave meaning to her dance. Ultimately, she made sense out of it by acknowledging, “As both the dancer and the scientist in this collaboration, I used old, but original, unpublished images to enhance my art.” Nevertheless, the artistic eyes of others also added to her science. She talked about her collaboration with an artist and architect, Angie, on this project:

[Angie] has taken my scientific images and made a beautiful abstract landscape, a cyber world in which I can play as a dancer... It lets me look at science in a different way... In terms of giving each other freedom, this was maximized.... I said, ‘Here are the images, do what you want.’ She returned with ‘Here are the landscapes, work with them however you want.’ So that’s a beautiful thing.... It’s someone having faith... The actual process itself was ‘Here you go.’ ‘Okay.’ *Poof!*

Naori found greater meaning in yet another artistic performance of hers through trust, improvisation, and collaboration with Eric. Eric’s “ambition was to become a science-

³ This was a collaborative work in which a visual artist used Naori’s images of lipids and cell membranes for an art project around turning the body inside out and making a statement about fat and fate.

⁴ This was a multidisciplinary project in which Naori integrated science, technology, and dance into a performance. Ultimately it was a dance piece that made use of collaborations amongst herself, an artist, a computer scientist, and a sound artist. In her performance report, Naori says, “Science and art are combined to explore our present use and abuse of technology, and its inherent duality.” It brought awareness to our use of technology by exploring our relationship to the organic world of soil, which is ironically depicted in projected cyber worlds. She used accelerometers (devices for tracking movement) and interacted through dance with a Theremin instrument, changing the projected soil world with her movement. It amplified the meaning of soil and its transformational powers.

based artist.” In this performance, where artists and mathematicians worked together around the theme of “Zero,” she acted as the dancer and Eric worked on the computer:

I was doing improvisational dance for an hour in the Arts Board window and I asked [Eric] to come with me largely because I was really nervous!... The really neat thing about this piece was that the audience could not hear anything through the window of the performance space. It was completely silent to them.... [Eric] ended up filling files with zeros and then linking them to other files and filling them with zeros. He was just sitting there all in black typing into this computer, and I was improvising in this really small space. It was all improvisational from both points of view –about three quarters of the way through the piece, he ended up getting this message on his computer screen that said ‘null result’ – it’s a zero. It was very trippy!... His computer freaked out. He had to close his computer and just sit there. So surprising things happen when you just improvise. That’s an example of the sort of collaboration where you just go in, fully trusting each other. We did have a collaborative *and* personal history that brought us to a certain place of trust to enter a situation and just improvise, and trust that something will happen. And something did happen that was really cool.

Naori interpreted this abstract result as an offshoot of the open and collaborative improvisation with Eric.

While it appeared that art and collaboration with artists and arts ideas could be tools to making greater meaning in science, science can also be used as a tool to give meaning to art.

Nina talked about using science ideas to enhance her art: “A lot of my ideas [for writing] do come from my work when I’m doing my science,” while in turn bringing awareness about science and technology:

I always extrapolate [science in my writing] thematically with what it is at a human level. At a spiritual, mental, whatever... Applying [science ideas] in terms of the feelings, the emotions, the consequences of science. Or the consequence of what science is showing us. And technology mostly.

Similar to Nina, David recounted how he makes sense of his scientific work by reflecting on it through the arts. He described a large painting of a butterfly with a spike coming out of it:

This is a metaphor for biology. First of all what you have to see is there’s a half-inch spike that sticks out of the canvas. This is a spike going into the butterfly. So the butterfly is pinned to the tree. The butterfly’s common name is ‘Idea.’...To me it epitomizes the way science treats the beauty in nature. I’ve been doing

biology for 40 years and I've been killing organisms all that time... it's interesting because it also is a crucifixion metaphor... that whole metaphor of taking that which is beautiful and destroying it even through studying it, is what we seem to do with gay abandon... It's the price you have to pay to learn some of the things you learn if you're going to do it that way.

While Nina and David talked about using science ideas to inform their art, Nina then interpreted the importance of using art as a way to make sense of science:

The heart, the soul is what you're talking to in the arts, more so than in the sciences you're talking to the intellect and the brain. And the intellect can always rationalize things whereas if you get at the heart of the matter or the heart of someone, you're reaching deeper into their motivations, and I think that's the place we need to be going to make a difference.

Amplified in another way that spoke to her personal desire in reaching out through the arts she said, "I would like to think my writing has soul in it. Because that's where I write from."

It is worthy to note, however, that while using scientific ideas to make meaningful art and using meaningful art to make discoveries or statements in science may be the case in some scientists' lives, Kent gave a different flavour in representing his experiences with using science and art as complementary tools with which to "look at" one another. His experience with using science as a tool to enhance art speaks not so much to making a statement about life and science, as Naori, Nina, and David illustrated, but more to using science to make a technically sound work of art. He explained, "The main focus of all this is, in particular, *building* tools and methods that artists can use when making films." While Naori's science images, Nina's science knowledge, and David's experiences in science have guided their artistic work, Kent's science skills have guided the artistic work of others. Whatever the case, their experiences illustrate what it is like when the arts and sciences fit together as complementary tools to "observe" one another's disciplines, the world, or their Selves for greater understanding.

Complementary Processes of Perception

Scientists who engage in the arts may feel that their artistic processes are a useful way to “look at” and understand their scientific processes, balancing principles of openness and discipline.

Nina made sense of her motivation in science by attributing it to the openness of the artistic spark in her: “I am mostly an artist doing science, but mainly because science is the tool and art is the process – is the motivation.” Nina seems motivated to make sense of the world by looking at it through her artistic eyes, from which she gains access to her motivations in science:

An artist – the driving part, the creative part, the ingenious part, the genius part, innovative part, the inquisitive part, the intuitive part. All those are incredibly important in science, but they have to come from the artist. So I think that every really good scientist is an artist at heart. At heart. That’s the word. At the core.

Reflecting on her own experiences, she interpreted that artistic spark as stemming from the part in herself that gets excited and asks “Why?”

Why do I go ‘My God! This is interesting! I’ve got to pursue this!’ Why do I do that? That’s not usually me as a scientist thinking. That’s me as a human being thinking. And I say that’s sort of the artist.

David spoke also to the human experience of asking “Why?” and how science cannot always answer his questions. When asked to describe his motivations for seeking truth, he explained:

I’m curious about what it means to *be*!... When I was 16 I had a dog... for a year or 2 years. And then she died. She died in my arms... I was holding her.... [T]o see her *cross over* – totally blew me away. All I could think about it [was] in terms of clouds going over the moon and it never comes out again.... So what is it to die? Questions like that. And science was the obvious way to go to find answers. But then in that time... another realization I had, was the questions that were driving me, like ‘What does it mean to exist and to be?’ I couldn’t answer with the science. Science was ‘How.’ Not ‘Why....’ But that’s not to detract from [science]. Because it really has actually formed the basis for coming to the theology I have now about what it means to be. And the Divine and things like that too. And how I feel about the world around me.

David makes sense out of the world around him by looking at it through his artistic eyes and asking “Why?” and blending that with his scientific question of “How?” In concordance with Nina’s interpretation of the artist being the human being, David noted that his artistic eyes are not something bound to artists alone, but to human beings in general. He went on to reflect on how this balancing of “Why?” and “How?” principles gives a rich way to observe the world in the inter-tidal tours that he does with preschool children:

When I go to the beach it’s not just a strange place. It’s not just rocks and seaweed. I know their names. Some of them I think are absolutely beautiful... And when you look at the leaves on the tree, I know how the cells are organized in the leaves... And that doesn’t detract from the wonder. It enriches it. It’s like ‘Wow!’

Nina went on to explain the process of a scientific discovery that she believes sprang from this artistic or simply human part of her that asks the “Why?” question:

I was doing a pollution study... I put out a surface for [periphyton / attached algae] to colonize. I put out these little glass slides, and I put one out in the polluted stream and one in the not polluted stream to see who colonized and what they were basically doing there... I was really looking to see the difference between polluted and non-polluted... but what I discovered by doing that was this cool thing! They were colonizing in a certain way according to the current... ‘Whoa! I made this neat discovery! Why are they doing that?’... To me, that’s more of an artistic question.

In turn, Nina went on to explore this phenomenon further and ended up writing a paper on it as an exciting discovery she made through the processes of being inquisitive and open - what she attributes to the artist in her, or as David called it “a philosophy of what it means to be human” rather than “the providence of art or science.”

Kent spoke also to the openness that artistic processes invoke in his work as a scientist, but more in a practical sense of the disciplines in and of themselves. While Nina and David emphasized an inner curiosity of the heart in this process, Kent spoke more closely to the

openness of intellect in the process of how he feels art and science inform one another in his experiences. He sees his artistic and scientific processes informing one another analogically:

How I approach painting to some extent, in an idealized fashion, is trying to come up with an intuition for how things work and making that concrete. So it *is* I think fundamentally the same way I do mathematics. Coming up with a mental model of what reality is like, and then developing that in whatever manner.

Kent continued to describe that, in his experience, artistic and scientific processes entail a number of progressions. He described his experiences in the openness of immersing himself, having a loose plan, allowing incubation through mind-wandering, intuitive understanding, and finally reverse-engineering. When asked to describe what this felt like, he gave an illustration of his scientific process, which he had likened to his process in painting:

You'd start off in an area with a vague idea of important equations to look at... if you want to get to understanding what it is or go beyond what's already being decided in the field then usually you have to go this hard route of questioning the basic assumptions and trying to figure it out. Generally speaking it starts off like a sea of symbols and it's not clear – you might have general rules of thumb that you're bringing in from other areas. Usually to me it's not clear what the real problem is. It's only after trying things out and seeing that they don't work and then trying to work backwards and analyze why they didn't work. Always by a process of elimination you start to understand what the crux of the problem is. So at some point there begins to be this kind of 'Aha' moment, where you suddenly start to see things click together and what used to be math symbols now, as a formal description of what's going, you no longer necessarily think in terms of those symbols... it's more mental pictures and it gets very hard to describe at some point.

While Nina, David, and Kent talked about openness as a prime aspect of artistic processes that offers a new perspective on their science, Naori also emphasized discipline as an artistic process that helps her to look at science. She talked about how she had disciplined herself to go to the studio every day while developing the performative dance piece combining art, science, and technology. Nevertheless, she allowed herself open space in a disciplined structure. Naori explained her artistic process of openness in a disciplined structure:

I was going to the studio every single week no matter what, no matter what I felt like and even if I felt blocked... and sometimes I even allow[ed] [my]self to get

derailed. So one day, I went into the studio, did my yoga set, warmed up as usual, but I discovered the need to express myself vocally instead of through movement... I had just discovered this awesome singer, and I wanted to learn this traditional song that she had on her album. I just started memorizing the song, started performing and singing it. That's what I had to do that day. After doing that I got to a *little* bit of working on the piece. But that's what had to happen. So it was the process of allowing. I gave myself a lot of time to work out my process for this first piece and attempted to be really non-judgmental....

Within this disciplined structure of openness, she referred to her work as a scientist and summed up:

As I was developing a process and a method in a different discipline [dance] it opened up maybe more possibilities for this discipline I've chosen as a vocation [science]. It lets you walk into a field where you feel like a child and allows you to be a child.... I allowed myself 'You're an emerging artist.' I tried to have no expectations of myself.... I felt like I could ask any questions that I needed to ask which was both freeing and very humbling, but I needed that. I felt sometimes in science I was trying to compete too much rather than admitting I did not know something.

Overall, Naori acknowledged the openness of dance within a disciplined framework and applies this process to her science, to make meaning in it through allowing space to play and ask questions.

In summary, the processes of openness and discipline in the sciences and arts are complementary perspectives for discovery and output, allowing each to be looked at in a different light. Balancing the two seems to be an important aspect. As David put it, the openness and discipline that go with both art and science may be “poles of a unity that must be balanced in order to discover novelty in both art and science.”

Feeling Connected to Something More through the Arts

Scientists who engage in the arts seem to interpret a state in their experiences that is beyond cognitive functioning. This state is about connecting to something more or connecting to something unexplainable. *Connect* comes from the Indo-European root *ned* - meaning “to tie” or “to bind” (ned-, 1997). This meaning alludes also to art, which stems from the Indo-European

root *ar-*, meaning to “fit together” (ar-, 1997). As such, this is a story about connecting or achieving a tie with something greater through the arts to make meaning in science. Participants found it difficult to explain at times, recounting experiences associated with hard-to-explain states beyond cognition such as intuition, serendipity, or spirituality. This theme is important to the experience of doing science as an artist because it illustrates the impact that the arts can have on one’s work as a scientist in light of reaching a state where creative ideas flow.

David described the bliss of it as “There’s almost no feeling. All the aches and pains go away.” Kent, on the other hand, described the alertness that goes with it: “Things just happen all firing.” Nina spoke to the energy that goes with connecting to something more: “I feel light, but I feel balanced. I don’t feel overly like I’m floating, but I feel like my whole being is singing. I feel very energetic. At one, with everything. And just really happy. I feel great!” Nina continued to emphasize a connection to everything: “When I’m connected I want to sing. I’m resonating with everything. Everything’s beautiful. I’m much more aware of everything. I’m in tune with everybody. And their feelings. My own feelings.” Finally, Naori described a similar richness of feeling connected to everything:

Sometimes when I feel really tapped in, I feel like I’m connected – I’m standing on my feet and I’m connected through to the core of the Earth and to whatever star is above my head... it’s a pretty open state... that is really useful for creativity.

Getting connected to this state seemed to be a matter of engaging in the arts. For Naori, that means tuning in to your body:

I think that if you’re really in touch with your body then you get the right answers. ... As scientists we use our intuition all the time... when you’re making decisions in experiments.... Things have to be really off for me to be not listening to my instincts... But generally dance just helps keep me there.

She seemed to be slowly making sense out of her artistic engagement as a way to tap into or release something more as she reflected also on her Mask and Voice work:

I guess I've come to a place in my life where I do actually believe that creativity stems from a connectedness that's a little bit bigger than yourself. And whether you look at that as tapping into a source or releasing to the environment around, which is really just opening up your senses... physically... When you're relaxed and open, ideas flow... It's really clear to me when I'm doing Mask and Voice work that I'm sourcing something greater than my corporeal self.⁵

Nina also recounted connecting to something more through artistic engagement.

Although she does not engage in music, she interprets it as “one of the major [ways of connecting to something more.]” Said another way, “I use music to get me back wherever it is I'm going. And music is art of course.” Similarly, she interprets her own engagement in writing as a way to connect:

How do I get there?... Usually it's to do with... connecting with my art.... Even in my science, connecting with something real that I'm doing usually *for* something [or] someone.... I think it relates back to finding the real higher purpose of your life. Which the arts are so good at conveying.

Nina further expressed her interpretation of what it means to connect to something more through her writing: “What I feel though, is that it isn't me. It's more than me. I always feel it's more than me when I'm there.” More specifically, Nina's beliefs in God seemed to tie into how she makes meaning in science and the role of the arts in that higher purpose of her life:

“The sciences is a way to see God. Period. Is a way to know God... And I do that

⁵ Naori explained: Mask and Voice stems from the traditional First Nation's clown. The clown was an integral member of the community who would stage performance in an every day setting to remind people of their shortcomings such as materialism and excess ego. This has cropped up Cameron's (1985) “Daughters of Copper Woman” and Halifax's (1979) “Shamanic Voices.” Sue Morrison, a famous Canadian clown says that Mask and Voice/Clown is “Based on the pioneering work of Richard Pochinko” and “this process synthesizes Native American and European clowning traditions to guide you in the discovery of clown. Participants are taken on a journey exploring colour, innocence and experience. Six clay masks are made which create a personal mythology. As they are worn and explored various characters emerge which form and define your clown. We need to build a clown who speaks to today, that is not just a collection of gags, but an archetype that reveals the essence of the performer. This clown gives us a larger sense of the divine in each of us, that celebrates our humanness, our animalness, and the times that we can touch each other in a moment of laughter” (Institute of Canadian Clowning, 2008).

through my writing.” Reflecting on her experiences, she felt that “when we write from the heart, from the soul, whatever – we’re in tune.”

In turn, Nina gave an example of resulting serendipity:

Whenever I run across something it’s because I need to. Because it’s the right time for me to see that. So often whether I’m consciously doing research for a novel... I pick up these things, serendipitously. ‘Wow! That just fits perfect with what I was trying to find out.’ And this new article pops up on the news. I never watch the news, and there it is! ...Or I’m talking with somebody and they bring up another person who does *this*... These things are always happening to me.

She interprets it as “very much of God. I think that’s what serendipitous events are.” To support her interpretation of connecting to God through writing which plays into experiences of serendipity, she reflected on a time when both the arts and God were absent from her life:

I think there was a time when I was going through my agnostic phase for instance, I let the science and the rationality and the logic take precedence over the creative pursuits and my intuitive nature... You’re not always in *tune* with yourself. It took me a while to get that way. In and out, in and out. Total lucidity and then poof!

Just as Nina’s connecting to something more means using her writing, David uses his engagement with stone sculpting as a way of reaching that point where novelty can be discovered, though he does not attribute it to God:

I’m in a state that’s not directed. That kind of connection I think is what it’s about. *Be still*. Many people look but few people see. To see means you have to get your head out of the way and actually take in what your eyes are telling you... Being able to go to that place where you can be open to novelty in a way and where you can be connected.... Stone carving can get me there.

He reflected on how it feels to be connected to something more during stone carving: “You start out cold and then you start working and when you forget *yourself*, there you are. The Self disappears.... that’s when you’re connected.” David reflected also on what it is like to connect to something more during Chinese painting and how he makes sense of that connection by attributing it to the Divine:

You [paint] thousands and thousands and thousands of bamboo. Until you can paint bamboo like you write your name. No thought... you just write it.... You don't think about what you're doing. You just do it. And that's what you aim for with Chinese painting. That's when you're connected. That's when you've removed the blocks for the Divine to come through. Or the Divine is speaking when that's happening.

To David, connecting means being able to *see* by being still and patient. Just as he saw himself as being still and patient in artistic engagements to connect to something more like the Divine, he interpreted his serendipitous moments in science to be a reflection of this same type of stillness and patience to connect to and experience serendipity:

As an individual, in the science that I've done the best things come like that. By accident. The neat observations or the novelty comes through accidents. And I think a key to that is being open. Being receptive. And making space. *Being* still and let things like that come forward.

A story that spoke to this experience is when he and his student made a discovery during her thesis by accident and were receptively open to that possibility:

The story she was looking at was that foam cells of atherosclerotic plaques accumulate with air pollution exposure; they accumulate underneath the fibrous cap and the endothelium, which is the layer of cells that line the surface of the plaque. And that they separate the endothelial cells from the fibrous material that serves as a *lid* to the plaque. Right at the end when she was putting her thesis together, she brought out pictures that I hadn't really seen before. There was a bunch of data that was sort of exciting. With the scanning electron microscope she had cells on the surface of plaques that didn't look like cells I thought they should...From *seeing* that picture made a whole bunch of other stuff fall into place... What happens is these mature fat-loaded foam cells are leaving the core of the plaques, crawling through, disrupting the integrity of the endothelium and actually leaving the plaque into the circulation...That whole thing only came together through all these little pieces that didn't quite fit. Until this one picture that cinched it.

Serendipity is like happy accidents that happen... Seeing that cell sticking out of the plaque, hauling extra cellular matrix with it, that's the only way the extra cellular matrix could've gotten outside the plaque is to have it dragged out by the foam cell...Now I could've completely missed that. It would've been really easy to miss it. So I can't tell you exactly. What I'm trying to say is that it's a mystery to me too.

While “connection” means binding with something spiritual for David, Nina, and Naori and tying into serendipitous occurrences, it does not always have to mean connecting to something spiritual. Kent’s outlook is pragmatic; “connection” means tying ideas together through intuitive means. He interpreted artistic engagement as a catalyst:

I think there’s a lot to just immersing yourself in something so that it kind of sinks deep into your brain and then forgetting about it and doing other stuff. And somehow things just happen all firing. I think artistic stuff is fantastic for switching gears and allowing that to happen.

How did Kent make sense out of his experiences of using the arts for incubation? Again, he interprets the mechanical experience of the arts to connect him to eventual intuitive understandings:

I think going and painting, and filling your life with active stuff, makes everything work better... (rather than) wishing that you could come up with exactly what you want to do next. So *doing* something. Even if what you’re doing isn’t very good. Just the act of doing stuff makes things happen.

Reflected on another way, using the arts to make intuitive connections is the essential meaning behind Kent’s science:

If I just tried to do my scientific work and nothing else – that was my entire life – then I might be semi-successful in some ways but I think a lot of the more interesting, weird, kind of wild ideas just wouldn’t happen if I was too focused on one thing without giving my brain time to make new connections that are more interesting.

Emphasizing the importance of mechanical processes in his artistic engagements, Kent contrasted painting with performing music and makes sense of mechanical process through this contrast:

I think there’s a lot to [painting] that’s more mechanical and so you can have your mind wandering and sort of thinking of stuff as you go. Whereas with music, when you’re performing, you certainly have to be more focused. It demands more attention. I’d say it’s more similar to almost a sport than painting in some sense.

In summary, connecting to something more as a scientist can mean connecting to a higher power or to extracognitive states such as intuition or receptivity to serendipity. Connecting to this state can mean a higher form of creativity in science, where loose ends are tied and novel bindings reside.

4.3 Summary

I have shared participants' stories of their experiences in doing science as artists in hopes of discovering what an artistic spirit might look like in science. They have all captured the experiences of 1. Risking success in a scientific vocation; 2. Feeling healthy through the arts; 3. Gaining and giving different perspectives through the arts; and 4. Feeling connected to something more through the arts. Implications of these emergent themes will be explored and discussed in more detail in light of the literature in the next chapter.

Chapter 5

Discussion

This chapter summarizes the results in answer to the research question, reflects on the results in light of the literature, discusses educational implications, notes the limitations and strengths of this study, and suggests future directions.

5.1 Recapping the Research Question and Results

“What are the perceived experiences of doing science by scientists who engage in the arts?” This study first aimed to obtain interpretive descriptions of the experience of doing science by highly able living scientists who also engage in the arts in order to understand the lived experience of doing science with an artistic spirit. The rationale for doing such a study stemmed from a search for a purpose or meaning of the arts in education as advocated by eminent educator, Elliot Eisner, and educational work influenced by him (Berghoff et al., 2003; Descollonges & Eisner, 2003; Eisner, 1991, 2003a, 2003b, 2005; Marquez-Zenkov, 2003) in a society that often marginalizes the arts (Eisner, 2003a; Winner & Cooper, 2000). Quotes by eminent scientists of the past revealed something of an artistic spirit in their work as scientists, a term in the call for participation at the Building the Scientific Mind Colloquium (2007). I was curious then to get a clearer picture of what an artistic spirit might look like in science.

By interviewing scientists who engage in the fine arts, results yielded four major themes of what it might interpretively mean to do science with an artistic spirit: a) Risking Success in a Scientific Vocation; b) Feeling Healthy through the Arts (Satisfying an Innate Drive; Coping in a Stressful World); c) Gaining and Giving Different Perspectives through the Arts (Complementary Tools of Perception; Complementary Processes of Perception); d) Feeling Connected to Something More through the Arts. In reflecting on these themes, I am brought to attend to whether or not they resonate with doing science with an artistic spirit per se or doing

science as an artist. Since the meaning of an artistic spirit is elusive at this point, these results will be discussed in more detail in the next section as I reflect on the literature and how I had come to a conceptualization of an artistic spirit in science.

5.2 Reflection on the Literature

If there was one common thread that I could pull from this research to probe for discussion, it would be the role of the arts in scientists' lives that enable them to: a) feel healthy; b) gain and give new perspectives in their fields of science, and c) feel connection with something more. All these themes from Chapter 4 resonate with their experience of doing science in a highly able manner and can be linked back to concepts of aesthetic experience (Dewey, 1934) and extracognition (Shavinina & Ferrari, 2004) under their shared themes of “the role of emotion in experience” and “unity in experience.” *Risking Success in a Scientific Vocation* will be discussed as ambiguous in its relation to the role of the arts, but still tied back to concepts of aesthetic experience and extracognition. The aim is to reflect on each of the four themes in an attempt to contribute to a conceptualization of an artistic spirit today.

This section will be organized with a brief recap on how I described “the role of emotion in experience” and “unity in experience” as found themes from the concepts of aesthetic experience and extracognition. Under each, I will reflect on appropriate themes from this study that it captures. When appropriate I will provide additions to the literature especially in light of the role of artistic engagement in the themes at hand. A brief reflection on the historical interplay of science and art in highly able scientists will also be included, relating themes with the words of historically great scientists when appropriate.

The Role of Emotion in Experience

“The Role of Emotion in Experience” was elicited from the concept of aesthetic experience and from the extracognitive phenomena of intuition and feelings of beauty. In terms

of aesthetic experience, it is the force involved in both process and product (Dewey, 1934). Emotion is neurologically connected to intuition (Greene & Haidt, 2002; Sadler & Zeidler, 2005; Sinclair & Ashkanasy, 2005; Volz & von Cramon, 2006) and emotion is evoked from beauty, resulting in excitement (Charyton, 2006; Girod et al., 2003) or moral goodness (Winston, 2006). Let us then explore which of these elements certain themes tapped into.

Risking Success in a Scientific Vocation

This theme was described as how scientists make sense of their vocations in a way that ignores the importance of money and reveres the importance of authentic self-propelled motives in their love for science. It speaks best to “the role of emotion in experience” in terms of specific feelings of beauty and adds specific feelings of direction (Shavinina, 2004; Shavinina & Seeratan, 2004), another extracognitive component. It is unclear whether or not the arts play a role in the extracognitive components of the experience of risking success in a scientific vocation. What participants add, however, is the experience of risk and bravery in carrying through with their feeling of direction at the possible expense of success.

In terms of specific feelings of beauty, participants either directly or indirectly alluded to a sense of moral goodness where Winston (2006) suggests that beauty can promote social justice and the experience of beauty itself can be seen as a moral sense. Indeed, participants talked about commitment to their values and ideas, which I am suggesting plays into the feeling of beauty to promote social justice in light of sticking to their own values, endeavours, and what feels right or steering clear of projects that do not sit well with their values or do not feel right. In turn, these feelings have given them direction in their point of study.

As it follows, “Specific Feelings of Direction” can be summarized as those specific feelings and cognitions of direction in studying scientific problems and the world as a whole

(Shavinina & Seeratan, 2004). For example, Shavinina and Seeratan (2004, p. 87) cite Albert Einstein in reflection of specific feelings of direction:

And so... as we did our work, I think, we almost felt at times that there was almost a hand guiding us. Because we would go from one step to the next, and somehow we would know which was the right way to go....

Indeed, participants indicated inclinations towards sticking to or steering away from projects at hand.

What the theme of *Risking Success in a Scientific Vocation* adds, however, to the literature is the experience of risk and bravery in following through on the feeling of direction. It appears that Einstein also talked of using his self-propelled motives to take risks into difficult areas of endeavour while others find success in the easier areas: “I have little patience with scientists who take a board of wood, look for its thinnest part, and drill a great number of holes where drilling is easy” – Albert Einstein (as cited in Clark, 1971, p. v). Participants all indicated a sense of bravery and risk in their scientific endeavours.

In terms of the role of the arts as a unique contribution to extracognitive relations of *Risking Success in a Scientific Vocation*, it is unclear. In other words, it is ambiguous whether this theme applies only to scientists who engage in the arts or if it is just that scientists who engage in the arts are less likely to care about adhering to the rules of the present day marketplace paradigm.

Gaining and Giving Different Perspectives through the Arts

This theme refers to art and science as disciplines that aid one another in investigation and output through complementary perspectives. It considers art and science as a) complementary tools of perception or also as b) complementary processes of perception in coming to one another's understandings. It contributes to the role of emotion in experience in terms of beauty, whereby participants come to greater understandings in science through the

excitement of art and science as disciplines reciprocally offering meaning to the other's investigation and output. Complementary perspectives of this sort are linked to beauty in terms of it providing a basis for emotion that threads together dissimilar parts of an experience to a unified whole (Dewey, 1934), resulting in excitement. In particular, Girod et al. (2003) show that aesthetic understanding of beauty involves emotion where understanding is compelling and dramatic, resulting in excitement.

Participants indeed spoke excitedly about these experiences whereby engaging in the arts or artistic mind-frame can generate excited dedication in the sciences, be it through the complementary tools of perception where artistic collaboration elicits scientific discovery, or through the complementary processes where the combination of openness and discipline elicit excitement and discovery. The excitement of complementary perspectives also suggests a close link to unity in experience in light of making serendipitous discoveries, which will be explored under "unity in experience."

Unity in Experience

In addition to "The Role of Emotion in Experience," "Unity in Experience" was elicited from the concept of aesthetic experience and from the extracognitive phenomena of intuition and feelings of beauty. In terms of aesthetic experience, unity is described as continuous flow where there are not holes but constant movement (Dewey, 1934). In terms of intuition, unity is about making unconscious connections between ideas as described in a number of neurological ways such as pattern recognition (Anderson, 2003; Frantz, 2003; Sinclair & Ashkanasy, 2005; Volz & von Cramon, 2006; Welling, 2005), flat activation (Gabora, 2002), and intuitive spontaneous thought (Christoff, 2007). In terms of feelings of beauty, unified connections are made between the self, others, and the world, which can make for a transformative experience (Girod et al., 2003). Let us then explore with which of these elements the themes struck a chord.

Gaining and Giving Different Perspectives through the Arts

As stated before, this theme reflects on when science and art provide lenses through which one can observe the other to make new meanings. It considers art and science as a) complementary tools for one another or also as b) complementary processes in coming to one another's understandings. While it captures an element of "the role of emotion in experience," perhaps it speaks best to "unity in experience" as particularly expressed through connections beyond consciousness. *Gaining and Giving Different Perspectives through the Arts* alludes to intuitive connections between ideas, and also beautiful connections between oneself and the universe.

In reflecting on history, I found this very appropriate quote by physicist Erwin Schrödinger who comments on how different perspectives are needed to understand knowledge in a unified way and to understand ourselves in a unified way with the world:

It seems plain and self-evident, yet it needs to be said: the isolated knowledge obtained by a group of specialists in a narrow field has in itself no value whatsoever, but only in its synthesis with all the rest of knowledge and only inasmuch as it really contributes in this synthesis toward answering the demand, 'Who are we?' (Schrödinger, 1951, p. 109)

Indeed, certain participants made connections beyond consciousness through intuitive means amongst ideas. Kent's experiences were exemplary in this way and spoke fully to intuitive spontaneous thought whereby when our brains are at rest, they are more highly activated than when involved in a task (Christoff, 2007), although Kent attributed activities like sleeping and painting as actually active engagements. Taking time out for our brains to rest or actively engage in a restful state through other means such as art seemed to be important for making intuitive connections, at least in Kent's experience. It is important to note, however, that these exploratory findings cannot be generalized and were not as strongly reflected on by all participants.

Other participants made connections beyond consciousness reflective of beauty's role in connecting with others and the world around. For example, Naori, in particular, talked about connecting with others whereby their unique perspectives lent themselves to a greater understanding, which might liken to a connection beyond consciousness that is transforming as suggested by Girod et al. (2003). Naori's experiences capture a connection with others in order to make connections beyond consciousness, while David talked more about the beauty in connecting to the universe in his work as a scientist.

In these experiences of making intuitive connections between ideas and beautiful connections between oneself and others and the world, their experiences added the role of the arts in both tool and process for achieving these states. Though specific examples did not speak to all participants, they beg further study, for instance, using art as a break to make intuitive spontaneous thoughts, collaborating with artists to find beautiful connections beyond oneself, and using artistic processes like asking "Why?" to enrich one's beautiful connection with the universe around.

Another role that engaging in the arts played in gaining and giving different perspectives in science in light of extracognitive experiences was making serendipitous connections. Though this notion does not come up in Shavinina and Seeratan's (2004) conceptualization of extracognition in Nobel Laureates, the experience of chance certainly comes up elsewhere in the phenomenon of extracognition (Simonton, 2004). Serendipity is "the faculty of making fortunate discoveries by accident" (Serendipity, 1997, p. 1248). Serendipitous discovery seems to tie in with "unity in experience" more specifically in regards to aesthetic experience where the moment involves a pure process of unity, flow, and movement (Dewey, 1934). Participants talked about serendipitous discoveries in their work and lives as scientists as the result of using the arts as a complementary tool or process of perception. For example, certain participants

spoke of surprising discoveries made when the arts were used as a medium or when they let their artistic processes of openness guide.

Feeling Connected to Something More through the Arts

This theme is described as connecting to or achieving a tie with something greater through the arts to make meaning in science. It speaks best to “unity in experience” as expressed through connections beyond consciousness, much like in *Gaining and Giving Different Perspectives through the Arts*. Similarly, it alludes to intuitive connections between ideas, and also beautiful connections between oneself and the universe, though an emphasis is placed on the latter. While Shavinina and Seeratan (2004) talk about feelings of beauty and Dewey talks about aesthetic experience in connecting with the world around (Girod et al., 2003), these participants add to it by sharing their experiences of how the arts can help to achieve these states.

Reflecting on historical scientists, Albert Einstein summarized the experience of feeling connected to something, more which might be likened to the mystery of intuitive connections between ideas or spiritual connections between oneself and the universe:

The fairest thing we can experience is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science. He who does not know it and can no longer wonder, no longer feel amazement, is as good as dead, a snuffed-out candle. (Einstein, as cited in Kaplan, 2001, pp. 73-74).

Though all participants spoke about making somewhat inexplicable connections, Nina, Naori, and David strongly spoke to the experience of making connections between oneself and the world, but added the component of spirituality and how the arts play a role in attaining this state. For this reason, this theme is different from *Gaining and Giving Different Perspectives through the Arts* because in my interpretation it puts more highly unexplainable phenomena like spirituality at the forefront. Spirituality as an extracognitive component suggests further research as it is not touched on in Shavinina and Seeratan’s (2004) delineation of extracognitive phenomena of Nobel Prize laureates. Furthermore, participants’ experiences give a distinct

account of engaging in the arts to reach a spiritual state, which can be useful for creative ideas even in science.

Kent, however, did not attribute the experience of feeling connected to something more to spirituality but talked about feeling connected to something more in light of physically intuitive occurrences. The reason why I placed Kent's "connection to something more" in terms of intuition in this theme rather than *Gaining and Giving Different Perspectives through the Arts* was because it seemed the highest or most mysterious of experiences to him though it did not resonate with the others in light of spirituality. This was a difficult decision to make because although I felt it could have been included in *Gaining and Giving Different Perspectives through the Arts* I felt it was important to retain the theme of *Feeling Connected to Something More through the Arts* in light of spirituality since it was so strongly spoken about by the other participants, at least to bring up in discussion. Whatever the case, Kent shared the similar experience of arts engagement getting him to this state of feeling connected to something more.

Feeling Healthy through the Arts

This theme was described as a wholeness that is found by first satisfying an inner artistic drive then using that wholeness through artistic engagement to cope in a stressful world. It speaks best to "unity in experience" in light of aesthetic experience of continuous flow and constant movement (Dewey, 1934), also reverberated by Csikszentmihalyi (1997) in order to produce an emotionally satisfying balance in life. Just as with the other themes of *Gaining and Giving Different Perspectives through the Arts* and *Feeling Connected to Something More through the Arts*, this theme captures the role of artistic engagement in attaining states of being that contribute to a conceptualization of artistic spirit in science.

Going back through the literature, Joseph Wood Krutch, a naturalist, conservationist, and writer (as cited in Kaplan, 2001) said:

Science has always promised two things not necessarily related – an increase first in our powers, second in our happiness and wisdom, and we have come to realize that it is the first and less important of the two promises which it has kept most abundantly. (p. 153)

This quote captured the theme of *Feeling Healthy through the Arts* by recognizing that science may promise health through happiness, but its attainment is always a challenge at the expense of attaining power. This theme then shows how scientists may turn to other means like the arts to reach that place of happiness and health.

Participants' certainly sought a positive state of emotions through the arts in order to satisfy an inner drive and cope in a stressful world, thus balancing life into a unified experience where flow can be found and result in well-being. In their experiences of unity, flow, and movement as central in unity of aesthetic experience (Dewey, 1934), engaging in the arts has promoted this sense of health and well-being through specific experiences like using painting to escape the cycle of depression or frustration that comes in science when you are struck, and more generally just using the arts to get back to a state of expressed wholeness and life flow in satisfying an inner drive.

5.3 Educational Implications

In addition to uncovering the perceived experiences of doing science by scientists who engage in the arts, this study sought to develop knowledge for the field of scientific creativity in light of an artistic spirit and to enlighten educators on how to foster the holistic growth of students (Eisner, 2005). In particular, it recognizes the relevancy of a shared spirit in art and science in the school curriculum, particularly in light of fostering the development of highly able students. Shavinina and Seeratan (2004) argue that extracognition as they have defined it is “probably the highest level of the manifestation of the intellectual and creative resources of a personality and, therefore, an important criterion of intellectually creative giftedness” (p.99).

Shavinina and Seeratan (2004) propose that the element of extracognition be taken into account in identifying gifted and talented children. This study suggests acknowledging a sensitivity to unexplainable phenomena like intuition, sensitivity to serendipity, ability to feel beauty, and sensitivity to connecting to something more. How to identify these sensitivities is another question altogether.

How can extracognition be fostered in our students? Findings from this study suggest that one way is through the arts. Certainly, Root-Bernstein and Root-Bernstein (2004) recognize that the devaluation of the arts in schools may have detrimental effects on creativity across disciplines. They note that many eminent scientists have held the opinion that arts education may be necessary for fostering the highest forms of scientific creativity. In particular, extracognition in terms of intuition, encountering serendipitous discovery, and having feelings of beauty and connection might be fostered through a variety of found experiences with the arts. For example, using art as a complementary tool can allow students to see science in a new way and give new meaning to it, just as David used sculpture to come to the scientific discovery about how white blood cells get out of blood vessels. Furthermore, allowing students to engage in art might foster intuitive leaps just as Kent talked about taking an arts break to allow incubation of new scientific connections. In another way, developing the artist within might foster artistic processes that promote these sensitivities just as Nina attributes her questioning attitude to her own artistic processes. Finally, arts engagement might invoke a connection to something more, allowing for highly creative ideas to flow just as Naori sources something more in doing Mask and Voice.

The above point also taps into implications for aesthetic experience in science education (Girod et al., 2003; Girod & Wong, 2002; Pugh & Girod, 2007; Wickman, 2006). In particular, it implies that using the arts might aid in transformative experiences whereby learning involves a

deep appreciation for the beauty of the subject matter, which transforms the learner's perceptions of the world around them (Girod & Wong, 2002). In particular, it suggests that fostering the excitement that goes with certain extracognitive phenomena might extend into a transformative experience as suggested by Dewey (Girod & Wong, 2002; Wickman, 2006). This has vast implications for science education in light of motivating the learner to engage further (Charyton, 2006; Girod et al, 2003; Girod & Wong, 2002) and possibly to find pleasure and flow in such area of endeavour (Csikszentmihalyi, 1997), one where girls, in particular, are engaged much less (Charyton; Innamorato, 1998).

Finally, it raises the question of interdisciplinary education, expanding on the structure of the Israel Arts and Science Academy (Donoghue, 1999; Erez, 2001; IASA, n.d.; Passow, 1992). Interdisciplinary education has implications in terms of a) interacting with people from other disciplines and b) allowing different disciplines to interact with one another in one's own mind. In terms of interacting with people from other disciplines, Naori's account of collaborating with artists as a scientist particularly speaks to the positive effects of interdisciplinary education whereby novel discoveries are made through cross-disciplinary collaboration. In terms of allowing disciplines to interact with one another in one's own mind, results resonate with IASA's philosophy of art and science complementing one another in the opposing mental processes of analysis and synthesis where art is primarily about synthesis and science about analysis (Erez). Certainly, participants experienced their artistic lives to be beneficial in gaining different perspectives through the complementary processes of art and science, but more in terms of openness and discipline.

To summarize, I would like to take this opportunity to briefly reflect on the experiences of aesthetics and extracognition in light of the approach to science education today as addressed by Nobel Prize winner, Dr. Carl Wieman (2007) since he is influential in looking for a better

approach to science education. Wieman (2008) calls attention to acquisition of the behaviour of mind that is shared amongst experts, rather than novices, in the field of science. Since I interviewed experts in science based on the expert-performance perspective of high ability (Ericsson et al., 2005), I believe there are some implications.

Particularly, Wieman (2007) outlines three key areas in acquiring the behaviour of mind of experts: a) How knowledge is organized and applied; b) Problem-solving; and c) Attitudes and beliefs about the subject. This study may add to the third behaviour of mind: attitudes and beliefs about the subject. According to Wieman (2008), developing in students the attitudes and beliefs about science that experts have is important in learning. Two aspects of this point are that teachers must a) make the students want to see the purpose of science and b) stress the cognitive processes of experts. Wieman (2008), however, makes no reference to stressing extracognitive processes of experts. This study, though exploratory, implies an explicit recognition also of stressing the extracognitive processes of experts in science education today in order to build a strong foundation for future generations of expert scientists. Furthermore, the concept of aesthetic experience in science (Dewey, 1934, Wickman, 2006) may more explicitly add to his call to ignite in students the desire to see the purpose of science whereby students experience a personal connection with the subject at hand.

5.4 Limitations of the Study

The first limitation of this study is reflective of the title. This study sought to capture “artistic spirit,” a concept that is not properly defined in the literature, but written in the call for participation at a colloquium I attended (Building the Scientific Mind, 2007). As such, it is somewhat elusive as to whether or not the results speak to the experience of doing science with an artistic spirit or doing science as an artist. It is a mere assumption that artists will have an artistic spirit.

Another limitation to this study is that although it aimed to recruit highly able scientists as defined by attaining a Ph.D. in the sciences, one participant did not meet that requirement of status. There was trouble in finding participants who both engaged in science at a high level and engaged in the arts. Not to mention, I was curious to have equal females and males. As such, an exception was made to include a female participant who did not attain a Ph.D., but was nevertheless an accomplished scientist. In turn, her perspectives may be slightly different, being in a different type of scientific career (consulting as opposed to being in a university setting).

The fact that only four participants were interviewed is a limitation as well. Although four were chosen on account of interviewing in depth, ideas and themes did not fully reach saturation, which would have given me more confidence though this is a requirement primarily of grounded theory methodology (Creswell, 1998). Although the themes found captured all participants' experiences, responses within them were still diverse enough to be explored further. In turn, data were lost if they did not speak to all participants. Perhaps through interviewing more participants, discarded data might be brought to life that speak more pertinently to already developed concepts in the literature such as aspects of extracognition and aesthetic experience.

In terms of using hermeneutic phenomenology as a method, I found that because it was artists who I interviewed, speaking and analysis of spoken text was perhaps not the closest way of communication unique to them, and certainly not to me. While hermeneutic phenomenology seeks to primarily analyze text (Ricoeur, 1981), indeed other modes of communicating their experiences of doing science as artists such as through sculpture, painting, dance, and writing may have sat more pertinently with their preferred modes of personal expression. I felt this might be the case by observing Naori's physically expressive way of communicating, Kent's quieter way of communicating, Nina's descriptive way of using etymologies to communicate, and David's way of communicating through drawing.

5.5 Strengths of the Study

Despite the limitations named, there were a number of found strengths in this study as well that offset its limitations. While one of the limitations I felt was in the study's attempt to capture the elusive concept of artistic spirit (Building the Scientific Mind, 2007), this study offers the beginning of a journey into its encompassing of rich concepts like aesthetic experience (Dewey, 1934) and extracognition (Shavinina & Ferrari, 2004). This exploratory research enabled insight into an unknown phenomenon, relevant and contemporary interpretations, and more questions as a result.

In turn, data collection through three open-ended interviews each proved an advantage. While few clear foci going into the interviews was unnerving, it offered this exploratory study new perspectives, insights, and rich offerings into the lived experiences of scientists today who engage in the arts. It provides a springboard for further investigation rather than answers to inevitably changing phenomena.

Another strength was the demographics of participants. There were an equal number of female and male participants, those early in their career and later in their career, and variety across the board in arts engagement and field of science. Having diversity in such a small sample size made it difficult at times to find saturation in themes of doing science with an artistic spirit. Nonetheless, it gave more confidence in the themes that were pulled since participants truly were diverse and met on four thematic fields.

Finally, this study gave scientists an opportunity to give voice to both a valued and at times hidden part of their lives: the inner artist. Through informal feedback, participants seemed happy with the interaction, be it a therapeutic process, a learning process, or an exciting opportunity to share their experiences, feelings, and thoughts.

5.6 Future Directions

Since this was an exploratory study into a new area, doing science with an artistic spirit, there are many avenues for future research. First, while this study was insightful about doing science with an artistic spirit from the point of view of accomplished scientists in the work force, it would be interesting to interview gifted children and adolescents about their experiences in doing science in order to understand different concepts of high ability that might tap into areas of extracognition (Shavinina & Ferrari, 2004) and aesthetic experience (Dewey, 1934). Certainly, Shavinina and Seeratan (2004) have begun to understand similar extracognitive phenomenon in gifted adolescents.

Second, future research needs to include more participants in order to access a deeper understanding of the experience of doing science with an artistic spirit as an artist. It would be useful to gain more saturated results to get a clearer understanding of such difficult to grasp concepts like extracognition. Research may want to use a different method that enables scientists who are artists to communicate in their preferred mode of artistic expression. Arts-based research may be a good point of departure and perhaps another form of analysis would have let the participants' unique and in depth voices stand on their own individually, such as the case study method or biography (Creswell, 1998).

Third, while this study alludes to the usefulness of the arts in education, on the backdrop of science, it is impossible to make any causal claims. Although first-person experience should not be discredited as a valid voice in arts advocacy, the experience of these scientists who engage in the arts cannot causally speak to the role that the arts plays in their science, though it was alluded to. Empirical evidence through quantitative studies might advocate more strongly for the arts in education.

Fourth, it might be interesting to study the different roles that the arts play in different fields of science. Certainly, an appreciation of beauty was alluded to strongly in David and Nina's accounts, who both study the natural sciences in depth. For Naori and Kent, on the other hand, though beauty may have been mentioned, there were stronger allusions to using art as a parallel process or tool to come to a greater understanding in their science. Pin-pointing more specific roles of the arts in specific fields of science may be interesting and useful in guiding science education with an artistic spirit.

Fifth, it might be valuable to flesh out the first theme of risking success in a scientific vocation in light of arts engagement. This theme seemed to capture the ethical impact that engagement with the arts may have on Western culture's science-oriented society. It would be interesting to investigate how scientists with no arts engagement approach their work in comparison with those that do, based on the allusion in this study that arts engagement may foster gentle and ethical ways of doing science.

Sixth, it might be useful to analyze the data collected by these participants on their opinions and/or experiences with interdisciplinary education. Unfortunately, due to time restrictions this part of the research was not further explored. Nevertheless, in the future, giving voice to experts of science who engage also in the arts, we might gain clear insight into how we educate today in light of interdisciplinary studies. Certainly, at a glance the participants saw the value in developing people as good citizens through a broad, interdisciplinary range of knowledge. There seemed disagreements, however, on the importance of interdisciplinary education for expert knowledge in the sciences. This topic needs to be further explored.

5.7 Impact on the Researcher

In reflection on and addition to the Spatial and Temporal Worlds described in Chapter 4, Van Manen (1990) notes also the Relational and Corporeal Worlds. The Relational World or as he states it, the lived other, is the relation we keep with others in the space we share with them. This is a reflection then of how my research participants have had an impact on me. It is an amalgamation of field notes and personal reflections after the research had taken place, which is hoped to give insight into the participants as individuals, but also into our interactions, which is pertinent to qualitative research. Assuming my own role as the researcher and writer of this thesis, I have alluded to each participant in the title as a way in which they have motivated me in the writing process. I have decided to represent the experience through poetry because it is one of my own personal forms of self-expression and it reinforces the value of offering different modes of expression in educational settings.

David – The Momentum

His name means Big Gate in Chinese characters.
I had no idea what I was in for.

His doors opened wide
Like a big gust of wind
I had barely yet knocked
Before being sucked in

He studies the lung
He sculpts for fun
And his passion for both
Slapped me silly

Full of his own rich theories
And so open to it all being Story
I can't help but become
Consumed in the details
That fluidly pour forth
Like a dam come undone.

He's an unlocked Big Gate.
"Come on in!"
Don't wait.
The force of his welcome
Wiped my quietness from the slate

I'm riding a wave
In the midst of my scatter-brained shame
Disorganized in research's name
But it's a ride
It's a trip
I'm comforted
Relaxed
Encouragement drips
I'm enlightened
Inspired
Absorbing sun tips

And fully
Realizing this privilege.

To enter the Big Gate.

On every day
That we met
The sun got sunnier
By the end

And I greeted others
With all my lung's breath
Stone sculptures of cold
Would dance out from their death
His energy flows
Raw

Words that flood out
Like a dam come undone
I unlocked my Little Gate.

Not necessarily in facts I know
But how I am and how we relate.

Naori – The Ebb and Flow

Contact improv is one form of her dance
In her professional artistry
And her walk on this land
She speaks in words

But flavoured in movement
The transcript is part sound-effect.

Moving through space
Going with flow
Our contact also
Rests on improv
 Where reception and connection
 Works best outside of structure

I was frustrated at first
When hopeful times of mutual space
Had to be changed around
For us to embrace
Conversation and contact
That was really only found
In last minute efforts
That were shared on a variety of Canada's grounds

Improvisational Contact #1

I assumed she was still residing two provinces over
In my hometown
So I gave her a call
In hopes of meeting her once I went back to visit

But I was redirected
To this city I already am in
Because by chance she has been here too
The past few months

And we still had a couple of weeks
To share this city
And a pot of tea.

Improvisational Contact #2

In this first city that we met
Naori stayed back
And I jumped the jet
To go back home
And soon enough
She came too
And on this different soiled ground
From which life springs
And other transformings...

We still had a couple of days
To share this city
And a pot of tea

Improvisational Contact #3

In this second city that we met
Naori stayed back
And I jumped the jet
To go back to studies
But a couple months later
Unknown to me
I bumped into her
On the street
By chance she was back
For a few days visit

And for a couple of minutes
We shared that city

Full circle improvised contact
She has taught me the rhythm
Of dancing through Western Canada

Kent – The Structure

The first days we had met
Nature sat in odd silence
Heavy grey sky

But in his office
Bright saturated paintings
Offset the weather
And offset the somewhat shy
Way I asked questions

Unchanged by the weather's moods
A backboned structure he has accrued
To give this thesis topic form

To help me organize my thoughts in a way
From which others' ribbed words
Could sway, meet, and play

Though sometimes I felt timid
His words were kind
His smile would bind
The uncertainties I had

To a mathematical clarity
Of his experiences
Although I'm sure there's still more had

With a smile that knows
And clarity that shows
Me how to focus
On the topic at hand

Through him
I understand
My question to begin with
The one that went awry

I'm grateful
For his algorithmic roots
That gave some order to the chaos

Nina – The Riddled Punctuation

Kicking confidentiality
Straight to the curb
and down the drain
There's simply no shame
In this lady's name.

Like an elbow to the side
Like a slap to the knee
The force of her humour
Propels me

She's an open book
And I'm there for a look
At her sci-fi terrain
Of which nothing's refrained
Her heart's ecology
Touches my psychology

And I feel tickled lucky
Much as the day is sunny
Near as bright as her eyes twinkly
As I spend our time feeling entirely

at home

Between our language, heritage, and the cottage cheese on the brunch table
My paranoia of getting facts right
Takes a rocket to the moon

And I am consumed
By this comfort she has given me
Of simply being a richly humoured human

5.8 Impact of the Researcher

According to Rubin and Rubin (1995) it is important that the researcher makes herself credible by journaling in order to keep track of ongoing thoughts, feelings, impressions, and processes so that the reader can plainly see how the researcher came to where she came. I approached this research with a prior interest in art and psychology. That said, the themes gathered were likely influenced by these interests. Themes, as such, may at times have a sound of “soul” as is the purpose of psychology.

In turn, I immediately felt a connection to Nina, David, and Naori who spoke of a belief in something more and whose voices gave a spiritual flair to the theme of *Feeling Connected to Something More through the Arts*. It was more difficult to relate to Kent in this aspect perhaps because he was very pragmatic in beliefs and in his journey as a scientist and artist.

The theme of *Feeling Healthy through the Arts* may reflect my own experiences of engaging with the arts during times of psychological distress. As such, I could relate best to Kent’s experiences of painting to overcome depression. In turn, I sought this theme out in other participants as well.

Gaining and Giving Different Perspectives through the Arts was a theme that popped up on its own for me. Since I do not engage in the hard sciences to which this theme specifically addresses, my bias to any one participant is unclear.

Finally, *Risking Success in a Scientific Vocation* may reflect my desire to elevate the underdog who dares to experiment. Since I could relate to David, Kent, and Naori who made mention of doing science because it was an obvious way to make a living, it may have been my bias to point out that they also engage in risk during this endeavour. I personally struggle to dare

embark on my own journey at the expense of security so I was perhaps biased in making this a noteworthy theme. In noting my biases, it is my hope that I have captured each participant's story without making it into my own or disowning it on account of my own.

5.9 Conclusion

There is no conclusion, so to speak. Van Manen (1990) states that it is inappropriate to ask for a conclusion for a study of this method. Certainly, I have had trouble tying things together and breaking them apart. Dewey (1934) expresses a beautiful notion of unity in variety. It is hoped that some sense of unity in the variety of participants was achieved that captured the essence of being a scientist who engages in the arts. It is hoped that by giving accomplished scientists who engage in the arts a voice on their experiences of doing science with an artistic spirit, we can at least begin to understand through first-person accounts the meaning of the arts in a science-driven society. While science and art etymologically stand on opposite grounds, perhaps it is merely a matter of language that separates the disciplines. Through the self-perceived experiences of scientists who engage in the arts, more questions might be raised on the art of fitting two disparate worlds together in education.

Chapter 6

Epilogue

As I was trying to write the Educational Implications in chapter five, I struggled with the question of “So what is the point of this really?” How did everything that I have learned from my encounters with highly able scientists who engage in the arts have anything to do with education? With what age range? With arts education? With science education? With gifted education? With Western education? What are the most pertinent matters of these intricate stories that weave into the already intricate oceans of journal articles in this educational setting? Poking through mountains of abstract literature, I realized it was finally time to go to a meeting. And this is where I found my educational implication.

The meeting was about putting on an event called “The Art of Science.” How did it come about? Through this thesis, David was so ecstatic about being given a platform on which to express his life as an artist that he wanted the same for his graduate students. He sent an email out of curiosity to the graduate students in his department asking who also engaged in the arts. With a hearty response, he decided to spearhead an arts night where graduate students in Pathology could be given a platform to showcase their artistic talents (Appendix G). Meeting these students, I am honoured to share in their warmth, brightness, and excitement to attempt a professionally set venue for artistic showcasing.

Moreover, the concrete implications of including art in science education are more evident to me by seeing such an event in action. From my observations, it seems as though switching gears to focus on artistic endeavours is a refreshing welcome. It is also a lesson for me on digging deeper into human life to bring up the colours of emotion, the excitement in motivation, and the spark of the inner artist. In so doing, I am reminded constantly to stop forgetting this part of myself. This is a photo that I will show at the event.

Simple
Beauty.

I find that...
Looking at anything long enough
With the faith that it holds
Pieces of life
We can't help but seeing
The beauty and power
In its smallest of details
Undenied.

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Appendix A

The Experience of Doing Science with an Artistic Spirit: A Hermeneutic Phenomenological Study

<date>

Dear <name>,

My name is Krista Fogel and I'm writing to request nominations for potential participants for my graduate thesis research project that I am completing as part of my Masters degree in Special Education at The University of British Columbia.

The intent of my research is to give accomplished scientists who engage in the arts a voice on how they see their engagement with the arts as relevant or not to their own work and experience as scientists. I am requesting that you nominate professors in your department who you feel are highly relevant candidates in terms of being scientists who engage in the arts. Once you have nominated them, I will contact them through a personal e-mail and more detailed information on my study.

I have also included a specific description of my research for you as well as a list of the general interview questions so you get a sense of the type of information I am seeking from participants. If you would like to contact me (for any reason at all), please send me an e-mail (xxx@xxx.xxx) or give me a call (xxx-xxx-xxxx). I'd be happy to answer any questions you may have or to give you more details on my research project.

Please send your nominations to me through e-mail by <date>.

Thanks so much,

Krista Fogel
Enc.

Enclosure:

Overview of Research Problem

The work of eminent educator, Elliot Eisner, and educational work influenced by him advocates for the arts in education (Berghoff, Bixler Borgmann, & Parr, 2003; Descollonges & Eisner, 2003; Eisner, 1991, 2003a, 2003b, 2005; Marquez-Zenkov, 2003) in a society that often marginalizes the arts (Eisner, 2003a; Winner & Cooper, 2000). History, however, shows that eminent scientists also engaged in the arts, such as “Renaissance man” Leonardo da Vinci (Deckert, 2001), not to mention, for example, 400 other cases of famous scientists who also practiced art at a high level (Root-Bernstein, 1989). If not entirely engaged in the arts, scientists throughout history have at least engaged in science with an artistic spirit. For example, scientists and artists use common tools for thinking such as intuition and imaginative processes (Root-Bernstein & Root-Bernstein, 2004).

What then do scientists today have to say about the relevancy or lack thereof of the arts in their work and experience? This qualitative study will attempt to learn about accomplished scientists’ perspectives on the issue of artistic spirit in their work through open discussion and using thematic analysis to gain results. The insights given by scientists who engage in the arts may contribute to the degree of relevancy of the arts in education and holistic education.

Purpose of Research

- To understand how accomplished scientists who engage in the arts make sense out of their experience of doing science.
- To gain the scientist's perspective on the context of their experience.

Research Questions

1. “What are the perceived experiences of doing science by scientists who engage in the arts?” As such, what can we infer about the role of the arts in doing science?
2. “Based on personal experiences, are there implications for the integration of the arts and sciences in education?”

Appendix B

The Experience of Doing Science with an Artistic Spirit: A Hermeneutic Phenomenological Study

<date>

Dear <name>,

My name is Krista Fogel and I'm writing to invite you to participate in my graduate thesis research project that I am completing as part of my Masters degree in Special Education at The University of British Columbia.

The intent of my research is to give accomplished scientists who engage in the arts a voice on how they see their engagement with the arts as relevant or not to their own work and experience as scientists. I am requesting your participation because you are a highly relevant candidate in terms of being a scientist who engages in the arts. If you would like to contribute to this research, we would meet for an informal interview (approximately one hour) some time in <month>. Two other informal interviews are planned to follow, spaced approximately one week apart in order to gain a greater and clearer understanding of your perspectives. You would be casually working with me to come to an agreed upon understanding of your perspectives and insight.

I have included a more specific description of my research as well as a list of the general interview questions that you may be asked to discuss. I will contact you by phone or e-mail in about one week to find out if you are interested or not. If you would like to contact me before this time (for any reason at all), please send me an e-mail (xxx@xxx.xxx) or give me a call (xxx-xxx-xxxx). I'd be happy to answer any questions you may have or to give you more details on my research project.

Thanks so much,

Krista Fogel

Enc.

Enclosure:

Overview of Research Problem

The work of eminent educator, Elliot Eisner, and educational work influenced by him advocates for the arts in education (Berghoff, Bixler Borgmann, & Parr, 2003; Descollonges & Eisner, 2003; Eisner, 1991, 2003a, 2003b, 2005; Marquez-Zenkov, 2003) in a society that often marginalizes the arts (Eisner, 2003a; Winner & Cooper, 2000). History, however, shows that eminent scientists also engaged in the arts, such as “Renaissance man” Leonardo da Vinci (Deckert, 2001), not to mention, for example, 400 other cases of famous scientists who also practiced art at a high level (Root-Bernstein, 1989). If not entirely engaged in the arts, scientists throughout history have at least engaged in science with an artistic spirit. For example, scientists and artists use common tools for thinking such as intuition and imaginative processes (Root-Bernstein & Root-Bernstein, 2004).

What then do scientists today have to say about the relevancy or lack thereof of the arts in their work and experience? This qualitative study will attempt to learn about accomplished scientists’ perspectives on the issue of artistic spirit in their work through open discussion and using thematic analysis to gain results. The insights given by scientists who engage in the arts may contribute to the degree of relevancy of the arts in education and holistic education.

Purpose of Research

- To understand how accomplished scientists who engage in the arts make sense out of their experience of investigating science.
- To gain the scientist's perspective on the context of their experience.

Research Questions

3. “What are the perceived experiences of investigating science by scientists who engage in the arts?” As such, what can we infer about the role of the arts in these scientific investigations?
4. “Based on personal experiences, are there implications for the integration of the arts and sciences in education?”

Appendix C

Consent Form

The Experience of Doing Science with an Artistic Spirit: A Hermeneutic Phenomenological Study

PRINCIPAL INVESTIGATOR: Dr. Marion Porath, UBC Department of Educational and Counselling Psychology, and Special Education, xxx-xxx-xxxx.

CO-INVESTIGATOR: Krista Fogel, UBC Department of Educational and Counselling Psychology, and Special Education, xxx-xxx-xxxx. This research is being done for a thesis in fulfillment of a Masters degree in Special Education. As such, it will be made a public document.

SPONSOR: Social Sciences and Humanities Research Council (SSHRC), University Graduate Fellowships (UGF)

PURPOSE OF STUDY: This study seeks to understand how accomplished scientists who engage in the arts make sense out of their experience of doing science, and to also gain the scientist's perspective on the context of their experience. You are being invited to participate in this research study because you have been identified as an accomplished scientist who engages in the arts.

STUDY PROCEDURES: You are being invited to voluntarily fill out a background information sheet and to take part in three interviews to discuss your experience in doing science in the context of engagement with the arts. The lengths and scheduling of the interviews are flexible, but are estimated to take approximately one hour each with approximately one week in between for a duration of 3 weeks. Each interview will be tape-recorded and then transcribed. There is also the possibility of photographing one of your artistic compositions if it is a visual work. Throughout, you will then be asked to review the written transcript and make any deletions or additions that you would like before the analysis takes place. I may also ask for your input on my interpretations during the analysis.

POTENTIAL BENEFITS: There are no direct benefits to participants other than voicing your own experiences, thoughts, and feelings as a scientist who engages in the arts. The hope is that your experience may contribute to the degree of relevancy of the arts in education and holistic education. If you would like a report on the findings, please include your name and mailing address at the end of this consent form.

POTENTIAL RISKS: No risks are foreseen other than the possibility of addressing personal experiences, unforeseen questions, and photographing your art if feasible to be used in the final report. It is always possible that you may experience discomfort and not want to continue with the interview nor wish to have your work photographed. You are free to discontinue the study at any time. In writing up summary statements I will be making interpretations and drawing conclusions from our conversation. Your words may be rephrased in ways you never intended. You will be given the opportunity to provide feedback on interpretations and conclusions.

CONFIDENTIALITY: Your name will not be associated in any way with your interview unless you choose to use your real name in place of a pseudonym. Your consent form will be stored separately from the interview. No identifying information will appear on the transcript of your recording and you will have the opportunity to delete or add information to the transcribed interview. No one will have access to the original recording of the interview other than the principal investigator and co-investigator, but portions of the transcripts and a summary of results will be made public.

REMUNERATION: There is no remuneration. Participation is on a voluntary basis.

CONTACT FOR INFORMATION ABOUT THE STUDY: If you have any questions or desire further information with respect to this study, you may contact Dr. Marion Porath or myself, Krista Fogel.

Principal Investigator: Dr. Marion Porath, Department of Educational and Counselling Psychology, and Special Education, Scarfe xxxx, UBC, 2125 Main Mall, Vancouver, BC, V6T 1Z2, xxx-xxx-xxxx. xxx@xxx.xxx,
Fax: xxx-xxx-xxxx (Attention: Krista Fogel, c/o Dr. Marion Porath).

Co-Investigator: Krista Fogel, xxx xxx St., Vancouver, BC, xxx xxx,
xxx-xxx-xxxx. xxx@xxx.xxx

CONTACT FOR CONCERNS ABOUT THE RIGHTS OF RESEARCH SUBJECTS: If you have any concerns about your treatment or rights as a research subject, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598 or if long distance e-mail to RSIL@ors.ubc.ca.

CONSENT: Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time without jeopardy to your present or future relationship with the University of British Columbia.

Your signature below indicates that you have received a copy of this consent form for your own records.

Your signature indicates that you consent to participate in this study.

Participant Signature

Date

Printed Name of the Participant signing above

MAILING ADDRESS REQUESTING A REPORT OF THE FINDINGS (optional):

Appendix D

Background Information Form

All the requested information will be kept confidential. Please use the back if you need more space.

Name: _____

Age: _____

Sex: *Female / Male*

Ethnicity: _____

Marital Status: _____

Highest Level of Education Completed: _____

Type(s) of Involvement with Science or Scientific Investigation

(List from most committed to least committed to)

1. _____
2. _____
3. _____

How long have you been in the field of science? _____

Type(s) of Personal Engagement with the Arts

(List from most committed to least committed to)

1. _____
2. _____
3. _____

How long have you engaged in the arts? _____

What kinds of accomplishments have you attained?

1. _____
2. _____
3. _____

Shade in the circle showing the approximate percentage that your engagement with the arts plays a role in your life as a scientist.

Appendix E

Ethics Approval

The University of British Columbia
Office of Research Services
Behavioural Research Ethics Board
Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - MINIMAL RISK

PRINCIPAL INVESTIGATOR: Marion J. Porath	INSTITUTION / DEPARTMENT: UBC/Education/Educational & Counselling Psychology, and Special Education	UBC BREB NUMBER: H07-01969
INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:		
Institution UBC		Site Vancouver (excludes UBC Hospital)
Other locations where the research will be conducted: - Interviews are planned to take place in the participants' primary place of work. Participants are accomplished scientists who also engage in the arts.		
CO-INVESTIGATOR(S): Krista M Fogel		
SPONSORING AGENCIES: Social Sciences and Humanities Research Council of Canada (SSHRC) University of British Columbia		
PROJECT TITLE: The Self-Perceived Experience of Investigating Science with an Artistic Spirit: A Hermeneutic Phenomenological Study of High Ability Scientists Who Also Engage in the Arts		

CERTIFICATE EXPIRY DATE: October 16, 2008

DOCUMENTS INCLUDED IN THIS APPROVAL:		DATE APPROVED:	
		October 16, 2007	
Document Name	Version	Date	
<u>Protocol:</u>			
Research Proposal	N/A	September 20, 2007	
<u>Consent Forms:</u>			
Participant Consent Form	N/A	September 21, 2007	
<u>Questionnaire, Questionnaire Cover Letter, Tests:</u>			
Interview Script	N/A	August 10, 2007	
<u>Letter of Initial Contact:</u>			
Letter of Initial Contact to Nominators	N/A	September 20, 2007	
Letter of Initial Contact to Nominees	N/A	September 20, 2007	

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

***Approval is issued on behalf of the Behavioural Research Ethics Board
and signed electronically by one of the following:***

Dr. Jim Rupert, Associate Chair
Dr. M. Judith Lynam, Chair
Dr. Laurie Ford, Associate Chair

Appendix F

Ethics Amendment

The University of British Columbia

Office of Research Services

Behavioural Research Ethics Board

Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - MINIMAL RISK AMENDMENT

PRINCIPAL INVESTIGATOR: Marion J. Porath	DEPARTMENT: UBC/Education/Educational & Counselling Psychology, and Special Education	UBC BREB NUMBER: H07-01969
INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:		
Institution UBC		Site Vancouver (excludes UBC Hospital)
Other locations where the research will be conducted: - Interviews are planned to take place in the participants' primary place of work. Participants are accomplished scientists who also engage in the arts.		
CO-INVESTIGATOR(S): Krista M Fogel		
SPONSORING AGENCIES: Social Sciences and Humanities Research Council of Canada (SSHRC) University of British Columbia		
PROJECT TITLE: The Self-Perceived Experience of Investigating Science with an Artistic Spirit: A Hermeneutic Phenomenological Study of High Ability Scientists Who Also Engage in the Arts		

Expiry Date - Approval of an amendment does not change the expiry date on the current UBC BREB approval of this study. An application for renewal is required on or before: October 16, 2008

AMENDMENT(S):	AMENDMENT APPROVAL DATE: April 24, 2008	
Document Name Consent Forms: Consent Form Draft5 - Amendment	Version 2	Date April 11, 2008
The amendment(s) and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.		

***Approval is issued on behalf of the Behavioural Research Ethics Board
and signed electronically by one of the following:***

Dr. M. Judith Lynam, Chair
Dr. Ken Craig, Chair
Dr. Jim Rupert, Associate Chair
Dr. Laurie Ford, Associate Chair
Dr. Daniel Salhani, Associate Chair
Dr. Anita Ho, Associate Chair

Appendix G
'The Art of Science' Poster

*The UBC Department of Pathology
& Laboratory Medicine
presents a Gala Evening*

Tuesday, June 17th, 2008

7 - 9pm

*xxx xxx xxx xxx
xxxx xxx Street,
Vancouver*

Tickets \$5