BUILDY-BOYS: A PORTRAIT

by

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THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In the
Faculty
of
Education

SIMON FRASER UNIVERSITY

Fall 2006

APPROVAL

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DEGREE Master of Arts

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ABSTRACT

This thesis used a multiple case study methodology to create a portrait of what may be a unique cognitive profile. Ten parents' descriptions of the traits, developmental characteristics and educational experiences of their children who are passionate about and precocious at complex constructive activity were compared to descriptions of the childhoods of engineers who do exemplary work in their field. Common characteristics included: gender, lack of pretend play, lack of interest in narrative, strong interest in computers and strategic games, academic competency, math and science subject preferences, intense focus on tasks of interest and possibly, a subtle lack of social focus and conflict avoidance. I discuss how this collection of descriptions may relate to and possibly illustrate theories related to play, giftedness and cognitive style. Eductational implications and directions for future research are suggested.

Keywords:

Academically Gifted, Aptitude, Asperger Syndrome, Autism, Behaviour Patterns, Cognitive Style, Constructive Play, Dramatic Play, Evolution, Labeling (of Persons), Individual Differences, Intelligence, Pretend Play, Science Process Skills, Social Cognition, Spatial Ability, Student Characteristics, Young Children

DEDICATION

To David

ACKNOWLEDGEMENTS

With many thanks for support and encouragement to my supervisors Paul Neufeld and Lucy LeMare; and to the participants who generously contributed so much; and finally, to my dear family.

TABLE OF CONTENTS

1 INTRODUCTION

Two children get on a merry-go-round. One is delighted by the ornate horses, attends to the squeals of the child next to her and responds in kind. When the ride begins she pretends she is riding a real horse and imagines a narrative in which she is winning a horse race. The other child notices that the different horses are moving up and down at the same speed but at alternate times. This child stares intently at the mechanism that creates this alternating up and down motion, and then observes that there is a spur-gear in the centre of the ride.

Two children enter a preschool playroom. One notices a group of children playing "store". After watching the children and moving closer, he places a block on the table and asks to buy a Popsicle. The teacher smiles, pleased with this child's successful entry into the group. The other child, however, notices the Lincoln Logs, and immediately becomes engrossed in building the complicated fort pictured on the box. This child focuses intensely on his construction activity. He ignores the other children near him and tries to avoid sharing the pieces he needs by hoarding them and moving away. The teacher wonders whether she should be concerned by this child's behaviour.

These vignettes are intended to illustrate how the same environment can create different experiences, depending on the focus of a child's attention or orientation. The second child in both examples is attending to "how things work," or "what things can do" while the first is more concerned with the meanings of things in a social context. This difference in orientation, if stable, can reasonably be expected to impact cognitive and

social development. The outcome might be an alternative developmental "route to maturity." If this were the case, then type-dependent theories of development would be needed in the child development literature.

"People concerned with developmental function are interested in universals" (Bjorklund, 1995, p.2). In the child development literature, what is presented as true represents what, on average, is thought to be true for all members of the species (Bjorklund, 1995). This literature informs educators, child-care workers, psychologists and parents, providing these groups with norms against which individual children can be compared. When children's behaviour or developmental traits do not seem to match up to expectations, then questions arise: Is this child normal? Is he/she gifted or delayed? Is intervention required?

In this thesis, I attempt to document what may be a systematic deviation from accepted child development wisdom: the development of children who, from a very young age, are passionate about complex constructive activity and figuring out "how things work". By "complex constructive activity," I mean an activity motivated by the desire to solve a set of technical problems, without the intent to support narrative or to create a symbolic representation of something else. Children engage in complex constructive activity when they build complicated structures for the sake of building, i.e., not for the sake of creating a representation of something else. In current Western society children's complex constructive activity often takes the form of very advanced and technical play with Lego and K'nex—where the "point" is to grapple with inherent technical problems. In previous generations, "complex constructive activity" may have taken the form of building with a Meccano set, or with bits of wood from the toolshed.

Another form of complex constructive activity would involve taking apart a household appliance, and then perhaps trying to put it back together. "Complex constructive activity" is motivated by a desire to solve a puzzle, to figure out "how something works," or to work out a set of if . . . then generalizations, for example: "if I pour water down one end of this tube, it comes out the other end." Thus, complex constructive activity includes mini-experiments, such as pouring water down a culvert over and over to figure out why it keeps going down, or playing around with a calculator to work out mathematical principles. While many children engage in these kinds of activities, in this thesis I investigated those children whose interest in this kind of activity is comparatively extreme.

The children of interest in this study are both passionate about complex constructive activity, and precocious in their understanding, specifically of what is described by Baron-Cohen (2003) as "systems." "Systems" refers to phenomena that are typically related to the physical world, that is, our understanding of the properties of objects; however, "systems", as described by Baron-Cohen, can also relate to abstract phenomena, such as mathematical systems, systems of classification, or systems of organization. In writing this thesis, I am interested in describing children whose behaviours indicate precocity and intense interest in understanding how "systems" work: for example, a child who "invents" a siphon at the age of three, a child who independently discovers negative numbers at the age of two, or a child who routinely builds Lego constructions or works with science kits recommended for children who are significantly older. These exceptional behaviours suggest the construct "giftedness" in this particular domain.

Joyce VanTassel-Baska (cited in Henshon, 2005), speaking about the future in the field of gifted education, called for attention to be paid to the profiles and patterns of special populations of gifted learners. She emphasized that knowledge of special populations would significantly enhance educators' effectiveness. Special populations like gifted girls, gifted children from minority backgrounds, and the gifted-learning disabled, are well represented in the literature. However, there exists no single study that explores the phenomena of young children who are precocious at complex constructive activity and thinking related to "systems". The present study represents my attempt to begin such an investigation into this special population of gifted children.

For many writers in the field of gifted education, giftedness is construed as a potential for extraordinary future achievement. For example, Tannenbaum (1997) writes:

> Keeping in mind that developed talent exists only in adults, I propose a definition of giftedness in children to denote their potential for becoming critically acclaimed performers or exemplary producers of ideas in spheres of activity that enhance the moral, physical, emotional, social, intellectual or aesthetic life of humanity (p. 27).

Do the children in this study have the potential to become "exemplary producers" in fields related to their current interests? Or is their seemingly narrow focus likely to stunt their intellectual and/or social development? Certainty can only be provided by a longitudinal study across the lifespan. However, I felt it would be interesting to compare the traits and characteristics of children who are avid and precocious builders to the recollected childhood traits and characteristics of adults who are now "exemplary producers" in fields related to engineering: that is, adults whose work with systems-related phenomena has proved to be very successful.

Finally, I attempted to systematically explore the characteristics of children who are avid and precocious at complex constructive activity and relate these to various theoretical frameworks. The following theories were considered as possible frameworks: Silverman's (2002) theory of the Visual/Spatial Learner, Baron-Cohen's (2003) theory of systemizing-empathizing, and the evolutionary psychology-inspired Hunters—Collectors—Toolmakers theory (Bonnycastle, 2004).

1.1 Initiation of the project

As a parent, teacher and friend, I have observed for years that children with a definite "bent" for complex constructive activity seem to display a set of common characterisitcs. For example, I have observed that very few of these children engage in much or any pretend play; they seem to be exceptionally bright, yet struggle in school; they seem to lack motivation to conform to their peer group's, or teachers' expectations; they seem to be far less aggressive than other children, and are frequently bullied. Furthermore, I have only ever observed boys display a truly intense passion for building, constructing, and figuring out "how things work." Some of my observations seem to contradict accepted child development wisdom: for example, that pretend play is necessary for the development of symbolic capacity, abstract thought, creativity and self-regulation (e.g., Vygotsky, 1976); that gifted children are gifted socially and are also highly imaginative in the traditional sense (e.g., Terman, 1925); and that boys' play is imbued with aggressiveness (e.g., Goldstein, 1994). Thus, years of casual observation, speculation, and discussions with parents, combined with my growing dissatisfaction with the literature's efficacy in addressing this profile, prompted me to launch this

systematic approach to documenting examples of people who as children, "loved to build."

I was also curious whether adults who are highly skilled in professions related to engineering displayed childhood traits similar to those of these children. It may be, for example, that some exceptionally able engineers, as children, engaged in little pretend play, struggled in school, lacked motivation to conform to peer and teacher expectations, and experienced bullying. Parents of children displaying such traits might take comfort that their child's unusual behaviour may predict a successful future in engineering, rather than indicate pathology. Thus, I wanted to see if a small, exploratory sample of successful engineers/inventors would yield examples of any of the childhood traits displayed by the children I had been observing. From my conversations with parents of these children, it was evident that this information would be extremely valuable.

Finally, I have been fascinated with the literature that attempts to explain how and why cognitive styles may be innately different within cultures. From my discussions with parents of children who love to build, it appears that they believe their child's interests, development, learning style, and personality were visible very early on. There seems to be no doubt in the parents' mind that these children were born with their fascination with things mechanical, physical, and structural, combined with a comparative lack of interest in more typical childhood pursuits, such as imaginary play. This, of course, dredges up the nature-nurture debate, a topic far too expansive for this thesis. However, my observations of these children's very early and intense interest in things physical seemed to correspond nicely with the evolutionary psychology paradigm of modularity. Modularity posits that our species' mental capacities evolved to solve

three distinct kinds of problems: physical (how things work), social (what other people are thinking) and biological (problems to do with food-stuffs), (e.g., Geary, 2005; Pinker, 1997). Thinking along these lines, I wondered whether the children I had observed who are intensely interested in complex constructive activity might represent a modern-day example of an evolutionary adaptation to the niche of tool-making within human societies. I explored the theoretical basis of this idea in an earlier paper (Bonnycastle, 2004). This thesis gave me the opportunity to see how the explanatory power of this theory might compare to some other theories of cognitive style when looking at an actual collection of cases.

1.2 Overview of the thesis

In the second chapter, I review the literature that is relevant to the study of children who are passionate about complex constructive activity and precocious in their understanding of how "things" work (that is, "systems"). This includes literature related to play, giftedness, cognitive styles, modularity and domain specificity, and the literature that discusses the line between "normal" personality and pathology.

In the third chapter, I describe my methodology. First, I defend my use of a qualitative framework. Then I describe the process I used to find and select my two samples: sample one consisted of parents of children who are passionate and precocious at complex constructive activity; sample two consisted of adults who are "exemplary producers in a field related to engineering". Then, I explain the procedures I used to communicate with participants and gather data. Finally, I describe the methods I used to conduct the analysis.

The fourth chapter presents the results of the analysis. Sample one results are presented first, followed by results from sample two. I conclude this chapter by comparing and contrasting the results from the two samples.

The final chapter highlights some of the implications of the research results. Each major topic introduced in the review of literature section is revisited in light of the results. Finally, I discuss implications for educational practice.

2 REVIEW OF LITERATURE

2.1 Intrinsically motivated activities of children: construction and pretense

My study focuses on children who love to build, are intensely interested in how things (and other "systems") work, and who seem to be precocious in their understanding of how things (and other "systems") work. Their preferred activity is characterized by "building": for example, building complicated constructions with Lego, K'nex or Tinker Toys. Additionally, they have great intrinsic interest in "how things work", evidenced by exploratory behaviour, such as taking apart household appliances and conducting mini-experiments. In the following discussion, I refer to both of these activities as "complex constructive activity", as distinct from "constructive play," a term commonly used in the literature.

"Constructive play" typically refers to the kind of building that children do to scaffold narrative (e.g., Christie and Johnson, 1987). It usually refers to play with blocks, such as building a simple block tower that is meant to be used in a pretend scenario, or making something out of arts and crafts materials for the purpose of representing something else. From my informal observations, it seemed to me that the problem-solving quality of the complex construction activity engaged in by the children I am interested in, was not fully captured by the term "constructive play." Therefore, I use the term "complex constructive activity" to describe an engagement with materials as a means to problem-solve, rather than for the primary purpose of representing something

else. For example, a child wrestling with the technical problems of recreating the complex Mars space-station pictured on the box of a Lego kit, is engaged in "complex constructive activity" if the point of the exercise to the child is not to build a representation of an actual space station, but rather, to grapple with the technical challenges of building the model. A child who pours water down a culvert over and over as a means to figure out the pattern of cause-and-effect, is engaged in "complex constructive activity." A child who takes a wind-up toy apart to figure out how it works is engaged in "complex constructive activity". My review of the play literature turned up no research that truly investigated children who are highly intrinsically motivated to engage in this kind of activity.

What Is Play?

When considering an activity that children freely choose to engage in, spend extended lengths of time doing, and appear to enjoy doing, one is tempted to call the activity "play." When we tell a child to "go and play," chances are, whatever that child chooses to do will probably be some activity we would call "play." Told to "go and play," the children of interest to this study would probably build something, tinker around with a broken toaster, or engage in some other kind of complex constructive activity. However, the vast literature on children's play appears to consider this kind of activity to lie outside the definition of "play."

Rubin, Fein and Vandenburg (1983) propose that the following six criteria characterize play: (1) it is intrinsically motivated; (2) it is characterized by attention to means rather than ends; (3) it is characterized by exploratory behaviour ("What can I do with this object?") as opposed to explanatory behaviour ("What is this object and what

can it do?"); (4) it is characterized by nonliterality or pretense; (5) it is free from externally applied rules (in contrast to games); and (6) it is characterized by active engagement in contrast to day-dreaming or idling. Importantly, criteria three and four exclude the type of activity I call "complex constructive activity." Criterion two (attention to means rather than ends) is also not met in many complex construction activities: when attempting to build a complicated Lego construction to replicate the picture on the box, the goal is, ostensibly, to finish the product. When taking apart a toy to figure out how it works, the intent is to solve the puzzle. Although some children engaged in complex constructive activity may work on a project for a while only to abandon it half-way through, much complex constructive activity is carried out with the intent to produce an end product or to discover some solution to a problem. Criterion five is interesting in its application to complex constructive activity: I speculate that externally applied rules are very much a part of this activity. In building a complicated Lego model, the physical rules governing what is and what is not technically possible entirely constrain the activity. Similarly, one can surmise that pouring water down a culvert over and over is motivated by a desire to figure out the rules governing water flow. Thus, complex constructive activity would not be considered "play" by the Rubin, Fein and Vandenburg (1983) definition, despite its great intrinsic interest to the children of interest to this study.

Another example of an emphasis on "pretend" in defining "play" is Russ's (2004) work. Russ used Fein's (1981) definition to circumscribe her entire work on play intervention: "Play is a symbolic behaviour in which one thing is playfully treated as if it were something else" (p. 282). This clearly excludes complex constructive activity from

both her definition and her research on play and play interventions: Russ's work is essentially a treatise on not only the benefits of play to children's development, but also of play training interventions when children do not appear to exhibit appropriate interest in pretend play.

Other major contributors to play theory and research do not mention complex constructive activity in their discussions of factors contributing to child development. For example, Vygotsky (1976) ascribes pretend play a direct role in the development of abstract thought and self-regulation, while failing to acknowledge complex construction activity as an existing or valuable activity choice for children. Similarly, neither Singer (e.g., Singer & Singer, 1990; Singer, 1994), nor Leslie (1987) mention complex constructive activities in their contributions to play theory, focusing instead on pretend play.

Sources that *do* include constructive activity within the definition of play tend to place it at the lower end of the developmental hierarchy. For example, Piaget (1962) described play as emerging in the following stages: practice play (first 24 months); symbolic, pretend or sociodramatic play during the pre-operational stage (2 years through 7 years); and games with rules during the concrete operational stage (7 years to 12 years). Within Piaget's scheme, complex constructive activity might fit into the category of practice play, that is, on par with simple object manipulation, characterized by the exploration of cause and effect.

Smilansky (1968) adapted Piaget's (1962) framework by adding "constructive play", which she simply defined as those kinds of activities with a more constrained end-point. Smilansky's scheme was described as a normative developmental sequence. It is

hierarchically ranked (lowest to highest) as: functional (simple repetitive movements); constructive (manipulation of objects to construct or "create" something); dramatic (the substitution of an imaginary situation) and finally, games with rules (the acceptance of pre-arranged rules and the adjustment to those rules). Note that in Smilansky's definition of constructive play, emphasis seems to be on the representational capacity of the constructed object, rather than on the intent to problem-solve that lies at the heart of my construct "complex constructive activity." The rest of her work focuses on interventions designed to enhance pretend play in low socio-economic-status children, essentially disregarding the value of complex constructive activity in child development (e.g., Smilansky, 1968).

Rubin (Rubin, Watson & Jambor, 1978) combined Smilansky's (1968) and Parten's (1932) play hierarchies into a model that nests Smilansky's cognitive categories within Parten's social categories. When used for assessment purposes, this model places social dramatic play at the top, and solitary, constructive play near the bottom of the hierarchy. It is interesting that Parten's model stipulates that solitary play is indicative of immaturity, although this assumption has been challenged by a number of researchers (e.g., Rubin, Maioni & Hornung, 1976).

In all three models (Piaget, Smilansky, Rubin), the ordering of constructive activity before dramatic play seems to rest on the assumption that the symbol use evident in dramatic play requires more advanced intellectual skills than do the cognitive processes involved in constructive activity (Christie & Johnsen, 1987). Importantly, many methods of evaluating cognitive development in young children assume a correspondence between cognitive functioning and the level of the child's observed

pretend play (see for example, Kelly-Vance & Ryalls, 2002). Such methods fail to acknowledge that engagement in complex constructive activity may also indicate cognitive competence.

Is Pretend Play Essential for Development?

In casually observing children who are passionate about complex constructive play I have noticed that they seem to be disinterested in pretend play. This raises the question: is a failure to engage in pretend play problematic? There is a body of literature that would have us believe that it is, making the claim that pretend play is importantly related to various aspects of child development. Smith (1988) calls this paradigm the "play ethos".

The "play ethos" has a long history. For example, Piaget (1962) considered pretend play to be a vehicle for practice and consolidation of newly acquired skills. Vygotsky (1976) called pretend play the "leading activity" for childhood development in the preschool period, required for the development of abstract and symbolic thought and self-regulation. Singer (1994) claims that symbolic play is "the foundation of a long-term incorporation and consolidation of a major human characteristic: our human imagination" (p. 7) and that "make believe or pretend play is critical for developing in the child a full-fledged theory of mind" (p. 15). Sutton-Smith (1998) considers pretend play essential to development, because it assures broad adaptive potential—that is, by engaging in pretend play, a child maintains his unique human ability to respond flexibly and adaptively to the needs of a changing environment. Sutton-Smith (1967) also considers play to facilitate symbolic transformations, thus enabling symbolic competency.

In addition to these theoretical claims, there is a large body of empirical research that supports the claim that pretend play is related to cognitive and social development (e.g., Smilansky, 1968; Dansky & Silverman, 1973; Dansky & Silverman, 1975; Pepler & Ross, 1981). However, the validity of this research has been questioned. In his 1988 analysis of the "play ethos" (the idea that pretend play is essential for development), Smith (1988) revealed two significant flaws in experimental studies that reported positive findings concerning the effects of pretend play: (1) experimental bias effects were present; that is, testers were not blind to the subjects' treatment condition; and (2) the experiments did not use an appropriate control group; that is, children in treatment groups were given play training by adults, yet control groups failed to receive equivalent adult interaction (Smith, 1988). In studies that *did* guard against tester bias and that provided adequate controls, no effects were found for the play treatment groups. Furthermore, Smith points out that of the large number of correlational studies examining play and development, only a select few with positive findings are ever quoted in the play literature. A host of recent studies has failed to find a significant association between the type, amount or complexity of pretend play displayed by individual children and various measures of cognitive or social competence (Cole & LaVoie, 1985; Connoly & Doyle, 1984; Davie, Hutt, Vincent & Mason, 1984; Johnson, Ershler & Lawton, 1982). In fact, one researcher, (Thomas, 1984) found a negative correlation between reading skill and fantasy-play in four-year-olds.

Despite Smith's expository work, there remains a strong "play ethos" in the child development literature, child psychology literature, early childhood practices and parenting mores. For example, the recently published *Play in Child Development and*

Psychotherapy (Russ, 2004) fully embraces the play ethos, and advocates play interventions to strengthen play processes in children who do not "play" (pretend play, according to her definition) well.

Against this backdrop of ambiguity about the importance of pretend play, then, it behooves us to consider cases where pretend play is minimal or absent. My literature review turned up no such study involving non-clinical cases. The present study begins to fill this gap.

Constructive Activity: The Existing Literature

As the children in the first sample of this thesis were chosen on the basis of their passion for constructive activity, I searched the literature for studies that directly examined this form of activity. In fact, constructive activity has received little attention in the play literature. Christie and Johnson (1987) attribute this "paucity of information on constructive play" (p. 440) to Smilansky's (1968) hierarchy: "If dramatic play is assumed to be the most advanced form of play which occurs during the preschool and kindergarten years, it is natural that researchers wishing to investigate relationships between play and indices of social and cognitive development would focus their attention on this type of play" (p. 440).

A number of studies have observed children during free play periods at school and documented the frequency of different types of play in order to identify age trends. These studies tend to use Smilansky's play categories, which include an activity described as "constructive play," thus yielding some information relevant to this thesis. Rubin, Fein and Vandenburg (1983) found that by age 3.5 years, constructive play

accounts for 40 percent of all play; between 4 and 6 years, this increases to 50 percent; by age 6 years, dramatic play has increased from 20 percent to 30 percent, while constructive play has declined. Pellegrini (1985) combined play and social interaction categories (after Parten, 1932), and found that solitary-constructive play decreased between ages 4 and 5, whereas parallel- and group-constructive play frequencies remained stable. Heatherington, Cox and Cox (1979) on the other hand, found an increase in both solitary– and group- constructive play between ages 4 years and 6 years, with a decline in parallel-constructive play. Rubin, Watson and Jambor (1978) found that between ages 4 and 5, parallel-constructive play increased, while other forms of play remained stable. These studies yielded no definitive trends in the frequency of constructive play over the preschool years; furthermore, their pertinence to this thesis is minimal, as they did not attempt to measure individual differences.

Research on individual differences in observed constructive activity (e.g., by gender and/or socio-economic-status) is also minimal. Johnson and Roopnarine (1983) found that boys engaged in more functional (in the present study, physical and explorative) play, while girls engaged in more constructive play (using play materials to build something). A few researchers have observed that girls engage in significantly more solitary and parallel constructive play than boys, while boys and girls engaged in roughly equal amounts of group-constructive activity (Hetherington, Cox & Cox, 1979; Pellegrini, 1982; Rubin, Watson & Jambor 1978). These studies contradict my tentative hypothesis that the children who avidly engage in constructive activities tend to be boys. However, it must be noted that in these studies, kindergarten and preschool classrooms were used as the observational setting. Christie and Johnsen (1987), point out that most

of the materials in typical preschool classrooms invite constructive activities, possibly affecting the observed play patterns. They cite Block and Walsh (1983) as a study that used random spot observations by parents to investigate 5 and 6 year-old children's home activities. The results of the Block and Walsh study contradicted those cited earlier. The researchers found that boys engaged in constructive play 16 percent of the total playing time, compared to 7 percent for girls. Thus, observational studies that use school settings may not give a valid indication of children's intrinsic motivation and interest.

In this thesis, I did not make direct observations; instead I relied on parents' reports. The reason I adopted this approach is that parents see their children over time and context, and thus have a broader base on which to provide information than do the kinds of school observational studies used by most play researchers. Of course, others may argue that homes may similarly structure children's play by the kinds of toys they expose them to. On the other hand, assuming parents have a finite budget, one could surmise that parents will tend to buy toys of the kind they know their children will, and want to, play with.

In my casual observations, children who passionately engage in complex constructive activity seem to demonstrate some weakness in social skills. I was able to find two studies that compared children's observed activity to measures of social competency. In the first, Rubin and Maioni (1975) observed 4-year-olds at play in a preschool context, coded their play choices, and related these to measures of perspective-taking. The researchers found no significant correlations between the two variables. In the second study, Rubin (1982), researchers again observed 4-year-olds at play in a preschool environment. Here, a small but significant correlation was found between

parallel-constructive activity and sociometric popularity ratings ($r = .16$, $p<.05$), verbal problem solving tasks involving peer relationships ($r = .15$, $p<.05$), and a small negative correlation with teacher ratings of social maladjustment ($r = -.18$, $p<.05$). These results contradict my casual observations. However, according to Rubin, the correlations may be explained by the preschool environment that was used for the study: that environment encouraged constructive play through its ample constructive materials and curriculum. Christie and Johnsen (1987) suggested that the small correlations in the Rubin study, combined with the constraints provided by the classroom materials can only support the notion that parallel-constructive activity has a "benign relationship with a number of different measures of social competence" (p. 445).

Another observation I have made is that children who are intensely interested in complex constructive activity are very bright, despite the insistence of the "play ethos" that pretend play is the leading activity in cognitive development. Johnson, Ershler and Lawton's (1982), findings seem to affirm my observations. They observed and coded preschoolers' spontaneous play and found constructive activity to be more strongly related ($r = .41$, $p<.008$) to intelligence test scores than group-dramatic play ($r = .22$, $p<.10$).

One of the few studies that explicitly observed children engaged in constructive activity was conducted by Wolf and Gardner (1979). There, researchers gave preschool children a set of blocks to play with, then observed and coded the ensuing activity. The researchers reported that some children, whom they called "patterners," appeared to be motivated by the desire to create intrinsically aesthetically pleasing designs. Others, whom they called "visualizers" or "dramatizers," used the blocks primarily to create

symbols, that is, to depict something else. The authors suggested that these two different styles of block play represent different aspects of children's symbolic imagination: the patterners explored aesthetic principles while the dramatizers explored the medium's representational capabilities. This acknowledgement that there is more than one "legitimate" play style is refreshing in a literature that places so much value on pretense (i.e., symbolic representation) in play. However, Wolf and Gardner's model fails to capture the kind of complex constructive activity that explores scientific, technological and mathematical concepts, such as the activities of interest to the subjects of the present study. Furthermore, Wolf and Gardner stopped at the observation that there seems to be an effect of cognitive type on block use. My study aims to delve deeper into the phenomenon of children who may fit Wolf and Gardner's "patterners" description, but who are involved in significantly more complex constructive activity than the block use Wolf and Gardner observed.

Jennings (1975) also conducted a study that dealt explicitly with constructive activity; furthermore, Jennings ventured into the area of cognitive style. Jennings examined associations between children's activity choices and their intellectual abilities. Her findings support the idea that some children are more object-oriented than others. Furthermore, object-orientation (characterized by solitary constructive activity) correlated with scores on tests of physical knowledge. Surprisingly, the children who were more people-oriented (tending to engage in group pretend play) did not perform better on tests of social knowledge; however, these children were more effective in their actual social interactions defined as leadership, popularity, and getting along with others. Interestingly, object-oriented children were more likely to interact with adults than were

people-oriented children, who interacted more with peers. The author stated that these results support the claim that there exist at least two distinct cognitive domains: one for physical knowledge and one for peer interactions. Jennings described such domains as being "apparently established early in life, with interest in the physical environment leading to greater knowledge of that environment and, in turn, greater knowledge leading to increased interest" (p. 517). A similar iterative mechanism would presumably apply to the social domain; that is, children with an early predisposition to attend to their peers would learn to interact successfully, which in turn would lead to more social success. This model may speak to the phenomena examined in the present study.

In sum: the play literature has given priority to pretend play, presumably because pretense is the component that is thought to be the most influential in developing children's thinking. There are very few studies that examine the nature or value of constructive play, none that explore the kinds of complex constructive activities of interest to this thesis, and none that investigate the characteristics of children who are inherently motivated to engage in such activity. My thesis attempts to fill this gap by documenting the profiles of children who engage passionately in complex constructive activity.

2.2 Varieties of Giftedness

The children who are the focus of the present study are passionate builders, tinkerers, and inventors. My casual observations of such children indicate that they seem to routinely engage in complex constructive activities appropriate for much older children, and that they may display a precocious ability to understand how things work.

This suggests a kind of giftedness that, I feel, has not been adequately explored in the literature on gifted children.

Historically, giftedness has been construed primarily as a unitary construct, typically defined in terms of Intelligence Quotient (IQ). For example, Terman's (1925) famous study on intellectually gifted children investigated children who had IQ's at or above 140. Hollingworth (1942), in her book *Children Above IQ 180* similarly used IQ scores to define her sample. Research of this sort attempted to describe the common characteristics and experiences of gifted children, without identifying which characteristics seemed to accompany strengths in different areas.

Some current literature in the field of giftedness has moved beyond a unitary conception of giftedness. Much of that literature acknowledges Howard Gardner's (1983) popular theory of multiple intelligences. For example, a popular manual used by educators to identify, nurture and challenge gifted children, *Teaching Young Gifted Children in the Regular Classroom* (Smutny, Walker & Meckstroth, 1997), portrays giftedness as a "type and degree of exceptional ability" (p. 6) in one or more or Gardner's eight intelligences. Similarly, Kanevsky's (1999) *Toolkit for Curriculum Differentiation*, also used to teach educators about the nature and nurture of gifted children, cites Gardner's multiple intelligences as possible areas of specific ability. However, despite acknowledging possible areas of talent, and pointing out that gifted children present with heterogenous characteristics, these sources do not attempt to address the kinds of behaviours, traits or characteristics that tend to be associated with the different ability domains. For example, there is no exploration of the differences in social

and affective abilities between children who are gifted linguistically and those who are gifted spatially (to use two of Gardner's intelligences).

Much of the current literature still treats giftedness as a unitary construct when describing the characteristics and needs of gifted children. For example, Gross (1993), in her multiple case study designed to investigate the development and educational experience of exceptionally gifted children, defined her sample as those whose IQs exceed 160 on the Stanford-Binet Intelligene Scale L-M. When such a unitary definition of giftedness is employed, generalizations can result that may systematically exclude special populations of gifted children. For example, Gross identified the games most strongly favoured by her participants as: board games, pretend or fantasy games, and puzzles; the least favoured were construction toys, cars and trucks and mock fights (p.182). This set of preferences may generalize to many gifted children, but may not apply to children like those in this study.

It may be that personality profiles, developmental characteristics and educational requirements are better aligned by cognitive profile than by a "gifted" label: for example, a gifted child, labelled by virtue of a high IQ, with a passion for building and finding out "how things work" may have much more in common with a child who has an IQ of 100 but whose interests are similar to her/his, than a with child with a high IQ whose strengths are in the dramatic and linguistic arts.

In his paper, *Varieties of Giftedness*, Stanley (1995) makes the point: "equal IQ does not necessarily mean equal learning ability in a particular subject area" (p. 6). He gives the example of a child with a Full Scale IQ of 150 having a verbal ability corresponding to 170 and mathematical ability corresponding to 130; this child, he writes,

would struggle in a fast-paced, high level math class, where other 150 IQ-ers may have a math aptitude of 170. At the same time, this same child would require advanced work in language arts. Stanley's paper, and other research in the field of mathematically precocious youth, focus mainly on giftedness in mathematical domains, which may relate to the type of giftedness explored within this thesis.

Importantly, however, the type of precocity I tried to capture in my study goes beyond high ability in mathematics. The children who are the focus of this study do seem to be fascinated by numbers and mathematical concepts, but their interests extend to "how things work" and to figuring out how to build complicated physical constructions. In thinking about the kinds of things these children seem to be precocious at, Baron-Cohen's (2003) construct of "systemizing" may be a better fit. Baron-Cohen identifies a cognitive module dedicated to thinking about and understanding systems: physical systems, mechanical systems, and systems of classification as well as mathematical systems. A child who is gifted in this cognitive area might well look like the children of interest in this study.

"Gifted behaviours" and other ways to identify gifted children

As the construct of "giftedness" is becoming more inclusive, multifaceted and multidimensional, teachers and professionals are relying less on IQ tests and more on analytic observation of behaviours to identify gifted children (Kingmore, 1998). For example, the following behaviours were taken from "trait lists" used to identify giftedness in children: precocious moral and ethical concerns (Kanevsky, 1999; Kingmore, 1998; Smutny, Walker & Meckstroth, 1997;), display of advanced, complex fantasy play (White, 1985); advanced sense of humour (Freeman, 1985; Kanevsky, 1999;

Kingmore, 1998), advanced language development (Freeman, 1979; Freeman, 1985; Lewis & Michalson, 1985; White, 1985), expressiveness (Kanevsky, 1999), vivid imagination and creativity in artwork, writing, or dramatization (Smutny, Walker & Meckstroth, 1997; Fisher 1998), sensitivity to feelings of others (Kingmore, 1998; Kanevsky, 1999), and social knowledge (Lewis and Michalson, 1985). A gifted child who is destined to become a novelist, actor or psychologist may very well engage in these kinds of creative, dramatic, sensitive, interpersonal behaviours. However, based on my casual observations, I speculate that the children of interest in this study may not display these behaviours. This leads to me to speculate that children who display precocious building/inventing/exploratory behaviours, and who may in fact become exemplary producers in an engineering-related field, may fail to be identified as gifted when such trait lists are used. Hopefully, my thesis can begin the process of raising awareness among educators of the kinds of traits that may, and may not, be associated with giftedness in the domain of "systems."

Today's engineers: what were they like as children?

Keeping in mind Tannenbaum's (1997) prospective conception of giftedness, those childhood characteristics and traits that are associated with later accomplishment should be good indicators of giftedness. As this thesis was to explore a "type" of giftedness—strength in systemizing—I felt it was important to include a sample of people who had achieved eminence in fields that might be related to these abilities, and to obtain a retrospective account of their childhood characteristics. Although strong "systemizers" could probably be found in various fields, e.g., computer science, physics, mathematics, I limited my search to engineers, specifically those, such as mechanical

engineers, whose work involves inventing, tinkering and developing technology. The purpose of this part of the study was to answer the question: were these exemplary and successful engineers, when young, similar to the children in this study? Is talent in this field observable in children, and does it co-occur with any other childhood traits, for example, lack of pretend play?

The literature that relates to this topic consists of those studies that take a sample of eminent or exemplary adults and attempt to generalize from retrospective childhood accounts. The largest of such studies is *Cradles of Eminence* (Goertzel & Goertzel, 1962), a survey of biographical data of 400 eminent people of the twentieth century. The aim of Goertzel and Goertzel's study was to shed light on the home environments of those who "stand in high comparison with others" (p. vii). The sample was defined as people of whom two or more biographical accounts existed in the Montclair, New Jersey public library, excluding those who were famous merely by virtue of their birthright (e.g., nobility). The researchers then surveyed autobiographies, biographies and testimonials to find commonalities among the homes in which these children were reared. The emphasis was on the rearing environment, rather than on the traits of the children themselves. This was inspired by the researchers' desire to inform and advise parents of bright children. "If there are Edisons and Einsteins and Thomas Manns among the younger generation, we want to anticipate their coming and to help accelerate their progress" (xii). Consequently, the authors of the study primarily describe the characteristics of the children's parents (e.g., drinking problems, smothering mothers, opinionated fathers, etc.) and home lives (e.g., economic status, religion, sibling relationships, etc.) As such, there is little in this work that informs the research questions of the present thesis, which focus

on the characteristics of the children themselves. Furthermore, Goertzel and Goertzel's sample consisted of people whose eminence was expressed in diverse vocations: primarily the arts, political leadership and humanitarian reform. Of the 400 eminent people surveyed, a mere 10 were physical scientists. The findings implied that the most troubled homes (poverty, parental alcoholism, psychological trauma) produced artists, actors, writers and musicians. Of physicians, lawyers and scientists, the authors wrote: "[they] come from family backgrounds which give them opportunities for outdoor explorations, considerable personal freedom, and early responsibility. They are often physically active, make collections, and are mischievous" (p. 272). No mention was made beyond this of the childhood interests, characteristics or traits of the eminent scientists when they were children.

More applicable to my thesis is the work by Anne Roe (1952) entitled, *The Making of a Scientist*. Roe surveyed 64 living scientists born in the United States, actively engaged in research, who were recommended by a jury of scientists as being the most eminent in the country. Her stated interest was to trace relationships between the scientists' personality structures and their choice of profession. As such, she investigated the family backgrounds, childhood recollections and life histories of the subjects, and conducted personality and intelligence tests on them. The sample was divided primarily into three groups: social scientists (anthropologists and psychologists), biologists, and physical scientists (including the fields of physics, astrophysics, geophysics, physical chemistry and theoretical engineering) for the purpose of analysing between-group differences.

Roe described many such differences. Pertinent to this thesis were her descriptions of the early interests of the physical scientists, and her observations that the physicists demonstrated a distinct lack of social orientation compared to the other groups.

Roe stated that "many of [the physical scientists] had quite specific and fairly strong feelings of personal isolation when they were children" (p. 88). For example, she quoted one of the physicists as saying: "'I was always lonesome, the other children didn't like me, I didn't have friends, I was always out of the group. Neither the boys nor the girls liked me, I don't know why but it was always that way'"(p. 88). She described the "characteristic pattern of growing up" among physical scientists as follows: "the pattern is that of the rather shy boy, sometimes with intense special interests, usually intellectual or mechanical, who plays with one or two like-minded companions rather than with a gang" (p. 92). As adults, "most of [the physicists] and practically all of the biologists dislike social occasions, except perhaps for very small gatherings of close friends. In general they avoid social occasions as much as possible . . . This is in marked contrast to the social scientists among whom a great deal of voluntary social activity is common" (p. 60).

Regarding the childhood interests of the physical scientists: "there are many reports of early intense preoccupation with gadgets, with radio, with Meccano sets, and so on. This was quite rare in biologists and social scientists. Both groups of physicists [experimental and theoretical] showed considerable early preference for mathematical and scientific subjects in school. The theorists, however, were strikingly omnivorous readers. . . . they usually made some such comment as that they read everything they could get their hands on. A few of them concentrated on science but a number were

interested in biography and history. Two of them remarked that they got their first interest in science from reading science fiction" (p. 78). This was in contrast to the social scientists, whose reading interest was described as comprising literature and the classics, whose early scholastic subject preferences were English, drama and creative writing, and whose childhood activities were described as being much more socially based.

Roe's description of the physical scientists' childhood interests is brief, but it would appear that the "early intense preoccupation with gadgets, with radio, with Meccano sets, and so on" would describe the kind of children of interest in the present thesis. In my thesis, I attempt to extend and update Roe's work—note that the scientists she studied were born early in the 20th century—and to obtain more detailed, in-depth retrospective information than the brief summary she presented.

It is interesting that Roe's work, published in 1952, made observations that predated evolutionary psychology theory by forty years, and yet foretold one of its main tenets. She observed that the scientists in her study showed an intense interest from a young age in ideas related to one of social, biological or physical phenomena, and that this interest remained stable throughout the lifespan, in that they subsequently developed this early interest into a career. As will be discussed in the next section, many evolutionary psychologists consider the human brain to be an organ that evolved to comprise three independent domains, or modules: a social module specialized to process information about other people, a biological module specialized to process information about foodstuffs, and a physics module specialized to process physical information (e.g., Geary, 2005). In the next section I discuss this topic in the context of theories of individual differences in cognitive style.

2.3 Cognitive Style, Modularity and Domain Specificity

When we talk about a child having a particular cognitive style, the implication is that she or he has strengths in a particular domain or domains, possibly accompanied by a weakness in another. Similarly, when we talk about giftedness, intelligence or creativity, the question arises: are these constructs domain specific, or do they transcend domains?

A psychological domain was described by Maratsos (1992) as "any organized content area in which one might imagine or propose there being innate, specific, distinctive mechanisms or ideas" (p. 4). He pointed out that domains we think of as unified may actually be made up of separable domains on further study. For example, Bever (1992) showed that while we tend to consider "language" to be one domain, there is evidence to suggest that there are two independent domains involved in language cognition: relational and unitary processes. Unitary processes, such as lexical access, involve retrieving word meanings separate from their context. Relational processes involve understanding the meaning of words as they appear in context. Bever explained that a preference for unitary processes over relational processes and vice versa, reflects a general difference in the way two groups of people process language. This would suggest that Gardner's (1983) portrayal of multiple intelligences, while correct in identifying that independent domains exist, may be inaccurate in the way he "slices up the pie." For example, his claim that "linguistic intelligence" comprises one domain may inaccurately lump together separate, independent processes. For example, journalists have been found to have different verbal thinking styles than poets (Kaufman, 2005), although within Gardner's paradigm, both activities would be considered products of linguistic intelligence.

The Visual-Spatial Learner

L.K. Silverman (2002) "slices up the pie" into two learning / thinking styles: visual-spatial and auditory-sequential. This theory is analogous to the right and left hemisphere dichotomy, also known as brain lateralization theory (L.K. Silverman,2002). Essentially, the Visual-Spatial Learner (VSL) thinks in pictures (right brain, according to brain lateralization theory), and the Auditory-Sequential Learner (ASL) thinks in words (left brain). Some problems arise with L.K. Silverman's (2002) theory, however. Simply dividing cognition into visual-spatial and auditory-sequential components fails to account for many significant processes. For example, would interpreting body language be a strength for visual-spatial learners, because gestures are visually displayed, or for auditory-sequential learners, because gesture pertains to language? What about other tasks that incorporate both a visual-spatial and an auditory-sequential component, such as developing a sequence of computer code, recognizing faces, or listening for an adjustment problem in a carburetor?

Research in neuropsychology supports the notion that L.K. Silverman's (2002) dichotomy is over-simplified as evidence abounds for the existence of independent systems within visual-spatial processes. For example, Farah, Hammond, Levine, Levine and Calvanio (1988), documented individual cases that presented with strong visual abilities alongside weak spatial abilities, while Luzzatti Vecchi, Agazzi, Cesa-Bianchi, and Vergani (1998) have documented the opposite profile. This demonstrates that the construct "visual-spatial" does not necessarily describe an associated set of processes. Even within the set of processes described as "spatial" and those described as "visual", it is possible to identify further independent processes. For example, I. Silverman and Eals

(1992) have shown that there exist dissociations between two-dimensional spatial abilities, such as map reading, and three-dimensional spatial abilities, such as mental rotations (see also Morton and Morris, 1995; Cornoldi and Rigoni, 1999 for examples of dissociations within visual abilities). This suggests that both L.K. Silverman's (2002) and Gardner's (1983) portrayals of visual-spatial abilities as a single cluster of correlated competencies may be over-simplified and problematic.

Mentalism and Mechanism

While L.K. Silverman's (2002) theory identifies cognitive domains by dividing processes into two thinking "styles," evolutionary psychologists such as Pinker (1997), Baron Cohen (2003) and Geary (2005) take a functional approach. In other words, they identify cognitive domains not by how thoughts are processed, but by the their content. These researchers posit that our species' innate cognitive abilities evolved in order to solve three different kinds of problems present in our evolutionary environment: problems related to the physical, biological, and psychological worlds. The result is a set of modular domains of the human mind, evolved to allow us to think in differentiated ways about inanimate objects (physical), living organisms (biological) and conspecifics (psychological). This tripartite model is supported by the work of numerous scientists in the fields of anthropology, neuropsychology, psychopathology, child development and evoloutionary psychology (e.g., Atran, 1998; Baron-Cohen, 1995; Brothers & Ring,1992; Hirschfeld & Gelman 1994; Pinker, 1997; Povinelli & Preuss, 1995; Wellman, Hickling & Schult, 1997). For example, Wellman, Hickling and Schult (1997) found that children as young as two years of age use at least three distinct causal-explanatory reasoning systems to understand events: a naïve psychology that reasons about human action in

terms of actors' internal mental states (also called folk psychology), a naïve physics that reasons about mechanical or material phenomena (also called folk physics), and a naïve biology that reasons about physiological states and processes such as illness, birth, growth and death (folk biology). The fact that such young children use distinct reasoning systems for these different classes of phenomena supports the psychological/physical/biological model of domain specificity.

The existence and distinctness of these three content domains leads to questions of uneven profile: could an individual with strength in one domain present with weakness in the other two (Wellman & Inagaki, 1997)? Simon Baron-Cohen (e.g., Baron-Cohen, 1987) examined this possibility. He showed that children with autism show significant superiority in folk physics while showing deficits in folk psychology compared to chronological and mental-age-matched controls (Baron-Cohen, 1987). This finding was replicated by Binnie and Williams (2003). Baron-Cohen (2003) also suggested that children with William's Syndrome display the opposite profile: deficits in folk physics alongside strengths in folk psychology.

Babcock (2005) coined the term "mentalism" to describe a profile of strong folk psychology alongside weak folk physics, and the term "mechanistic" to describe strength in folk physics alongside a weakness in folk psychology. "Mechanistic" may be useful to describe the cognitive style of interest in the present study.

In the Binnie and Williams (2003) study, in addition to the results mentioned above, there was a significant inverse relationship found between the folk physics and folk psychology test results across all of the comparison groups, comprised of typically developing preschoolers, 7-year olds and 10-year olds. This supports the notion that

there is a cognitive trade-off between these two reasoning systems in non-clinical populations.

Hunter-Collector-Toolmaker Theory

Bonnycastle (2004) suggested that uneven profiles may have evolved as an adaptation during our evolutionary past. Because our species' cranial capacity is constrained, net benefits to a human community during our evolutionary past (the Pliestocene era) would have been conferred upon a community of individuals with complementary, uneven profiles. Frequency-dependent selection could have resulted in an optimal mix of profiles within the community. Such profiles would follow an optimal division of labour selected for by the evolutionary environment. According to this theory, then, it is inevitable that our species would evolve to produce, among other profiles, such as the "Hunter child" posited by Hartmann, (2003), individuals with strengths in folk physics alongside deficits in folk psychology ("mechanistic," after Babcock, 2005). People with a mechanistic profile would have filled the niche of technology-producing (as opposed to hunting, warring or gathering) specialists in the community during our evolutionary era.

Supposing an optimal niche-filling in the pliesctocene produced an advantageous mechanistic cognitive style in some children, then how would this phenotype present in today's context? Compared to the small tribal setting of our ancestors, a contemporary playground and a school whose curriculum emphasises social abilities arguably present significant social challenges. Perhaps a child with a cluster of mechanistic traits, who would have managed well in the Pliestocene, would struggle today. Perhaps, in today's

schools this child might be diagnosed and pathologized. This brings me to a discussion of how context impacts the point at which personality ends and pathology begins.

2.4 Pathology vs. Personality

When presented with a child who (a) fails to engage in pretend play; (b) is introverted and/or shows signs of weakness in social skills; and (c) demonstrates strong specialized interests, one familiar with diagnostic criteria for any of the autism spectrum disorders might surmise that an autism-related label is applicable. Appendix A lists the diagnostic criteria for both autism and Asperger's Disorder (a variant of autism).

Levine (2002) specifically warned us against over-pathologizing children whose personalities and cognitive styles happen to echo pathologies. Similarly, Webb, Amend, Webb, Gowerss, Beljan, and Olenchak (2005) stated:

> Asperger's Disorder is a significantly impairing condition for those affected by it, and it is not an appropriate label for those who are simply awkward, eccentric, or uncomfortable in social settings. Yet there is a tendency to leap to the diagnosis of Asperger's Disorder for persons who have difficulty reading and responding to social cues. (p. 94).

There are a number of scholars who have documented so-called "shadow syndromes". For example, Ratey (1997) described functional members of society who present with faint versions of what, in a much more extreme form, would warrant a diagnosis of psychiatric pathology. Shadow Syndromes, according to Ratey, merely "colour" the personality.

Hartmann (2003) explained that "interferes with daily living" is the critical line that separates normal personality and pathology. Baron-Cohen (2003) explained the role context plays in determining where that line is drawn:

> (Those whose personality and cognitive style tend towards the autistic spectrum) do experience a disability, but only when the person is expected to be socially able. Remove this expectation, and the person can flourish. Unfortunately, in our society this social expectation is pervasive: at school, in the workplace and in the home. So it is hard to avoid. (p. 172)

For example, people who are intensely interested in "how things work" and less interested in the workings of other people, may flourish in a research lab or a workshop, but suffer at a cocktail party or on the school playground. Similarly, such people could have flourished in our species' ancestral environment where this profile may have evolved, yet in current society, a person with this same profile may find social demands overly challenging.

Evolutionary psychologists use the term "mismatch" to describe a trait that evolved to confer a fitness advantage in the ancestral environment, but that is maladaptive in its current context (Buss, 2004). "Mismatch" could well be used to describe the struggles that may result from having a mechanistic profile.

In a similar analysis, Hartmann (2003) described how traits associated with Attention Deficit Hyperactivity Disorder (e.g., impulsivity, tirelessness, risk-preference) would have been beneficial in a hunter-gatherer society, but detrimental in a pastoral-farming context.

Similarly, I posit that traits associated with the profile of interest to this study may have been beneficial in a hunter-gatherer society which valued tool-making abilities, and in which so-called "people skills" were not essential for all members of the community. Given the small stable societies in which our ancestors lived, high levels of social skill may only have been necessary for those needing to negotiate with outsiders (such as traders) or for those hunting or warring in teams. A tool-making specialist, working

intensely and independently on tool manufacture and technical innovation, would need only to interact with the familiar members of his/her small home community. However, in the present day context, this profile would certainly be detrimental, for example, on an elementary school playground, where very large groups of relatively unfamiliar children are required to work out complex social interactions.

In the present study, I attempted to document the characteristics and experiences of children who may, by virtue of their orientation towards the physical world, be considered to be "mechanistic." Baron-Cohen, Wheelwright, Stone and Rutherford (1999) described three adult individuals who demonstrated an extreme variant of this tendency. The subjects of their study possessed exceptionally high intellectual ability as evidenced by their achievements: two were exceptionally advanced university students in physics and computer sciences, the third was an award-winning mathematics professor.

The study results (which included IQ tests, tests involving reading mental states from photographs of the eyes, and tests of folk physics) strongly suggested that in these cases, ability in folk psychology is independent of IQ, executive function and ability in folk physics. Strong social weaknesses were evident in all three cases: one subject was described as: "very gauche and (socially) abnormal" (p. 476); another subject was known to throw colleagues off the computer when he could not wait his turn. In summary, the researchers described the three individuals as being examples of "pure social deficit".

The participants in the Baron-Cohen, Wheelwright, Stone and Rutherford (1999) study were all diagnosed with Asperger's Syndrome. The present study differs from the Baron-Cohen, Wheelwright, Stone and Rutherford study in that my sample was not selected from a clinical population. Rather, the participants in this study were selected on

the basis of an activity preference and on evidence that their understanding of how things work is precocious. I made no attempt to determine whether or not the behaviours and traits exhibited in this study could be considered pathological. Instead, this study was designed to explore whether, in this group of children, there appeared to be evidence of subtle social deficits and/or any other attributes that might be compatible with various theoretical frameworks.

2.5 Conclusion

My literature review clearly points to a need for investigative research into the nature of children whose development is marked by a passionate engagement with "systems," especially children from a non-clinical population. As such, this thesis was developed to address the following questions: (a) in what ways are children who are highly interested in mechanical/physical thinking similar, (b) what theory best accounts for the pattern of results and (c) did adults who are highly successful by virtue of demonstrated work in a field related to engineering display these characteristics when they were children? The results of this thesis were meant to inform parents, educators and professionals working with children whose characteristics are similar to the subjects of this thesis. It was also hoped that the study results might help to illuminate theory related to child development, child learning, and play.

3 METHOD

3.1 Case Study Methodology

In the first part of this study, I used a multiple case study methodology to document the traits, interests, development and educational experiences of ten children who are avid and precocious at complex constructive activity and figuring out how things work (sample one). In the second part of this study, a similar process was used to compare the findings from the analysis of the sample one data to the recollections of five adults who are now exemplary producers in the fields related to mechanical engineering (sample two). For example, I wondered whether the adult group had displayed the disinterest in pretend play that I had noticed in children who are passionate about constructive activity and finding out how things work. I also wondered whether the adult group had demonstrated, when they were children, the weakness in social skills that I had observed in the children I was interested in. However, despite questions such as this, and despite my interest in understanding the theoretical underpinnings of the data, this study was primarily meant to be exploratory and descriptive. I wanted the methodology to permit a richness of data, a palate of impressions, and a canvass open to possibilities, rather than be limited to predetermined hypotheses. Thus, I decided that a qualitative research design would be most appropriate for this project, as it would permit the detailed and individualistic descriptions provided by the participants to yield a portrait of what may be a particular cognitive style.

3.2 Sampling Strategy

3.2.1 Sample One

As this thesis aimed to investigate children who are avid and precocious builders, I speculated that potential subjects might be found in a school for gifted children where precocity in various domains is common, and/or in an extra-curricular engineering program designed for children interested in mechanics, science and building things—a program for which presumably children with some degree of interest in building and how things work would sign up. There are two schools for gifted learners in the Lower Mainland: St. Charles school for Gifted Learners[1] (school population: approximately 60) and Brentworth School[1] (school population: approximately 14). Administrators at both institutions were happy to support and facilitate my investigation. The one organization in the Lower Mainland that draws a large number of children for an exclusively physical science and engineering-based extra-curricular program is run out of a local university's mechanical engineering department. This program is called Tooltime[1], and operates weekly summer day-camps for approximately 500 children. One of the week-long programs is exclusively for girls; the other seven weeks are open to co-ed registration. The administrators of this program were also amenable to assisting me with my study.

Written permission to solicit parents was obtained from the administrators of both schools and the Tooltime program. A letter was sent to all parents, describing my study, and inviting parents to participate if their child fit the following description:

"Do you have a child who loves to build? (K'nex, Lego, marble-run)

[1] pseudonym

Is your child interested in how things work (the vacuum cleaner, the CD player)?

Is your child between ages 2 and 16?"

(See Appendix 3 for a complete copy of this letter).

There were 19 initial respondents. Respondents were then sent, by electronic mail, the following documents: the Parent Questionnaire (see Appendix 4), the Study Information Document, the Informed Consent form and the optional feedback form (see Appendix 5). Eleven completed questionnaires were returned. Three follow-up enquiries suggested that the reason for non-replies was lack of time.

Recall that this study aimed to explore the characteristics and experiences of children who are *both* passionate about *and* precocious at complex constructive activity as described in the introduction section of this paper. Therefore, to be included in the study, participants' responses to the questionnaire had to include evidence that their child was *both* an avid builder, tinkerer, and explorer of physical phenomenon *and* precious in his or her building behaviours and understanding of "how things work". This required an initial analysis of the eleven responses to determine whether both criteria were met, before the respondent could be included in the study. (See the description of this "preliminary" analysis, below.) Initial analysis yielded ten suitable participants.

3.2.2 Sample Two

Sample two comprised adults whose careers and professional accomplishments demonstrated exemplary, innovative and creative productivity in fields related to engineering. This was meant to reflect the prospective orientation of Tannenbaum's (1997) definition of giftedness, discussed in the introduction.

As I am not well acquainted with the fields of engineering, physics and related areas, I deferred to the professional judgement of a tenured professor of mechanical engineering at a local univeristy. Based on my description of the study, he recommended two people (a colleague and a former student) who, in his opinion, were exemplary in their technical, innovative and creative accomplishments. Both recommendees agreed to participate. Furthermore, they were able to recommend other potential participants based on my description. Using a Snowball Sampling procedure (Bogdan & Bilken, 1998) I was able to find five suitable adults who were willing to participate in my study. They were each sent, by electronic mail, the following documents: the Engineer's Questionnaire (see Appendix 4), the Study Information Document, the Informed Consent form and the optional feedback form (see Appendix 5). All the questionnaires were returned. In three of the cases, the participants' parents agreed to collaborate on the responses. As the questions were primarily about the participants' childhoods, parent involvement provided valuable information.

3.3 Participants

3.3.1 Sample One

For sample one, the parent-responders are referred to as "participants"; their child is referred to as the "subject." To maintain anonymity, parent-participants are identified by one of letter A to J; their children have been given a pseudonym with its first letter corresponding to the participant's letter. For example, Andrew (not his real name) is A's son. Subjects were aged 8 to 16 years at the time of data collection. In every case, the parent-participant was the child's mother.

Andrew is twelve, an only child living primarily with his mother, part-time with his father. He has just begun attending McNaught House School[2], a private school for children with learning disabilities. Prior to this, he attended his local public school. His mother works for the city government in a diverse, multi-tasking oriented environment. His father is a self-employed tradesman. According to Andrew's mother, his grandfather on his mother's side had both mechanical engineering gifts and a learning disability; his maternal uncle has a gift for mechanical and technical innovation.

Ben is eight, and lives with both parents and his older sister. He attends the local public school. His father is a mechanical engineer; his mother works in sales. Both of his cousins are mechanical engineers.

Conrad is sixteen, and lives with his parents and two siblings. He attended St. Charles School for Gifted Learners[2] during his later elelmentary school years, but now is homeschooled. He is diagnosed with ADD and dyslexia.

Daniel, a ten and a half year old, is an only child, living with both parents. He has attended St. Charles School for Gifted Learners[2] since grade one. He is diagnosed with ADHD and written output difficulties. His mother teaches at a local college, his father is an occupational therapist, and his maternal grandfather was a mechanic.

Edward is eleven, an only child, living with both parents. He attends St. Michael's School[2] (a private school known for its small class sizes and individual attention). His mother is a scientist working as an administrator; his father is a medical engineer, working for a medical equipment manufacturer. His maternal uncle is an

[2] pseudonym

engineer, his maternal grandfather is a chemist; his paternal grandfather was an aeronautical engineer.

Felix is nine, lives with both parents, an older sister and a younger brother and sister. He attends a small, private Waldorf school. His mother teachers college physics, his father is a high school math and physics teacher, his maternal grandfather was a mechanical engineer and systems designer.

Gregory is eight, the oldest of three children (two boys and a girl) and lives with both parents. He is homeschooled. His father is a computer scientist; his paternal grandfather is a chemist. His mother stays home to care for the children; she wrote that she "sometimes wishes she had studied engineering".

Henry is nine, an only child living with both parents. He has been homeschooled since grade three; prior to that he spent 3 years in the public school's French immersion program. His parents both work in the film industry: his mother is a film editor and his father is a cinematographer.

Ian is ten-and-a-half, an only child living alternately with his divorced parents. He has attended St. Charles School for Gifted Learners[3] since kindergarten. His mother is an artist, his father is an accountant, who is described as being able to fix anything; his maternal uncle is a mechanically skilled inventor; his maternal great grandfather was a "brilliant inventor type".

James is nine, an only child living with both parents. He attends a " tiny" public elementary school. His mother is a writer, his father a merchandise buyer, his maternal

[3] pseudonym

grandfather was an entrepreneur in the field of technical innovation, his paternal grandfather was an electrical engineer; uncles on both sides are computer programmers.

3.3.2 Sample Two

In sample two, reflecting their adult status, surnames (pseudonyms) are used to identify the subjects. Two of the subjects responded to the questionnaire themselves: Mr. (Alex) Alberti and Mr. (Carl) Chopin. One of the questionnaires was completed entirely by subject's mother: Mr. (Brian) Bach; Mr. (Daniel) Debussy and his father co-wrote his response; Mr. (Eric) Elgar and his mother co-wrote his response. The parents are identified by the pseudonym's initials, for example, "BB" refers to Mr. Bach's mother.

Mr. Alberti is an inventor and the founder of a highly successful technical innovation development firm. He also is a frequent lecturer in the engineering department of various universities, specializing in applied technology. He is over fifty years old.

Mr. Bach is an inventor and scientist, working on his own inventions and patented technology. He is over forty years old.

Mr. Chopin is the Chief Engineer of a technology development firm. He is responsible for technology insertion and assessment for ongoing, proposed and future projects. He also lectures occasionally at the university level in mechanical engineering.

Mr. Debussy has worked as an aircraft structure designer and is currently on parental leave from work in medical device research, development and design.

Mr. Elgar is a senior master's student at University of British Columbia in the mechanical electronics program. This program is, according to the professor who made

the recommendation, an elite program for the brightest of the engineering students at the university. Mr. Elgar is over twenty years old.

3.4 The Questionnaires

The questionnaires for sample one and sample two were designed to obtain rich, information that might be used to generate and illuminate theory. Thus, both questionnaires contained open-ended questions centred around certain areas such as play-style, behaviour and social thinking. The questionnaires for sample one and sample two were essentially identical, with small changes in the engineers' questionnaire to reflect the adult stature of the sample two participants. Participants were requested to provide details, stories and elaborations beyond what the questions specifically asked. My goal was to have participants "paint a picture" of the unique traits, characteristics and developmental patterns of the subjects, and be free to add any details that they felt were characteristic of their child, and in the case of sample two, themselves.

To obtain a description of childhood behaviour and traits, some reference needs to be made to "norms". A child's unique qualities are remarkable when they contrast with those around him/her. If we describe a child as having "dark" hair, presumably we perceive her hair to be darker than the other children in her class, neighbourhood, family or village. Similarly, in this study, if a parent reports that her child is aggressive, then the implication is that the child is more aggressive than children of the same age with whom that parent is acquainted. One can expect parents in this study to have some basis on which to form these opinions. Although only four of the parents in sample one have more than one child, one can assume that all have come into contact with other children through their child's school, the neighbourhood, friends and relatives.

Parental reports cannot be construed to comprise conclusive evidence. For example, the questionnaire asks whether the child is "good" at remembering faces: responses to this question could never provide the quality of evidence that a norm-referenced facial recognition test would supply. However, from the responses to the questionnaires, I hoped to capture any truly remarkable qualities. For example, if a parent had noticed that her child was extraordinarily good (compared to his peer group) at remembering faces, then I hoped that this question would prompt the parent to remark, illustrate and describe such ability. In such a case, I would consider this response to provide some interesting information. A less emphatic response, on the other hand, would not indicate that the parent perceives the child to be really different from her comparison group in any remarkable way. Thus care was taken in the analysis to not construe as evidence any responses that do not seem to describe a significant difference from other children.

Research in the field of gifted education has shown that parent reports do, in fact, provide reliable sources of information about a child's exceptionality. Jacobs (1971) showed that a parent's opinion of a child's high intellectual ability is a strong predictor of intelligence test scores; similarly, Hanson (1984) confirmed the accuracy of parent recommendation for gifted education interventions as a predictor of other, more objective identifiers.

Parent reports are also regarded as reliable sources of information in the diagnostic process for psychiatric conditions. For example, diagnosis of Asperger's Syndrome relies on parent responses to a questionnaire (Attwood, 1998). The Australian Scale for Asperger's Syndrome requires parents to answer normative questions such as:

"Does the child have poor motor coordination?" (Attwood, 1998, p.19). This test assumes that the parent has some notion of what normal motor coordination looks like in other children of a similar age to their child. Thus, some reliance on parent perceptions and opinions about their child's uniqueness is justified.

Sending out the questionnaire

I found email to be the most effective and reliable means of obtaining responses. This medium made no demands on participants' schedules: they were able to respond at their leisure, to take time to reflect on their answers, and to take as much space as needed for their responses. The email medium also provided some protection against interviewer bias by ensuring that each participant received identical stimuli.

After the initial analysis had been conducted (see "Analysis", below), I prepared a draft manuscript of the results chapter of this thesis. This draft was distributed to each of the participants. Participants were requested to read and edit the copy for completeness and accuracy of their contribution (called "member checks"). The current manuscript reflects amendments from this editing process. Additional comments made by participants upon reading the draft (for example, "my son did that too") were also incorporated in the current paper, and are identified as "responses to the draft."

3.5 Analysis

3.5.1 Sample One

Preliminary analysis involved combing through the responses in search of evidence to support or refute whether the subjects fit both criteria required for participation in the study (passion and precocity regarding complex constructive activity

and understanding how things work). I compiled a list of direct quotes to support the evidence for each case. Where there was insufficient evidence in the response text that both criteria were clearly met, I conducted a follow-up interview with the parent-participant. This preliminary analysis of the questionnaire responses plus interview data yielded sufficient evidence of both precocity and passion in every case except one. The exception was excluded from participation in the study (see section 4.1 – Preliminary Analysis – for the rationale behind this decision).

Having completed the preliminary analysis and determined which cases could be included in my sample, I was ready to begin the analysis proper. According to Patton (1990) "The first decision to be made . . . is whether to begin with case analysis or cross-case analysis" (p. 376). As my intention was to determine what commonalities existed between the cases, I decided that cross-case analysis was appropriate. Within this approach, I used the constant comparison method to group answers to the questions and to allow other commonalities to emerge. This openness to new categories of analysis reflects the partially inductive nature of this enquiry. According to Patton (1990), inductive analysis permits categories to "emerge out of the data rather than being imposed on them prior to data collection and analysis" (p. 390). At the same time, the theoretical constructs discussed in the introduction chapter generated specific research questions, which in turn influenced the process of category formation. For example, the research question *to what extent did the subjects engage in pretend play?* generated the category of pretend play. Nevertheless, I wanted to be able to allow commonalities to emerge that were not necessarily aligned with extant theory or research questions. Hence, the request in the questionnaire to "please add any other information that you think would

be helpful for me to get a sense of the kind of person your child is, the way she/he developed, thinks, plays and learns" (question 34) opened the inquiry to other theoretical possibilities.

According to Lincoln and Guba (1985), the task of categorizing consists of bringing together temporary categories whose data bits appear to relate to the same content. To this end, one must "devise rules that describe category properties and that can, ultimately, be used to justify the inclusion of each data bit that remains assigned to the category as well as to provide a basis for later tests of replicability" (p.347). I devised tentative categories based on "inferences from the data, initial or emergent research questions . . . intuition and previous knowledge" (Dey, 1993, p. 100).

Having devised tentative categories, I proceeded to break down the data into data bits. After reading through each response as well as the transcripts from the interviews, I cut out bits that appeared to relate to one of the tentative categories, and grouped the bits into separate piles. I then compared each bit within each pile, looking for similarities or differences. I repeated this entire process three times, each time refining the categories, clarifying the criteria for including and excluding observations, and becoming more precise as to what constituted an individual data bit.

One difficult aspect of the analysis involved processing themes that emerged from two or more cases but which had not been addressed by the responses of other participants. When such themes emerged, I attempted to elicit more information via short telephone interviews and email correspondence with the other participants, taking care to use non-leading questions. Transcripts from the telephone interviews were then added to the data set, as were the responses from the email correspondences. This additional data

required that I review the entire data set to further clarify the categories and incorporate the additions.

Creation of categories and constant comparison of data bits was an iterative process. It was frequently informed by the participants themselves, who in many cases drew my attention to aspects of their children's behaviour, development and cognitive style that they felt were unique. More often, it emerged from my noting multiple occurrences of phenomena across cases. I was careful to note and report deviations from emergent patterns, as well as the multiple occurrences.

The next step involved uncovering over-arching themes that might unite the various categories in a way that could relate to the relevant and/or emerging theory. By re-immersion in the data, and engaging in a process of moving back and forth between the texts, the literature and my process notes, I created a draft of the results.

The last step incorporated additional data that resulted from the member-checking process. I sent each participant a copy of the draft results, with a request to edit the copy for completeness and accuracy of my portrayal of their contribution. I also invited the participants to provide any additional anecdotes, examples or counter-examples that they thought might be helpful to illustrate any points made by the other participants' descriptions and my interpretations. This process generated a not unsignificant amount of additional data, which required further modification of the categories and over-arching themes.

3.5.2 Sample Two

Sample two analysis involved a less inductive process. The sample two texts were meant to be used to answer the following question: did adults who are exemplary performers in fields related to engineering exhibit similar traits and developmental patterns when they were children as those that emerged from the sample one texts? As such, I used the categories that emerged from the sample one analysis as the organizing template for analysis of sample two texts.

I began the analysis by cutting data bits from the sample two texts and classifying them within the sample one categories. When categories were not addressed in the sample two questionnaire responses, I sent a query by email. It was not possible for each sample two participant to address every category that emerged from the sample one analysis: sample two adults were not able to remember details of their own infancy or early childhood, for example.

With the data bits sorted into the sample one categories, I then looked for divergence, that is, indications that the kinds of similarities found in sample one were not evident from sample two texts. Divergence is discussed further in the results section.

Because an inductive process was not used with the sample two texts, this analysis does not speak to any relationships between elements of those texts outside of those that emerged from the sample one text analysis. In other words, if there were a unique common trait, experience or developmental pattern in the childhood of adults who are now exemplary producers in fields related to engineering that was not evident in the descriptions provided by parents whose children are avid and passionate about

constructive activity and figuring out how things work, this method of analysis was not designed to find it.

As with the analysis of the data from sample one, the last step involved incorporating the data that resulted from the member-checking process into the analysis. All participants were sent a copy of the draft results section, with a request to edit the copy for completeness and accuracy of my representation of their contribution, as well as an invitation to add additional anecdotes, examples or counter-examples that they thought would add to the analysis. This generated some additional data, which required further revision of the results section.

3.6 Trustworthiness

This study drew from constructs used in qualitative research to provide a framework to evaluate the significance of the inquiry. These concepts offer a set of criteria for judging the quality and rigor of the investigation. The notion of trustworthiness was defined by Lincoln and Guba (1985) as an intention to persuade the audience of the value and worthiness of the inquiry. Constructs associated with trustworthiness include credibility, transferability, dependability, and confirmability.

Credibility in qualitative research consists of ascertaining compatibility between the constructed realities in the respondents' narrative to what is reported and attributed to the respondents in the inquiry. This study employed member-checking to enhance credibility: each participant was provided with a draft copy of the results section with a specific request to read and edit it for completeness and accuracy of their contribution. In some cases, this process was completed not only by the person who had provided the

initial texts but by an additional participant as well, e.g., another parent. This provided a source of triangulation: for example, two parents can bring diverging perspectives to their experience and recollections.

Peer debriefing is considered by Lincoln and Guba (1985) to contribute to confirmability. I was fortunate enough to have this opportunity during my data analysis stage. Midway through the process, I consulted with a group of graduate students in gifted education at the University of British Columbia about my emerging findings. They offered many valuable insights and alternative perspectives, especially on my tentative categories and my interpretation of particular data bits.

Transferability is the extent to which the findings can be applied in other contexts. In this study, transferability of findings is left primarily to readers; however, the process of evaluating its application to other contexts is assisted by (1) purposeful sampling of a specified population (children who love to build and figure out how things work, and who have a precocious ability to construct things and understand how things work; for sample two, adults who are exemplary performers in fields related to engineering); and (2) the participants' use of "thick description", which has been preserved to a certain extent and reproduced in the results section of this paper. According to Gall, Gall, and Borg (2003), "thick description" refers to statements that attempt to re-create a situation and as much of its context as possible. The use of thick description provides the reader "with a depiction in enough detail to show that the author's conclusion 'makes sense' (Merriam, 1998, p.199). As such, I have relied heavily on the actual texts provided by participants to allow their words to "speak for themselves". My aim was to provide the reader with the tools with which to evaluate my conclusions or to draw their own.

Dependability refers to the quality of the integrated processes of data collection, data analysis, and theory generation. It is also identified as the capacity of research findings to be replicated given similar respondents and contexts. In this study, the following processes may be considered to have contributed to dependability: 1) relying primarily on a written standard questionnaire and written participant responses provided some limit to the possibility of interviewer bias in data collection; 2) using "large" data bits—using large chunks of participants' responses—preserved to some degree the contextual quality of the data and 3) maintenance of an "audit trail" comprised of all original written responses, transcripts of interviews, copies of all emails, and traces that supported the categorization and classification processes.

Confirmability refers to the degree to which the conclusions are the products of the focus of the inquiry and are not dominated by the biases of the researcher. In this study, the sample selection method (described above), reliance primarily on written responses to a standard questionnaire, and members' checks (taking the draft results section back to participants) were the primary means used to minimize researcher bias.

3.7 Limits to Objectivity and Generalizability

Breuer, Mruck and Roth (2002) stated that "research is inherently structured by the subjectivity of the researcher" (p. 2). This is especially so in a qualitative study performed by a single investigator, such as this thesis. I entered the research process with specific questions in mind, and particular theories I felt might pertain to the results; thus this study cannot be considered completely free of researcher bias.

A second important limitation is the nature of the data itself: the data represent the recollections of parents and (in sample two) the subjects themselves, and as such, cannot be considered perfectly objective. Sample one participants recorded their recollections from their 9-15 year old children's infancy, up to and including the present. Sample two involved retrospective accounts going back decades: the tainting effect of memory is well-documented. Nevertheless, it is hoped that the combination of fifteen retrospective accounts may provide some valuable insights.

Generalizability of the findings of this study is limited by the sample selection method: sample one was selected from families whose children were enrolled at a relatively expensive school for gifted children and from families who had enrolled their children in a somewhat costly summer program at a local university. As a result, sample one subjects are from families who have the resources and the motivation to send their children to such programs. Children from families with restricted financial resources are therefore not represented. It is noteworthy that nine of the ten families in sample one had opted not to send their child to public school: again, this choice was possible because the parents were financially able to support the alternative. Sample two resulted from recommendations made to me by a tenured university professor in a mechanical engineering department, and from subsequent snowball sampling. For this sample, bias in sample selection results from the reliance on the personal opinions of the individuals who made the recommendations, and thus contain any personal bias on the part of those individuals.

Sample size also limits the generalizations that can be made on the basis of observations reported in the results section. Descriptions of the experiences and

developmental characteristics of ten children and five adults cannot be considered sufficient evidence to support or refute theory. However, it is hoped that this study's method has resulted in a descriptive composite portrait that may be of use for heuristic purposes and will encourage further research.

4 RESULTS: SAMPLE ONE

4.1 Preliminary Analysis

Preliminary analysis of the eleven original responses to the questionnaire was conducted (as discussed in the "methods" section) to determine whether or not the candidates did appear to represent the construct being investigated (that is, children who are passionate and precocious at complex constructive activity). This preliminary analysis initially suggested that nine of the eleven candidates were suitable. The following data bits are examples of the kinds of evidence that I used to support my decisions to include the candidates in the sample.

> *[Andrew was a] Lego builder, especially the theme Lego pieces i.e., the Mars Space Station version . . . built in less than 30 minutes by the visual picture on the box at age 6 (A); (precocity)*

> *My God, the Lego! (A).*
> *[Andrew's mother became speechless when she tried to express the quantities of Lego her son played with. She finally described his passion for building in terms of the five 50-gallon Rubbermaid tubs full of Lego at her house, purchased in response to her son's constant demands for more Lego and passionate involvement with the toy.] (passion)*

> *[Ben's preferred play choices are] Meccano, Lego, and he does love SuperMario Nintendo games which are basically puzzles . . .people are always pointing out to me that he is figuring out how stuff works or is put together (B); (passion)*

> *[Conrad] enjoys pulling things apart and trying to understand how they work. He would spend hours building with Lego and still has many of his creations on display . . . He got so that he could program the micro chip in the Lego [robotics] to follow commands to move the robot (C); (passion)*

[Edward] has an amazing mind: can comprehend seemingly difficult concepts . . .at age four he could tell whether a parked car was front or rear wheel drive by looking under it—don't ask me how he learned to do this! Neither of us parents have any interest in cars. And we were in Germany—his sources of influence didn't exist. I believe he just put together some aside comments we might have made or he might have seen in a book. He was right though . . . He has amazing 3D visual perception: he has always been able to build K'nex and Lego and Mechano from the instruction pictures regardless of the orientation of the page. And he can see, with stunning accuracy, what might just fit where: he has managed to firmly lodge marbles in very strange places. (Plop. "Mum look it fits!" How many were lodged and never retrieved?) (E); (precocity)

[Edward] designed and carried out his own experiment at two and pointed out his learnings to me for weeks afterwards: leaving friends he took a bucket of water up the street and poured it into the small brick-lined culvert, following it as it went downhill. Repeated experiment. For the next few weeks "see mum, water goes down." . . . He created a siphon at three . . . and was thrilled to discover it was something he could learn to do and repeat at will. We had layers upon layers of siphoning in the sink (E). (passion and precocity)

[Does he/she engage in building, tinkering, or exploring how-things-work more or less than other children?] Much more. Much much more. His favourite shows on TV tend to be building things: monster technology, junk yard wars, modifying trucks, how things work . . . He'd be over the moon happy if he had a car he could take apart (forget that he couldn't). He collects electrical stuff that doesn't work so he can take it apart and maybe use bits of it later. He would be super happy if we had a work-shop in which he could tinker—with wood, with anything (E); (passion)

[Felix] just thinks about stuff--he'll just pop out with a theory about how something (a roller coaster or a tool or a machine) works, so that you know he's thinking about it inside his head even when he's not doing anything along those lines . . . He seems to build and tinker more than average, and he seems to have a gift for understanding how things work. He is very curious about it in general. He'll often just come up with ideas about how things might work so that you know he's been thinking about stuff like that in the world around him (F); (passion and precocity)

[James] has always been a builder—Lego is his preferred tool. Since he was far too young to use Lego, he has been. He's 9 now and builds many of his own very intricate designs . . . he built a very complicated dinosaur out of Zoob Toobs, from 4:30 to 9:00 pm, without a break, using only the picture on the box . . . this is typical" (J) (passion and precocity)

He really has a much more developed sense of mechanics and 3 dimensional space [at age 9] than I do (H). (precocity)

In two cases (Ian and Ken), evidence of precocity and passion were not clear, and required a follow-up interview.

Ian's mother explained to me that her son was extremely fond of building blocks, Lego and mechanical toys when he was very young (under four years of age), but quickly moved on to an interest in games of strategy, especially computer and video games. His focus seems to have been less on "how things work" than on how "systems" work in a broader sense. His mother reported that while he is currently (age 10) "somewhat" interested in building, tinkering and exploring how-things-work, his main focus is "games that build by strategy acquiring skills reaching certain levels of mastery and achievement." She also described an extremely early fascination and precocity with mathematical systems:

[Ian] can do amazing calculations in his head . . . I remember him playing on the kitchen floor (age 2) lining up a bunch of baby food jars (15 or so) he started counting down from one end: ten, nine, eight . . . and then he got to one and zero then without a hesitation started down the negative scale, can't remember the exact word he used, like less one, less two, less three or something . . . (he) memorized many phone numbers when two-ish, and referred to his friends by their house numbers. (I)

His mother explained that when he was very young (two-plus years) his favourite toy, along with his Lego and building blocks, was a calculator.

After some deliberation, I decided to include Ian in the sample, because he clearly is a child who is precocious at and passionate about "how things work" in the broader sense of "systems"—that is, in Baron-Cohen's (2003) use of the word: something that can be understood according to rules or laws, such as mathematical systems (algebra, computer programs) or mechanical systems (computers or cars). Additionally, as will be seen from the analysis below, all of the other children in the sample transitioned from an interest in building things and figuring out how things work to a passion for computers and computer-and video-games of strategy when they were older (around age 9). Ian appears to have made this transition at age 4, possibly because his early reading (at age 2) gave him access to these activities at a younger age. Thus, I determined that he does represent the construct, or a slight variation on the construct, being studied in this paper.

Ken was the other case whose response did not provide clear evidence of passion and precocity related to complex constructive activity. In a follow-up interview, his mother explained to me that she had responded to the study because she has done graduate work in psychology and knows how difficult it is to get participants—in effect, her response had less to do with her son's fitting the description and more to do with wanting to help me out. Speaking to Ken's father yielded the following: "We own a lot of Lego, mainly because people kept giving it to us for birthday presents. [Ken] plays with it a fair bit, but I wouldn't really consider Ken an avid builder. He is more into reading and playing imaginative games with his sister than building." This convinced me that Ken failed to demonstrate the criteria required for inclusion in this study.

Thus, ten subjects: Andrew, Ben, Conrad, Daniel, Edward, Felix, Gregory, Henry and James, were included in sample one of this study.

4.2 Major Categories

The major categories that emerged from my analysis of the sample one texts were: (1) gender; (2) evidence of above-average general intelligence; (3) failure to exhibit certain gifted behaviours; (4) interest in constructive play transitioning into computers and games of strategy; (5) interest in non-fiction rather than narrative; (6) child-led pursuit of interests; (7) lack of interest in pretend play; (8) lack of social orientation; (9) aggression and conflict avoidance; (10) early development (temperament, speech and reading); (11) scholastic preferences; (12) visual-spatial abilities; (13) concrete thinking; (14) tenacity, focus and problems with attention; and (15) school experience.

4.3 Results from Sample One

(1) Gender

Although the request for participants was gender neutral (see Appendix 3), every respondent to my request was the parent of a boy. I will return to this point in the discussion.

(2) Evidence of above-average intelligence

"Intelligence" is a slippery construct. It has various definitions, each of which requires a different approach to measurement. However, the overall sense I got from the sample one texts was that despite their preoccupation with constructive activities, despite their limited interest in pretend play and narrative, these children seem to be very "smart". They seem to learn things quickly, have strong memories, learned to read easily and early (except Conrad, labeled with dyslexia), and have no difficulty with learning scholastic content. Furthermore, in every case except Ben's, parents described events or

occurrences that suggest that the children in the sample possess mental abilities typical of older children. These are the kinds of descriptions made by the parents to support this observation:

> *He doesn't yet realize what a powerfully sticky mind he has: if he concentrates he can read something, claim he doesn't remember what he read two seconds later, but when told to relax and try to tell what he read, he pretty much regurgitates paragraphs word for word. (E)*
>
> *. . Learns everything immediately and quickly. Grasping it right away. Impatient and doesn't understand it takes others longer . . . Just devoured K-3 exercise books, puzzles, etc. when 2-3-4 years old. He loved doing his psycho-ed testing: wanted to keep coming back for more, more challenges (I);*
>
> *He is a voracious learner and reader; he understands concepts far above his age level; he can problem-solve in amazing ways; his brain is very logical and can make sense of the world and very complicated concepts (G);*
>
> *[When Felix was 7 or younger] we flew to California (from the east coast) . . . so our kids experienced the time change. For the other kids it was just something to know: it's earlier in California [than it is on the east coast]. But Felix thought about it— apparently a lot, although I didn't know at the time. I found out three days later when he said "Daddy, I think I know why the time is different in California from here." He held up his hands to illustrate the planet Earth and the sun going across the sky, and explained that when the sun gets to [the east coast] here, it will still be hours before it gets to California there. I was stunned, and just sort of said 'Yes, that's right.' (F).*
>
> *[In kindergarten] when they were counting from 1 to 10, James would carry on after 10 saying numbers by 10s up to 100 (J).*

Advanced and voracious reading, coupled with high verbal intelligence were mentioned in (5) cases (Daniel, Gregory, Henry, Ian and James). For example:

> *Henry reads copious amounts. He has read six Hardy Boys in a day and that is with lots of other activities in the day. He read the*

last Harry Potter book in 5 & ½ hours, in two sittings on one day [age 9] . . . this summer he had a complete psyche-ed test and his language comprehension is rated as 22 years plus level (H);

Daniel went to day-care until five. The caregivers found they had to constantly find puzzles to challenge him. They found him very bright and highly verbal (D);

James started day-care a week before he turned three and he was speaking as well as most of the 5-year-olds. In fact, he played with the 5 years olds since, as he said at the time, all the other kids were babies! . . . The care givers used to be amazed at his language skills and maturity and often told us that they thought he was gifted . . . in grade 2, his teacher told us that he [the teacher] was having trouble finding challenging reading for James since he was reading at a grade 4 level and James's interests were grade 2 interests (J).

By virtue of their being accepted to attend St. Charles School for Gifted Children, two of the subjects (Daniel and Ian) were labelled "gifted" by traditional standards; that is, they scored above 130 on an IQ test. Henry has also been tested and labeled "highly gifted" by a psychologist. According to his mother, James was excluded from his school's gifted program because he missed the school board's required IQ cut-off by 3 points. The other participants did not mention the gifted construct. As this study is concerned with children who demonstrate arguably gifted behaviour and thinking in the domain of folk physics, parents were not explicitly asked about a gifted label, in the traditional sense. In fact, some of the parents (e.g., Edward's) mentioned to me that they were not comfortable with the gifted label, nor with sending their child to a school for gifted children, because it seemed elitist.

(3) Gifted behaviours that did not appear

Although the children in this sample are cognitively competent, possibly at a level that could be considered above average, there were certain traits that are commonly

associated with "giftedness" that did not appear in many of the cases. These are: precocious moral and ethical concerns; display of advanced, complex fantasy play; early talking; vivid imagination and creativity in artwork, writing or dramatization, expressiveness; sensitivity to others and social knowledge. In the introduction, I presented a brief review of the literature that considers these to be "markers," or indicators, of giftedness.

Precocious moral and ethical concerns

Gifted children are typically described as precociously concerned about the suffering of others, world problems and broad-scale morality (Kanevsky, 1999; Kingmore, 1998; Smutny, Walker & Meckstroth, 1997). Of the ten cases in this sample, only one (James) described this kind of sensibility:

> *Even when he sees a stranger in crisis it can move him to tears of concern. He will give some of his allowance to people asking for money on the street sometimes. When he hears of stories of poverty, he gets quite upset about the people who let that happen – in his world, that's George Bush and Gordon Campbell! . . . He's driven by injustice—perceived and real. He sees himself as an inventor in the future. He wants to invent devices that will make sure nobody in the world is ever hungry, that people aren't ever killed in accidents, that his cat never dies, that George Bush was never born (J).*

The other nine participants did *not* mention this kind of interest in the hardships of people in the larger word. This is certainly not to say that these children are uncaring or self-absorbed—most of the participants were described as "kind" and "non-aggressive"; however, it would seem that their intellect is engaged elsewhere.

Although Ian was described as being concerned with "justice," and enjoys a good argument—his mother described him as "a little lawyer"—this seems to be driven by his

passion for logic; in fact, his mother stated: "[Ian] never bothered or cared too much about others," (I). Instead, Ian's focus is on statistics, numbers, logic, computers, etc.

Display of advanced, complex fantasy play

This trait, considered to be a "marker" of giftedness (White, 1985), appears to be absent from this group with the exception of Henry, whose fantasy play emerged late and is quite idiosyncratic. See results (below) under pretend play.

Early talking

Of the ten subjects, only two (Gregory and Ian) reported early speech development. Ben and Daniel developed speech relatively late compared to age norms (see discussion below on speech development). This is in contrast to the expectation that gifted children are "early talkers" (e.g., Freeman, 1979).

Vivid imagination and creativity in artwork, writing or dramatization.

The participants' responses did not provide evidence of the vivid imagination and creativity expressed in artwork, writing or dramatization that is commonly thought to be associated with giftedness (Smutny, Walker & Meckstroth, 1997; Fisher 1998). James was a possible exception: his mother reported he enjoys "drawing—especially detailed dragons and other mythical animals." He also enjoys and excels at creative writing: "in grade 3 he wrote a short novel using Hypercard . . . it had animation and static images to accompany each chapter." In the other nine cases, however, the subjects were ***not*** described as engaging passionately or precociously in drawing, writing or dramatizing. In fact, these activities were often described by the participants as their child's least-preferred activities (see results under 'scholastic preferences').

Expressiveness, sensitivity to feelings of others, social knowledge

These traits, though described by Kanevsky (1999), Smutny, Walker & Meckstroth (1997), Fisher (1998), Lewis and Michalson (1985), Kingmore (1998) as "markers" of giftedness, were *not* displayed, on the whole, by the children in this sample. In fact, quite the opposite emerged as a common theme in the analysis. See results (below) under 'lack of social orientation.'

(4) Interests in constructive activity transitioning into computers and games of strategy

Descriptions of the kinds of activities the children engaged in when they were young were overwhelmingly focused on constructive activity and scientific exploration. Lego was mentioned in every case as a preferred toy, especially advanced play with Lego, such as Lego Robotics and building complicated Lego models.

Other constructive activity materials that were mentioned frequently were: K'nex, Mechanno, building blocks, Erector, and Marble Run. Although most children enjoy playing with these toys, there was an overwhelming and remarkably early preference for this type of play described by the parents of the children in this sample. For example:

> *[What kind of toys or objects does he/she like to play with?] [Daniel] enjoys manipulatives: Lego, Lego Robotics, computer games (Civilization, Runescape, computer games of war or building like Roller Coaster Tycoon). . . K'nex, marble rail, Hot Wheels (D);*
>
> *[What is your child's preferred type of play?] Besides computer games? And horsing around outside on his bike or have water fights? Building. Building. Creating. Solving physical problems. . . he has enjoyed Lego Technic, for the 14+ age group, at the age of 4. He also enjoyed an electronics lab at the age of 5. He now [age 11] has a soldering iron and kit . . . He enjoys the computer, and really enjoys summer courses where they take computers apart and*

rebuild them, create their own computer games, and animation. Using Technology—what can I do with whatever." (E);

He wants to build stuff out of wood, blocks or Lego-type kits. He also likes science kits and other projects where you are trying different things out and learning from them. He builds train tracks and car tracks and he makes ramps to race-cars or marbles down. He has always liked working mazes and puzzles, but he is less interested in doing artwork overall (F);

Notice the emphasis on puzzles and problem-solving: these descriptions seemed to me to be of complex constructive activity not with a view to support narrative, but with the intent to solve a technical puzzle, to explore a physical phenomenon or to figure out how something works.

In every case, with the possible exception of Ian, a passionate exploration of "how things work" was evident very early: science experiments, pulling things apart, questioning and investigating the physical world appeared to develop from a younger age than in other children. For example: "He has always, from day one, been interested in how things work." (H);

[He] has never really "played" with toys. By age 2 he was insisting on taking apart any toy we could that had moving parts or something inside it. We thought all kids were like this and were shocked when his sister came along and actually played with toys as they were designed to be played with. As well, his book of choice for reading for at least two years [age 4 to 6] was Daniel Macaulay's The Way Things Work *and we often read that exclusively for months (G).*

E responded to the draft that *The Way things Work* was also her son's favourite book as a very young child, and that his play style was the same as Gregory's, described above.

In every case, participants described their child's interest in constructive play transforming into a later interest in computers, computer games and strategic games (such as strategy video, computer, board or card games). Some examples:

> *Age 6-9, Lego/robotics were very popular . . . Now, at age 12, he is into "strategic war" games video and board games. . . he would like to learn how to "create a video game" i.e., build it . . . he has all the ideas for the games written down (A);*
>
> *Henry's main interest now [age 9] is computers. He wants to be able to program computers. I try to control it, put on limits, but he would say his main interest now is computers (H);*
>
> *Until age 6 or so he was entirely focused on how things work. Now [age 8] he memorizes all types of game cards (Pokemon, Yugioh, Magic) and designs video games (G);*
>
> *Conrad now [age 16] creates most often using a computer and makes Power Point presentations and creates videos etc. (C).*

In most cases, the interest in computers was described as being very strong. Participant (G) called her son's interest in computers "an obsession".

In Ian's case, this transition from an interest in constructive play to interest in computers came at a very young age (age 4). At age 2 to 3, his favourite toys were a calculator (as was Ben's), building blocks, Lego and mechanical building toys. By age 4 his favourite activities were playing Nintendo and other computer games, especially "games that build by strategy, acquiring skills and reaching certain levels of mastery." As discussed in the pre-analysis section, his early transition may have been the result of Ian's learning to read at age 2, which gave him access to computers and computer games at a much younger age than the other children in this sample.

(5) Interest in non-fiction rather than narrative

For Ben, "reading was something he needed to be reminded to do;" however, "this is now changing at the age of 8" (B). The other nine subjects, on the other hand, were described as being avid readers and book lovers from a very young age. Given this predilection, I felt that information about the children's book preferences could give an indication of their intrinsic interests.

Interestingly, in their early years (under eight years), at a time when most children engage in stories, fairy tales and fantasy (Egan, 1988) five of the children in this sample (D, E, G, H, and I) preferred informational texts. For example: "When Henry was little . . . he was really into non-fiction books. We would go to the library every three weeks and take out 25 books on non-fiction things, like rescue vehicles, dinosaurs – whatever his interest was at the time" (H); "[Ian] used to enjoy reading game manuals at 4 years. I have this on tape" (I); and "Edward's favourite books as a young kid were build-it-at-home and experiment books" (E).

As they matured (after age 8), four of these children's (E, G, H and I) choice of reading material expanded to include the following genres: fantasy (such as *Harry Potter, Deltora Quest, Lord of the Rings, Goosebumps, Redwall*), science fiction, and detective/crime/spy stories (e.g., *Hardy Boys*) as well as non-fiction especially related to, but not limited to, science and computers. Participants A, B, C and J described similar reading interests.

It occurred to me, as I read these descriptions of the children's preferred reading material, that although the later choices did embrace narrative, there was still a "systems" component to the boys' fiction choices. For example, the kinds of fantasy enjoyed by

many of the children, such as *Deltora Quest, Harry Potter, Lord of the Rings*, are based on very complicated, rule-bound fantasy worlds. I speculate that the attraction to these stories may not be to their narrative components, but rather to their detailed, factual, quasi-scientific worlds, and to the complicated strategy problems faced by the heroes.

In contrast, Felix read widely: his was the only response that mentioned a general interest in stories:

> *[Felix] definitely likes reading almost anything. He loves his magazines: Boy's Life, Muse [a fun magazine about science for young teenagers], etc. He loves factual articles, articles about science or experiments. He also loves stories. Fantasy, science fiction, mystery, drama, classics, he seems to like them all. (F)*

Interestingly, Felix is also the subject who appears to be the most sociable and well-liked by his peers. He is described as "a very popular kid" who "plays with many different friends . . . [and] gets along with pretty much every kid in his class." (F) (See further discussion on social relatedness, below.)

(6) Child-led Pursuit Of Interests

There was some indication that the parent participants in this study perceived their children's inclination towards constructive play and scientific exploration to be child-initiated, rather than being the result of parental steering, exposure or teaching. E's story illustrates this: "At age 4 Edward could tell whether a parked car was front or rear wheel drive by looking under it—don't ask me how he learned to do this! Neither of us parents have any interest in cars." (E)

Some participants (I, G) described interests in math, science, constructive play and computers being evident by the time their child was age 2:

Ian was using the computer by two-ish, keying in his friends' phone numbers . . . you could tell him the year you were born in and he could instantly tell you how old you were (or was it vice versa?) This was at 2 and 2.5 years. (I)

This extremely early appearance of Ian's fascination with numbers suggests that it has a "hard-wired" quality to it; to wit, his mother denied having "taught" him any of these skills.

Parents of Gregory, Felix and Ben noted how different this child was from his sibling(s), suggesting that their child's abilities could not have resulted from the shared home environment. For example: "Ben's sister has absolutely none of Ben's mechanical aptitude, and she is eight years older!" (B) From comments like these, one may infer that the parents believe there to be an innate component to the interests and orientation of their child. Note also (from section 3.3) that eight of the ten participants mentioned close relatives of the child having an engineering-related profession or talent, suggesting that an inheritable component is one possible explanation for the early and unique appearance of these traits. I will return to this issue in the discussion.

(7) Imaginative Play

A remarkably common theme that emerged from this analysis was a distinct lack of interest in imaginative (pretend, or dramatic) play when the subjects were young (5 and under). For example: "I am not aware of any imaginary play at all that [Ben] would do." (B); "Inventive play: he wasn't much into roles but loves to build and create." (C); "He was not into fantasy play, definitely not" (I). Edward's pretend play was described as being existent, but very limited:

When he was younger, the only imaginary play was when he was about 4, playing with me: our fingers would become different people he knew and he would build Lego things and then our fingers would enjoy using all these things. This was also, I think, a way for him to understand situations that had occurred with other kids. Other than that he is pretty much here and now—no imaginary stuff. (E)

Disinterest in pretend play at a young age was described by every participant except F and J. Felix did engage in imaginative play; however, this play did not seem to function as a scaffold for narrative:

"Felix's imaginative play is less structured, it seems to me, than his siblings at similar ages. He is less likely to weave a big story, and more likely to run around the house screaming being a monster or marching and singing something loudly." (F)

James's constructive activity incorporated pretend components into it: "when he's building, he's imagining the scenes in which the characters he's built are interacting" (J). This corresponds to the speculation made by Christie and Johnson (1987) that "constructive play is actually a varying combination of functional and dramatic play" (p.450). However, of the ten subjects, James was the only child whose constructive play was described in this way. The other nine cases appeared to describe not building for the sake of scaffolding narrative, but building for the sake of solving a puzzle, or of grappling with a technical challenge. For example, when Andrew's mother discovered him, at age six, engrossed for half an hour in building the Mars Space Station, his intent was, she explained, not to pretend it was an actual space station, but to solve the practical and technical problems of replicating the picture on the box.

Pretend play in two cases (Gregory and Henry), although absent when they were under seven, did eventually emerge, apparently mediated by their interest in computer or

strategy games. A fascinating account was given by H, who reported that her child engaged in no pretend play at all prior to the following episode (at age 9):

> *It started when I asked his friend Thomas and him to stop playing a computer game. They complained, but got off. Then I observed they created their own computer game in their heads . . . They began to create a whole game with a complex array of characters weapons, places, castles, job categories (e.g., blacksmiths), food, water supply, and cost breakdowns (i.e., how much you would have to pay for a cook to feed your troupes, how much per meal, a sword, a rapier, a crossbow, etc.). It seemed as they worked on this "world" they also began to "play" the game in a parallel way. They would set up a character, a scenario. It seemed that Henry would take on the role of "player" and Thomas was more the "ruler" of the play or the "computer". Once they began they played continuously for about 3 hours with no stops. They met up the next week and put in another 5 hours, again completely focused! (H)*

Henry's mother explained that this type of play has continued since that episode, and now has evolved into a very complicated, detailed, and passionate pursuit of his interest in spies:

> *He spends a lot of time designing the organization: junior spy levels, badges, equipment, etc. He draws by hand the equipment designs. They are very specific. He designed the membership badges on the computers. Now he is designing the headquarters building. He also asks real questions about where he could buy land cheapest in Canada – what kind of land, zoning issues . . . He asked his Dad that if he raised $10,000 between members, would he (dad) put up $20,000 to purchase a lot to build on in Saskatchewan where land is cheap. He takes it all very seriously. When I mention "pretend" to him, he is offended. [This play is] quite imaginative, not always completely original (he loves the Spy Kids movies) but very complex and thorough. (H)*

To summarize, of the ten accounts, only one described an engagement (under age nine) in pretend, narrative-based play: in this case, such play was imbedded within constructive play. In all other cases, pretend play was minimal, absent or (in Felix's

case) not narrative-based. In two cases, pretend play appeared to emerge much later (age 9) than is typical, and seems to have been mediated by the child's interest in computers and games of strategy.

(8) Lack of Social Orientation

In all cases but one (Ben), participants gave some indication that their child displayed a lack of social orientation—that is, a relative disinterest and/or inability to attend to the thoughts and intentions of others. Social awkwardness, dislike of large groups, displays of subtle social insensitivity (e.g., failure to pick up social cues), or preference for one-on-one-play, were some of the traits that emerged to support this claim.

Large groups

Of the ten participants, seven (Andrew, Conrad, Daniel, Gregory, Henry, Ian and James), described an aversion to large groups. For example:

> *As a preschooler Andrew would "ground himself" within the book corner (quiet area) as he was easily overwhelmed and over-stimulated after one hour with 20 plus kids around . . . he is most sociable and comfortable in a safe setting of friends he knows and smaller groups. I always had to pull him out of daycamp situations until last year [age 11] when he could join in a camp that maxed out at 13 kids who went on adventures as a separate camp with their own van and not with the other camps on a rented bus (A);*
>
> *"Gregory loves to play one-on-one with other kids but is uncomfortable and removed in groups and greatly dislikes them." (G)*

Preference for individual sports over team sports

The dislike of group situations described above was echoed by a distinct preference for individual sports over team sports in seven of the ten cases (Andrew, Conrad, Daniel, Edward, Gregory, Ian, James): "James isn't big on group play or any group activities, preferring one-on-one play always. He has never enjoyed any team sports (hated soccer), but loves swimming, biking." (J)

The aversion to team sport is not due to a lack of physicality: some of the individual sports participants described their children enjoying are: martial arts (Gregory); karate, kayaking, hiking (Daniel); water fights, climbing, sailing, "horsing around outside on his bike," flying a stunt kite, kayaking and rock climbing (Edward); skiing and rock climbing (Conrad). Andrew, on the other hand: "would choose computer over sports. If he does engage in sports it is with a lot of coaxing and/or an ultimatum from me, his mom. He prefers individual sports, absolutely."(A)

Ben, however, loves most sports—soccer was mentioned—in fact, prefers sport to any other kind of activity, including building play. Felix enjoys "group games and sports with other kids," including soccer and baseball, "but often loses concentration, playing monster games instead of right field." (F). Henry enjoys hockey.

Peer relationships

Across the ten cases there seems to be a spectrum of interest in and ability to manage peer relationships. At one end is Conrad: "[He prefers to play by] himself, younger children or people who are older than him. He has rarely been able to engage with peers his own age. He finds them undirected and frustrating." (C) Daniel and Edward describe a more ambivalent preference for peer interaction:

He is initially very sociable with other kids, but still prefers adults to engage with if available. He will often go off and play by himself if he is not interested in what the other children are doing (D);

"As a young child he was more interested in the toys of "friends" than the friend. He'd ask to go visit kids just because of a special toy." (E)

Parents of Andrew, Ben, Daniel, Gregory, Henry and James, described a definite preference for one or two close, well-known friends – friends who share their interests and who can provide a safe, predictable interaction, for example: "He is most sociable and comfortable in a safe setting of friends he knows and smaller groups" (A). While Edward will play with:

. . . the neighbourhood kids: anyone who is available when he is. He is pretty non-picky in that regard . . . although it depends on who they are (boys or girls) and what they are doing (wild and crazy stuff or quiet stuff) and if he has a buildy project he is particularly keen on underway . . . (E)

in a response to the draft, Edward's mother added: "Close friends are few and far between." (E)

Felix was described as non-discriminating:

He's pretty comfortable with just about anyone; he is not tentative with new kids – he'll just go up and try to get in on whatever others are doing. At other times he is content just reading to himself in a corner. He usually likes company when he wants to do building/experimenting . . . if there are kids around, he will generally interact with them rather than staying by himself. The exception to this is if there is something that he really wants to read; then he'll ignore other kids and just read. (F)

Henry was described as being popular with other children, but perhaps because of personal attributes, rather than as a result of his involvement with and interest in his peer group: "He has a couple of good friends, but didn't connect too well with kids at the

school he was at. He was well-liked: kids thought he was funny and smart." (H) Of the ten, only Ben, Felix and James were described as being truly "sociable":

> *[James has a] great sense of humour – loves to make people laugh; always singing or talking in funny voices; very popular at school; loves to play with kids of all ages . . . [he is very] sociable. He hates to come home from school without a friend. He is invited to most birthday parties – and is sometimes the only boy at girls' parties! He is part of a few different "gangs" at school. (J)*

But, like Felix, for James, peers can come second to building and/or reading interests: "He will sometimes not invite a friend over who doesn't like to build rather than be 'forced' to engage in some other kind of play with a friend." (J)

Ben was described as being "very sociable, however not terribly outgoing"; his mother reported that he would prefer to play with other children given the option.

Social skills

The ten participants described a spectrum of social ability, from a clear statement that their child is weak in this area (C, D and H) to more subtle examples that may suggest a possible social skills weakness. In none of the cases did participants describe their child as having strong, good or even average social skills.

Three participants (C, D and H) explicitly stated that one of their child's main weaknesses was in social skills. Additionally, Conrad experienced "significant social challenges on the playground" (C); Daniel was described as having difficulty: "judging the [social] situation, integrating." Henry's mother described "weaknesses in the areas of confidence and social skills."

Less strongly, Ian's mother described Ian as "socially awkward a bit." (I)

Sensitivity to others; interpreting social situations.

In the other six cases, parents provided no clear evidence suggesting their child's social skills were weak; however, a lack of social orientation might be inferred from comments that indicate an inability to "read" others or to interpret social situations. For example, four subjects (Daniel, Edward, Felix and James) were described as not knowing when their jokes were not appreciated—in other words, not picking up or attending to the subtle social cues that indicate when certain types of humour are inappropriate. Some examples: "He enjoys puns and jokes, but repeats them to the point where it annoys others." (D) "He is also insensitive—over-riding other's thresholds because he is having fun, oblivious to the fact that he is driving other people nuts."(E); and:

> *He is easygoing and not very emotionally sensitive . . . Felix gets criticized by his teachers because he is too eager to make the other children laugh – often at inappropriate times . . . he likes to taunt his siblings a bit—he sometimes thinks it's funny when they get mad at him. (F);*
>
> *[His kindergarten teacher] told us that daily he'd interrupt the class and make all the kids laugh with his jokes (usually word plays on something the teacher had said). (J).*

In reading these comments, one could surmise that these are commonly-occurring child behaviours, and not unusual in any way. However, I would point out that these were comments presented by the participants as examples of their child's personality: such comments presumably would have been chosen because in the parent's view, they represent aspects of their child which contribute to his uniqueness. It is possible that, for example, Felix's taunting his siblings, and James's interrupting the class were mentioned by the participants because they seemed excessive compared to other the behaviour of other children known to the participants.

Kindness towards others vs "mindblindness"

In every case, participants described their child as caring, loving and kind: there were no indications that these children are heartless or cold. There were no descriptions in any of the responses of mean, aggressive or cruel behaviour or intent. Instead what emerged seemed to be a subtle failure to detect others' thoughts and emotions, coupled with a failure to respond appropriately. For example: "He will comfort his own siblings but probably not other kids. He is pretty awkward when confronted by others' feelings but I wouldn't say he is not empathetic." (G)

Empathy, however, is described by Baron-Cohen (2003) as the ability to "mind-read:" that is, to intuitively sense what other people are thinking and feeling. This, as discussed in the introduction, comprises a significant aspect of folk psychology. The following description seems to illustrate what Baron-Cohen (1995) calls "mind-blindness", that is, a lack of ability to "mind-read" and/or a lack or interest in attending to the thoughts of others:

> *Felix is much less likely than our other children to notice how other people are feeling. He just doesn't pay that much attention to the feelings of others . . . he is not a bully or anything, but he often behaves in annoying ways, just to get a reaction (F).*

Edward's mother provided a similar description:

> *Behavioural problems are endless. But I see them not so much as problems as part of the parcel. Perhaps boredom is at the bottom of it – getting reactions from others. He's been doing that since he was 14 months. And, too, I think people are mini-experiments for him . . . (I wonder what this button does?) (E).*

Talkative about favourite topics but difficulty discussing feelings.

Another indication of subtle lack of social orientation may be a tendency to be very talkative about a favourite subject (in these cases, typically building projects, science experiments, the computer and computer games) alongside difficulty discussing feelings or emotions. This combination was described by participants B, C, E, G and H. Henry's mother used a teddy bear puppet to draw him out when he was otherwise not able to discuss difficulties at school:

> *He had a puppet teddy bear, and we used the bear to talk about feelings. He would talk to the bear, but wouldn't talk to us otherwise [about feelings]. He really shut down, by the end of grade three. He didn't know how he was supposed to feel – he closed down and wouldn't talk about anything. The bear helped. (H)*

Henry was subsequently removed from school and homeschooled. According to his mother, he is much happier now (see "school experience" below). Other examples:

> *I am aware that he [Conrad] was teased in elementary school because his sister complained about being called "computer boy's sister." He also would get very upset each year as school approached at the end of summer. He rarely talked about this and it is only through others and gathering data that I am aware of this. (C)*

> *Weakness – he [Ben] is not particularly communicative. For example, in May, one of this friends at school died – he didn't tell me until he was home from school for a good hour or so . . . He has [been bullied] a bit, by a very good friend. He was completely devastated. Unfortunately he didn't tell me for a couple of months after the fact (B);*

> *He internalizes a great deal – not expressing his unhappiness, but rather exploding totally inappropriately, without warning over trivial things. He only explains the source of his frustration (usually a situation at school where others are manipulating or creating situations in which he feels inadequate: harassment and bullying) after he explodes and realizes what it is that is really gushing from his volcanic fury (E).*

Alongside a tendency to be uncommunicative about emotional or personal subjects, C, D, E, J and H were described as being extremely talkative about their favourite subjects. For example:

> *He loves to talk, and tell all that is happening in his brain with some creation – as it is being created and amended. He can talk for 20 minutes straight, all about some contraption "wouldn't it be neat to build" which starts with the bare bones at minute 1, and by 20 minutes is very elaborate indeed – all vocalized. (E)*

Naive/honest:

A trait that could be evidence of a difficulty "reading" others is gullibility or naivite; what Pinker (1997) calls a weakness in "cheater-detection." For example of this might be the following:

> *He pretty much accepts anyone the way they are, doesn't hold grudges and if asked what he thinks of this child or that will invariably answer – "they are ok." He forgives everyone of their "misdeeds" against him to a fault: he is hurt over and over by the same people—though is slowly learning from whom to keep his distance in order to avoid trouble. (E)*

Question 14 of the questionnaire directly asked; "*Would you describe your child as tending to be honest/naïve or street-smart?*" All ten participants responded "naïve." E provided a detailed description of the kind of naivite displayed by her son in a response to the draft:

> *If you're going to "get someone back" as kids do, most kids I've observed are pretty clever at watching and choosing the moment so they aren't "caught". Edward? Nope. He just reacts or waits for his opportunity and is oblivious to the watchful eyes of others. That's the naivite I refer to. And while many other kids know how to suck-up to adults (smile, look them square in the eye and say what the adult wants to hear), Edward can't/won't. If it isn't how he's feeling he's not going to fake it, pretend to be polite and say*

stuff that isn't true to him . . . I'd like to see a little less naivite – not to the point of some of the master politicians I've observed in his grade 5 class – but at least to defend himself so he isn't labeled the trouble maker as he reacts. (E)

This is clearly a description of problematic naivite. In addition to weak "cheater detection" skills, E's description (above) illustrates another aspect of naivite: failure to deceive others. This was mentioned by (J) in the following comment: "[regarding naivite]: Overall, naïve. He's starting to tend towards underplaying facts to get himself out of trouble, but that's in the last year [8-9 years old]." (J)

Underplaying facts to get oneself out of trouble typically occurs in western culture in children aged 4-5 (Lewis & Saami, 1993). James is certainly late, compared to norms to develop this capability (see discussion below regarding "improvement with age"). Henry's mother responded to the draft by adding:

This is why Henry got into so much trouble around ages 6 – 7 (and a bit of 8). He would engage in the same activities with peers that he shouldn't; they would have the know-how and the sense to stop (when they sensed that they were about to get caught), but he wouldn't. He'd always be left 'holding the bag', so to speak. It resulted in many visits to the principal's office . . . Now, at 8.5 to 9, this has changed. He has developed this sense and does not get into these situations anymore. (H)

Edward's mother also responded to the draft that Edward is now developing the ability to tell "partial truths to mislead if it will get him out of work or trouble", but this did not begin until grade three or four.

Remembering faces

Baron-Cohen (1999) regards face recognition as one of the skills that coexists with facial interpretation in the social domain. As such, his theory would predict that a

child with relative weakness in the folk-psychology (i.e., social) domain would struggle to recognize people. Question 18 addresses this: "Is she/he good at remembering who people are?"

The responses did not give a clear indication one way or the other, nor did the answers suggest that the respondents made the important distinction between remembering names (a capability related to memory) and recognizing faces (a capability related to folk-psychology). For example: "Names? No. The people? No. Unless they have something really cool. But he still won't remember their names."(E) Ian's mother's response ("Excellent memory even more so with numbers etc.") suggests that he remembers numbers better than people, but again, this is not clear. This construct would perhaps have been better addressed by a clearer question, or a facial-recognition test (see discussion).

Overall, four participants responded that their child was not good at remembering who people are (Andrew, Daniel, Edward, and Gregory); three reported average ability (Ben, Conrad, James) and two (Henry and Ian) described their child as "good at remembering who people are." F remarked: "I'm not sure—he is not aware of others as he could be, but I have not noticed him forgetting people either." There does not seem to be any remarkable pattern in these responses.

Improvement with age

In many descriptions of their child's social development, participants noted a change from the kinds of tendencies described above to more "normal" levels of social

orientation as the child matured. For example: "(*Is he/she a sociable child?)* No. Very shy and introverted. This is changing now." (I);

> *[Ian preferred playing] by himself mainly; now (age 10) friends are more important. Never bothered or cared too much about others . . . Not (empathetic) when young – didn't demonstrate this at all. But now (age 10), this is showing through. (I)*
>
> *He is slowly learning from whom to keep his distance in order to avoid trouble (E);*
>
> *When he was in Kindergarten he used to act out and be silly to get the attention of his friends, to make them laugh. This was a problem for quite a while. Now that he is older, it seems to be more under control. Not that he doesn't ever do it, but more often and predictably his participation is seen as positive and engaged at school (F).*

Henry was described as exhibiting behaviour similar to Felix's in grades 1-3, now changed for the positive in grade 4. Other descriptions of the subjects' becoming more socially oriented are: "He tends to be empathetic as long as he didn't cause the discomfort. Then he can have difficulty saying sorry. This is getting much better though" (H) and "[Regarding behavioural difficulties]: He's much more in control now than he was at 7 or 8, but we still have moments" (J). See also the description (under 'naivite/honesty', above) of James, Edward and Henry developing the ability to sense and avoid trouble at age 8-9. I speculate that the developmental pattern of these children may be somewhat skewed—that is, their folk physics develops early and precociously, and their folk-psychology catches up at a later age. I will return to this point in the discussion.

(7) Aggression, conflict avoidance and bullying

In six of the ten cases, subjects were described as tending towards conflict avoidance rather than aggression (Andrew, Ben, Conrad, Edward, Gregory, and James). Ian's mother wrote that her son "actually always gets along really well: compromise etc." and Felix is "extremely good-natured so he is certainly not prone to get into fights." Only Daniel and Henry were described as aggressive; in Daniel's case, "aggressive verbally." As for Henry: "In school Henry was regularly getting into pushing, shoving conflicts at school. He was quick to anger at school." (H) Note that H suffered extreme frustration with the school environment (see "school experience", below). His mother reported that these problems dissipated when he was removed from the school.

Among the ten cases there were five reports of being teased and/or bullied (Andrew, Ben, Conrad, Daniel, and Edward): "He is often teased or harassed by his cousins of the same age. He is not as athletic as them and is not able to process situations and information quickly." (D) In the other five cases, it may be that bullying has been avoided by virtue of educational context: Gregory has been homeschooled from a young age; Ian has attended a very small, special school for gifted children since age 5, where bullying is arguably less likely. James attends a school of 100 students (K-5) in which his mother reports there are "no such problems." Felix attends a Waldorf school; this may or may not contribute to his having avoided any such problems.

In sum, out of the ten cases, only two showed signs of aggression, in one case, verbal aggression only, in the other case, aggravated by an "intolerable" school situation. The other eight children are best described as non-aggressive, and in six cases, conflict avoidant.

(8) Early Development

Temperament

Participants were asked "*As a baby, was your child easy or difficult (e.g., colicky or regular sleeping and eating)*" as a means of obtaining some basic information about temperament (e.g., Chess & Thomas, 1977). The results were mixed. Three (Daniel, Edward and Ian) were described as difficult: "extremely colicky—do I have stories!" (E); five as easy (Andrew, Ben, Felix, James and Henry): "James didn't cry until he was 2 . . . really!" (J) Gregory was a regular sleeper and eater but exhausting, and requiring constant attention and stimulation when awake. Edward also required constant attention when awake. Ben and Andrew were described as average. From this there seems to be no evidence of an association between early temperament and the construct of children who are passionate and precocious at complex constructive activity and figuring out how things work.

Speech

According to generally accepted standards of speech development, normal development is assumed to occur as follows: single words by 18 months, sentences by 3 (Epstein & Reilly, 1989). Against this standard, five of the parents reported normal speech development (Andrew, Conrad, Daniel, Edward, and Felix), Ben's mother described late speech development, and Gregory's and James's mothers reported early talking. "Ben learned to speak very late. He was in speech therapy since he has been 18 months old – weekly till the age of 5. He talks fine now – however, he is not a 'chatty' person."(B) "Single words: before age one; sentences: eighteen months." (G) "James

was speaking very early and in full and clear sentences at 2. By 3 he was talking like 5 year olds." (J)

Henry's mother did not record his first words, but reported that he had an "amazing vocabulary" when young. Adults frequently commented on his use of big words, such as "evidently" when 3-5 years old.

Ian's mother could not recall the age of speech development; however: "His first words (wish I could remember when! Pretty early . . .) were not "ball" "car" etc. (objects) but prepositions: on, through, under, over, between." (I) This represents a significant departure from language acquisition norms: prepositions typically are ignored until after the child has mastered two-word combinations of nouns, verbs, adjectives and adverbs (Shetter, 1998).

Atypical language acquisition was also described by Edward's mother: she reported that Edward reversed pronouns (he used "my" for "you") as a very young child. Pronoun reversal occurs frequently in autism and related conditions, and in fact, comprises one of the criteria for diagnosis (e.g., Bishop, 1989). However, there is some literature that suggests pronoun reversals can occur in non-clinical populations, and suggest that reversals reflect a risk-taking approach to language acquisition, which may be typical of precocious children (Dale & Crain-Thoreson, 1993).

Beyond these two examples of atypical acquisition, there does not seem to be any remarkable pattern to the children's speech development.

Learning to read

With the exception of Conrad, who was diagnosed with dyslexia and learned to read in grade 3, none of the children learned to read behind grade-level schedule. Interestingly, in seven cases, (Andrew, Daniel, Felix, Gregory, Henry, Ian, and James) there were descriptions of what may have been instantaneous and/or self-taught reading acquisition: "We don't know what age he learned to read—probably age 5 but he refused to do it until one day around age 6 he picked up a book and started reading and never looked back." (G) "Reading words at 2. Full sentences with punctuation flowed smoothly and effortlessly by 3 years. Instantaneous! No phonics—immediate pronunciation of multi syllable words, inflection, expression." (I) "Andrew demonstrated reading skills in preschool (age 3). His preschool teacher said he would sit in the reading corner and read to the other kids." (A) "Daniel resisted learning to read . . . [in kindergarten] we gave him phonics books . . . he was reading "Magic Tree House" books within a few months. His reading acquisition seemed to jump ahead every few months. He read Harry Potter books by 7-8." (D)

> *He was reading well beyond his age level in kindergarten . . . I recall the first word James read. We were in the car and passed a billboard. He read it and asked what it meant. From there he just started to read. He can read "difficult" words, such as 4 or 5 syllable words with little effort. If he's heard a word used in conversation, he seems to be able to recognize it pretty easily in print. He's also a good speller—better than me. (J)*

I suspect that the homes of these children provided an environment conducive to reading, such as access to books and positive parental attitude toward reading. Within this context, however, the children in these descriptions appear to have figured out how to read with little or no direct assistance, at remarkably young ages.

H's description was ambiguous: "He read by the time he was in Kindergarten. He learned by himself, did not use phonics, just memorized words." (H) The act of reading in non-transparent alphabetic orthographies requires both decoding skills and the ability to identify some words as wholes (Adams, 1990). H's statement could be interpreted to mean that Henry was not *taught* phonics, but that he figured out the English "system" of quasi-phonetic spellings on his own, at a young age.

Felix was also described as "self-taught;" however, without the rapid acquisition described in the cases above: "Felix taught himself to read during kindergarten. It was relatively gradual; he was not interested until he really saw the merits of reading, and then when he began to see them, it took off." (F) Again, it is unlikely that this child received no supported reading experiences; however, the implication is that Felix learned to read with less direct assistance than most children require.

On the other hand, Ben's reading acquisition was described as typical: "Ben learned to read in grade 1, and improved greatly in grade 2. Now that he is going into grade 3, I only expect him to improve. Logical process." (B)

For Edward, learning to read was complicated by the fact that he spent kindergarten and grade 1 in Germany, learning German phonics. When he moved to an English school in grade 2: "Applying German phonics to English caused huge difficulties – diminishing slowly. By grade 6 he's a good speller. I think it speaks to the glue of his brain." (E)

(9) Scholastic Preference for math, science and computers

A common thread that ran through the sample was a scholastic preference for math, science and logical processes. Six of the ten participants (B, D, E, F, G, and I) listed math, science and/or computers as their child's best subject. For example: "Felix loves math. He asks me at home to give him math problems for fun – and often has pretty startling insights into answers." (F)

In three cases (Andrew, Edward and James), some difficulties with math were related to a requirement to "show work" and/or with math facts memorization, for example:

> *He's really great with math – but because he has to show his work and do math cards that are "too easy" before he can move on to more challenging math, he hates math in school. He uses math at home all the time though. (J);*

and "[Andrew] did very well with geometric concept math and not remedial memorization." (A).

These comments underscore the need for pedagogy that is appropriate to the cognitive profiles of these children.

The preferred curricular areas (math, science and computers) would appear to rely on similar cognitive strengths: i.e., logical, systematic thinking. Music might also be considered a logical, systematic discipline, depending on the way it is taught. Typically, classroom music pedagogy relies heavily on language, creative and group processes (Mills, 2005). It is no surprise, then, to note that while many of the subjects are musical (e.g., "It is pretty funny listening to a kid of 3 or 4 humming some of the more unknown

sections of Dr. Zhivago, or some classical work." (E)), participation in school music classes was not listed as a favourite.

The exception to this pattern of school subject preferences is Felix: he was described as loving "expression/drama," a school subject that seems at odds with the "logical process" trend noted above.

The questionnaire asked parents to list their child's comparatively weaker scholastic subjects. This question was purposely ambiguous: it draws on both preference and ability, two distinct constructs that are usually intertwined: the less a person likes a subject, the less he is likely to engage in it and excel, and so on in iterative fashion. In response, participants listed French (A, D and E), and story writing and/or language arts (B, C, D, E and H) – despite strength in reading skills. Four participants described difficulty with "written output" and/or printing: (A, D, E, G and H). Two participants listed oral presentations in front of a group (A, G); two listed visual art (F, and G) as being their child's least favourite subjects. C, E and J listed group work:

> *James is good at self-directed work and not so good at team work, where a group of kids have to work together to accomplish a task. He says it's because nobody ever listens to his ideas, or they work too slowly. (J)*

E wrote, in a comment to the draft, that this also describes Edward's experience.

None of these school subjects (French, writing, oral presentations, visual art) were described as well-liked by the subjects, with the exception of James and Henry:

> *His teacher was very impressed with James' creative writing in grades 1, 2 and 3. In grade 3 he wrote a short novel using Hypercard [a computer program]. It had animation and static images to accompany each chapter. In fact, in grades 1 and 2, he*

used to spend all his "choosing time" writing and drawing, either in his journal or with Hypercard. (J)

Henry enjoys French and is good at it; however, unlike the other subjects, he learned his French in an immersion context.

Overall, it appears that math, science and computers comprise most of the children's favourite subject areas; academics that rely more heavily on folk psychology (creative artwork, story writing, group work, language arts) are least preferred.

(10) Visual-Spatial Abilities

One goal of this analysis was to determine whether L. K. Silverman's (2002) construct, the "Visual-Spatial Learner" (VSL) might apply to the subjects' learning profiles. The questionnaire purposely did not use the term Visual-Spatial in order to prevent suggestive power. In fact, only A mentioned the term "Visual-Spatial Learner" to describe her child's cognitive profile. Edward, however, was described as having "amazing 3D visual perception." (E) Other than this, clues that could indicate a Visual-Spatial learning style (according to L.K. Silverman's model) include the overwhelming interest in building with Lego and manipulatives, and the strength in math reasoning and mechanical abilities that are characterisitic of this group. Nevertheless, not all of L.K. Silverman's VSL profile "rings true" for these children. For example, artistic ability or interest is not found consistently across the sample: "[In preschool], Conrad enjoyed playing with the building items and sand play. He rarely did the art." (C) "Likes art and finds it interesting – learning about technique and colour, etc. Not a good drawer. Likes to try though." (H) "He has always liked working mazes and puzzles, but he is less interested in doing artwork overall." (F) James, Edward and Andrew, however, enjoy

drawing: "especially detailed dragons and other mythical animals."(J) Andrew also does very detailed artwork – so detailed, in fact, that he struggles to complete his work within the limits imposed by the class schedule. Edward enjoys art "as long as it is his creation or idea." (E) Overall, there is no clear preference across the group for the kind of artistic creation that Silverman's construct describes.

L.K. Silverman (2002) describes the Visual-Spatial Learner as having an excellent sense of direction. The questionnaire asked about this trait directly as parents would probably not have thought to mention it: (*Does he/she have a good or poor sense of direction, compared to other children his/her age?).* Results were mixed: Ben, Conrad, Felix, Henry and James were described as having a good sense of direction ("he has a great sense of direction and a great memory for recalling details and landmarks when we're driving" (J); Ian as average ability; Andrew, Daniel, and Gregory as having a poor sense of direction. Edward's response is interesting:

> *I really can't say. I used to think he was pretty good, but now I think he is so caught up in his head with some new rendition of something that he doesn't notice where he is or where he is going/where things are. He can find his way just fine once he really knows the way, but he isn't particularly observant of places – just the interesting cars or vehicles or machines he might have seen on the way. (E)*

Thus, there is no clear indication that the excellent sense of direction that L.K. Silverman associates with the "Visual-Spatial Learner" is common across the sample.

Another Visual-Spatial Learner characteristic is an intuitive sense of other people's emotions (L.K. Silverman, 2002). This was certainly not a common trait that emerged from this study—see the section above on social sensitivity.

Another Visual-Spatial Learner trait is poor spelling. Two of the participants are described as being exceptionally good spellers (Ian and James); poor spelling is mentioned in only one of the cases (Andrew).

In follow up interviews, one participant (G) stated that she had read L.K. Silverman's work and found that although some of the characteristics seemed to fit, it did not, in an overall sense, seem to describe her child. Based on the above observations, it seems that this conclusion applies across the sample.

(11) Concrete Thinking

An interesting descriptor that came up in four responses (Daniel, Edward, Ian and James) was "concrete thinking." For example: "Takes everything very literally . . . "I'll only be a couple of minutes." (I) In a response to the draft, James's mother pointed out that James is also "very literal about time and use of 'a couple' (two) or 'a few' (three)." Similarly, regarding social situations: "Daniel is a concrete thinker who still sees the world in black and white. Idealistic." (D)

The term "concrete thinking" means the inability to abstract. It typically refers to a failure to look beyond the words to uncover the meaning behind the words. However, I posit that failure to abstract in language does not necessarily equate with failure to abstract in general. Instead, failure to abstract in language may simply be evidence of precision and a strong sense that things, even language, should be systematic. The term "concrete thinking", as used by E, I and J may be a misnomer: a better descriptor could be "precise language use." In D's case, inability to abstract may be limited to thinking

about social situations, rather than an indication of an inability to abstract in general. I will return to this point in the discussion.

(12) Tenacity, Focus and Problems with Attention

Andrew, Conrad, Daniel, Edward, Gregory, Henry, Ian and James's mothers' responses contained descriptions that underscore the intensity, tenacity and determination with which they pursue their interests, for example:

> *His determination to figure something out was shown at 9 months. He and his dad sat on the floor for 20 minutes – Dad opening an empty video box and closing it. Edward grunting for it and his turn, would take it and try, and pass it back to Dad and grunt. He would watch intently as Dad opened it and closed it again. And then he would try again. This continued for a full 20 minutes. (E)*

In some cases, this appears as a desire to watch videos or read books over and over: "[James enjoys] watching and rewatching certain movies, memorizing lines and speech patterns, and then repeating them ad nauseum." (J); "His book of choice for reading for at least two years (age 4 to 6) was Daniel Macaulay's *The Way Things Work* and we often read that exclusively for months." (G); and:

> *Other books – he took a real liking to at 4 and we re-read those about seven times. As with children's movies – he would watch them (in 20-minute bits) over and over and then bang, not again. He does the same with music he likes to listen to: listens to the same disc every chance he can for perhaps a month and then, bang. He might not listen to it again. (E)*

Daniel and Gregory were described as having a distinct preoccupation with computers and computer games above and beyond the interest usually shown by boys this age. Gregory's mother described his interest as an "intense obsession", although she added "not to the point of interfering with life." (See section above re: interest in

computers.) Edward was described as: "Incredibly tenacious, and full of initiative. He holds his own against ridicule, and is undaunted to try something if it might work. His motto used to be "you'll never know if you don't try." (E)

Perhaps as an aspect of this tenacity, Edward, James, Henry and Ian were described as being argumentative. Note the common use of the word "lawyer," as a reference to the child's close attention to rules and logical reasoning:

> *He is argumentative, sometimes just because, but especially if something might be technologically feasible someday. He is stubborn as a goat (E);*
>
> *I think of Ian as a "little lawyer" sometimes. Always remembering the details of everything—making me accountable for everything I've mentioned (I);*
>
> *(James is) stubborn, argumentative; a lawyer since the day he could speak." (J); and*
>
> *His grade 1 teacher called him 'the lawyer". (H)*

Problems with attention.

Of the ten subjects, seven were described as having problems with attention to tasks not of interest.

Two of the ten subjects (Conrad and Daniel) have a diagnosis related to attention (ADD and ADHD respectively):

> *He was at a school with only eight children in the class and the teacher observed him "daydreaming" 80percent of the time. The funny side to this is that if he is working with Lego or a project that interests him it is difficult to move him to something else. (C)*

Similarly, D reported: "[Daniel is] intense, hyper-focussed when interested. Has ADHD so can be very distracted." (D)

In four other cases (Andrew, Edward, Felix and Gregory), there were descriptions of intense focus when engaged in a favourite activity or interest alongside distractibility when not interested:

> *More often and predictably his participation is seen as positive and engaged at school. However, in his school they learn how to knit and crochet, and he has been described as easily distractible by those teachers in particular. At home he has problems staying on task with chores and other such things—he is VERY easily distracted. But if he's doing something he enjoys, he has much less trouble with that (F);*
>
> *Attention 'difficulties' – yes, if he is bored. He is extremely fast at picking up concepts. He has a hunger for the next step – the more complicated step. They don't teach the next steps, so these baby steps he "masters" (if he was paying attention) first time around, and he'll shut off for the repetitions. Unfortunately, he shuts off and doesn't realize when to tune back in (E);*
>
> *If he is completing a task he is not interested in then his attention wanders and he has trouble focusing. He needs to move around to think and process information (G).*

Andrew's mother explained that her son's grade 3 teacher recommended he be tested for 'petit mal' seizures, as she would frequently catch him staring blankly in class. Tests were not done, as the child's paediatrician seemed to think these occurrences of "stuck gaze" were related to inattention, not to seizures. At the same time, Andrew's mother reported that she was "not able to pull him away" from activities he was interested in, such as building with Lego.

James was described as "extremely focused (like when he's reading or building Lego) and quick to boredom [when attending to tasks not of interest]." (J)

(13) School Experience: What Works, What Doesn't

Schooling for this group of children has been in most cases, problematic: nine of the ten participants reported their child having some degree of difficulty in school. As a result of incompatibilities between the public or mainstream school system and their needs, Conrad, Gregory and Henry are homeschooled, Daniel and Ian attend a special, small school for gifted children, Edward attends a private school that can support small class sizes, and Andrew (as described above) was able to attend a special school when finances permitted.

> *Obviously [what school experience works for him is] not the public school system. His preschool teacher, a caregiver we had in Andrew's preschool years and his Kindergarten teacher all recommended Andrew attend preschools and/or schools which maintained smaller class ratios. We were unable to support this venture financially until now. He will be attending McNaught House for Grade 8. [McNaught House School is an independent school for children affected by learning disabilities. It features small class sizes and one-on-one tutoring.] The public school system is so focused on the "Ministerial Standards" and provide awards based on "the Three R's." . . My son's strengths have been in early reading, strong comprehension, visual/spatial, i.e., did very well with geometric concept math and not remedial memorization. His learning style was officially recognized by Grade 5 yet the public system did not have resources to support it. (A)*

Felix's difficulties in school can be considered minor: his mother reports that "he was overwhelmed by kindergarten at first" but later "settled in". And then:

> *It was really in kindergarten that we started getting complaints. His teacher really liked him, and, she said, he contributed a very positive energy to the class . . . but when he was supposed to sit still or participate in a quiet, orderly activity, he would often be silly to get attention and laughs. (F)*

This behaviour settled down during first grade. He currently attends a Waldorf school, and this "seems to be working for him right now." His mother reported that:

> *Some of the reasons I think Felix has not experienced difficulties: 1) He is in a small class and many of his classmates are exceptional, 2) he is also very athletic, and 3) he is not very sensitive—social interactions seem to impact him very little emotionally, at least so far, 4) he is in an alternative school, where arts, music and PE are valued along with academics and grades are not given in the elementary school, so there is not so much academic awareness – and no labeling like "nerd" or the like. I won't be surprised if this changes as he gets older and if he goes into a more traditional setting, but numbers 2 and 3 (above) are probably still going to mitigate things for him. (F)*

Only Ben attends a mainstream large school. He is the exception among the group with no problems reported; in fact, his mother reports he "loves school." His kindergarten and grade 1 experience are described as being "very positive on both accounts." (B).

In many cases, school experiences were described as difficult because of a conflict between the child's needs and what the teacher/and or classroom is able to provide: "Awful kindergarten. Acting-out behaviours. The psychologist felt the teacher was not meeting his needs. Grade 1 [at St. Charles' School for Gifted Children] was a huge transition which required my husband to stay in the classroom most days of the week." (D)

> *Grade 1 was abysmal – but that was the German system. The teacher yelled a great deal, there were 26 students and she had little control. They were expected to sit and colour and write numbers and letters over and over – and then come home and do some more for about one hour a day. Math and reading were so repetitive and there was no exploration or science . . . He went every day with a stomach-ache. (E)*

This difficulty with following a prescribed curriculum and a need to do self-directed work is echoed by descriptions provided by I, G and J:

> *[Ian went to] Montessori preschool at 3, [and] was reading with the five year olds – found it too structured – didn't want to waste time moving through progression of tasks – just wanted to do the upper ones! . . . [he needs] total flexibility to do what he needs: to find a challenging level of study. Detests too much drillwork, going over things he "got" the first time. (I)*

In a response to the draft, E wrote that her son was similar: he also was frustrated by learning in progressive steps, and "just wanted to do the upper ones" (E). Other examples: "Structured learning is hopeless; he cannot stand a classroom environment and needs enriched learning opportunities or he completely tunes out. [He much prefers] independent, self-directed learning."(G); and "[he prefers] self-directed environments. He hates to be directed. In anything!" (J)

Henry's experience at school was similar to the ones described above, exacerbated by French Immersion:

> *Kindergarten was fine. Grade 1 was not good. It was not a good fit. He was in French immersion. All he wanted to do was talk about science and social studies and read copious amounts (in English). That was not what 1st grade French Immersion was about. It was about rote learning of basic French vocabulary . . . He was an early reader, and he had to slow down to learn French. It's low level learning at the beginning: memorizing vocabulary, not being able to discuss or explore because the language limits what you can do (although he found the French easy – he picked it up gracefully and had a beautiful accent). He got frustrated, and this escalated into grade 2. He wasn't happy. By Christmas, grade 3, he had behavioural issues . . . Before he went to school, he was interested in so many things: he had creative energy, he had a joy of learning. He could talk to adults so well, look them in the eye, engage them. But by grade 2, he was sad, and losing interest in*

everything, and no longer made eye contact with adults. He's much happier now that he's homeschooled." (H)

In James' case, failure to "conform" to expectations was problematic:

Kindergarten was a challenge for us. His teacher only had one year previous teaching experience and didn't know how to deal with James. She told us, at our first parent-teacher meeting, that we had to "change James's personality" if he was going to make it through school. (J)

Later, however, James did find a teacher who was able to respond to his individual needs:

Grade 1 was very different. In fact, his grade 1 teacher opted to keep James in his class for three years since he was able to give James the environment he needed and other teachers were less likely to make room for James's learning style. (J)

Similarly, Conrad responded well to a teacher who seemed to understand his needs, appreciate his strengths and was willing to respond: "We were very lucky to have a teacher who *loved* children that are creative and "don't fit the mold." We had her for two years both K and grade 1 so these were good years." (C)

In other cases, positive school experiences were described when circumstances permited similar flexibility and responsiveness to the child's individual interests:

Edward went to a Montessori kindergarten in Germany from age 3 until grade 1 (3 years). It was a good experience, and he spent the vast majority of his time in the building block corner. They had an amazing supply of wooden blocks with which he built a seemingly endless number of amazing (I am serious – they were amazing) things like planes and very fancy walls (one resembled the wall of a famous Turkish library) . . . he had little interest in learning school type stuff. Just building. And swinging. And digging in the sand box – deep holes. Very deep holes. They saw to it that he got around to all the available learning tools, which he did without

protest, but always gravitated back to the block corner – happy as a lark (E);

He attended a play-based preschool. It was a wonderful experience in which he could go in whatever direction he wanted, and was encouraged to do just that. It was not Montessori. Our kids go to a Waldorf school; Felix's home-based preschool was based on Waldorf ideas (F).

In contrast, D reported that her son requires a need for teacher-direction: "We've been at St. Charles' School for Gifted Children since he was 5 ½ years old. I suspect a larger class with less adult support would prevent his success. Teacher-led, concrete expectations, chunking of assignments and explicit instructions work best for him." (D)

A, C, F, G and H also note that small classes work best for their children. Arguably, I expect that most parents desire small classes for their children. What suggests that the children in this sample are unique is that ostensibly the parents felt this need to be extreme enough to warrant special educational placements: all, except for Ben, are either currently enrolled in schools that support small class sizes or are homeschooled (Conrad, Gregory and Henry): "He likes to be homeschooled. Small groups work best. Classes that really interest him that are in-depth on a subject works best." (H)

In contrast, Ben has gone to daycare since he was 10 months old and had a very positive experience in kindergarten and grade 1. The response to the question "*Would you please describe what educational experiences/environment "works" for your child, and which do not*", was: "Not sure, haven't come across anything that doesn't work yet. Ben loves school, and in the summer always goes to lots of summer camps (Tooltime, summer at St. Bartholomew's etc.) and loves it all." (B)

4.4 Summary

Despite their passion for constructive play, building and finding out "how things work", the ten children in this sample are very different from each other. There are introverts and extroverts, children who are early readers and a child whose dyslexia delayed his reading, children who enjoy rough play and those who do not. Nevertheless, it is possible to make some observations that seem to be common to most of the cases:

- strong intrinsic interest in physical phenomena from a young age,
- descriptions of precocious constructive play, inventing and exploration of physical phenomena;
- descriptions of some social discomfort as indicated by one or more of the following: preference for individual sports, naivite, weak facial recognition, dislike of large groups, weakness in social skills, preference for one or two close friends, and bullying experiences;
- tendency towards conflict avoidance; dislike of aggression;
- little or no motivation to engage in pretend play; little or no interest in narrative (as opposed to factual books);
- intense interest in computers and computer/video games of strategy;
- prolonged intense concentration on tasks of interest coupled with inattention when tasks are not of interest;
- aptitude for maths and sciences in school, less interest in language arts, oral presentations and working in groups.

5 RESULTS: SAMPLE TWO

While the children in sample one were selected on the basis of their interests and abilities, the adults in sample two were selected on the basis of their accomplishments and performance. Sample two adults are meant to represent the fulfilment of potential possibly demonstrated by the children in sample one. This section examines whether this premise is tenable. I begin by looking at the childhood interests and abilities of the adults in sample two to see how they compare to those of sample one. I then examine the sample two texts in terms of the categories that emerged from the sample one texts.

5.1 Childhood Interests and Abilities of the Adults in Sample Two

5.1.1 Avid Interest from a Young Age in Complex Constructive Activity

Indeed, each of the sample two responses contained descriptions of an avid interest from a young age in complex constructive activity. Note the frequent reference to "taking things apart."

> *My father and an uncle used to give me things to take apart, sometimes I'd use the parts to try to build something. . . .[my main interests were] building things and taking things apart, play outside with friends, mischief, no sports. (AA)*

> *From an early age, he had a keen curiosity about what "makes things work." At first this resulted in his dismantling as many of his mechanical toys as possible. One day when he was four or five years of age, his father said "Won't it be nice when Brian begins to put things together instead of taking them apart?" We actually were able once to find a toy tractor that was designed to be taken completely apart and then reassembled – it was one of his great*

favourites. He of course loved Lego and spent many hours building with it. (BB)

In terms of toys, I enjoyed building things out of wood, metal, Meccano, tinker toys, models, etc. I had several chemistry sets and a microscope. . . At a very young age (2 or 3) my parents got us the Childcraft book set. My favourite book was "Make and Do". We/I made many projects from it. . . . As a very young boy I loved to take things apart and put them back together again. I would always go to the dump with Dad to see what kind of junk I could find [to take apart and build things with]. . . Later, as a young teen, I took a correspondence course on electronics. I didn't quite finish it, but did get a lot out of it. It and the multitude of building projects set my path to being an engineer. (CC)

In response to the question "What kind of toys or objects did you like to play with?" Mr. Chopin wrote:

"I liked models of all kinds. But most of all, I suppose I liked tools. I was never really big on little cars (Hot Wheels etc.), race sets, trains, etc. I wanted to make things."

Daniel could play and work for hours in his room and be quite happy. Later, this turned out to be a prodigious output of model planes and rockets. (DD)

As far back as I can remember I enjoyed the following pastimes: building and playing Lego and other construction toys, building Mecano with my dad . . . working in the garage with my dad: we built a small workbench together that I could work at while he worked at his. (EE)

Mr. Elgar reported a very early passionate interest in aeronautics:

Above all, airplanes and Space Ships interested me. Airplanes caught my attention at around the age of 3 years. When I was 3 years old, my family was visiting Disney World, and I started becoming tired and irritated from the long day. My parents decided to go into the Aerospace museum to watch a movie about the history of flight, allowing me to sleep on my mom's lap during the movie. According to my mother, I sat upright throughout the entire movie and did not blink an eye. (EE)

As these participants grew up, their interest in building and physical sciences continued, expressed in increasingly advanced "building" activities:

> *When [Daniel] was about 14 he built an 8-foot speedboat complete with sponsons to lift it out of the water and go fast. I loaned him my 5.5 horsepower fishing motor which he used. Soon thereafter he and his friends were trying this boat out on the waterway near our house . . . (it took a sharp turn and sank) . . .Daniel dismantled the motor . . . some months later, he put it [the motor] back together and after about 3 unsuccessful tries got it together correctly and it worked for another 10 years. (DD)*

> *As Brian grew up, he was very often his mother's willing assistant and "idea man" in dealing with a large variety of house and garden problems and repairs. He was—and is—very much a kind of inventor person, always looking at mechanical devices with an eye for thinking of a better way of making them function. (BB)*

> *That [building, tinkering, exploring how-things-work] was my main interest. I always had, and always have to this day, many projects on the go. Most involve building things physical or in software. My father gave me a granary that I turned into a shop. On our farm there was lots of old junk and wood to work with. I learned to weld, cut metal with a torch etc. (CC)*

> *Later on [grade 4 and on] we built a lot of bombs. (AA)*

5.1.2 Precocity in complex constructive activity and understanding how things work

In addition to the passion described above, the following seems to be evidence of precocity in complex constructive activity and figuring out how things work:

> *One day Eric came home from somewhere (about 10 years old) where he had seen an automatic door with a mechanical arm and could not figure out how the mechanism worked. So he started to build a similar door so that he could figure it out for himself. [He] sometimes came home from school (age 6-12) with an idea of what to build with his LEGO. While the teacher would try to explain something to other children, Eric would quickly complete his work and then daydream about things to build at home. (EE)*

[Brian] showed a great fascination and curiosity about the mysteries of electricity, terrifying his mother more times than I can tell you with his numerous experiments. Other forms of energy also intrigued him, particularly solar and wind power (about which he became very knowledgeable). During his high school years, he and a friend successfully built a geodesic dome out of old hockey sticks and metal tubing in our back garden. Later, while a college student, he single-handedly built a 60-foot tower on his uncle's farm property and installed a propeller in order to produce wind energy power. He devised a system that fed current back into the Ontario Hydro wires. . . By the time he was in graduate school at Queen's (where he did his master's degree in Mechanical engineering) his marks were in the 90's. . . . He applied for and received a U.S. patent for one of his inventions – which is I understand, a major achievement of its own! (BB)

During that year [grade 7], Daniel was building model rockets and flying them. He entered the Greater Victoria Schools Science Fair with an experiment on drag forces on flying objects. He had tried flying 3 models of the same rocket with different surface characteristics. He measured the height achieved with each (maximum around 1200 feet) by using a protractor and trigonometry. He wrote his findings on cardboard and made a display. When the three scientist/judges came to look at his entry he was asked questions about it. He gave a terrific dissertation of his findings and the scientists were very pleased with his entry and the fact that he had done it without parental help . . . He won top grade seven prize. (DD)

Note that these quotes provide evidence of precocity at a somewhat later age than the sample one texts; however, these are retrospective accounts. The examples that stand out in the participants' minds may be these more memorable achievements of later childhood than more remote and possibly less remarkable memories of early childhood. Note also that these texts were supplied by the participants' parents rather than by the participants themselves.

Neither Mr. Chopin's nor Mr. Alberti's accounts include specific examples of precocity in the physics/mechanics domain. Recall, however, that these two participants'

responses did *not* include parental contributions. Mr. Alberti appears to be a man of few words when writing about himself. In response to the question "What were you really good at? (before age seven)" he responded: "anything to do with science and building things." Compare this to the long and loving description provided by Mr. Bach's mother (above). While Mr. Chopin's description of his childhood includes clear descriptions of passion for complex constructive play (for example, see his quote in the previous section), the tone of his contribution seems, like Mr. Alberti's to be one of modesty. It may be that modesty prevented him from describing his own precocity at length. He did make the comment that "My favourite non-core class in high school was metal shop and I did very well at it."

In sum, it appears that the participants in sample two were passionate about and precocious at complex constructive activity and figuring out how things work, despite a lack of specific evidence of precocity in two of the responses. In this regard, it seems that these adults resembled, as children, the subjects from sample one. I will now examine whether the other attributes, characteristics and experiences from sample one texts resemble those from sample two.

5.2 Sample Two texts applied to sample one categories

(1) Gender

All five participants in sample two were male. There was no suggestion in my request for recommendations that participants be male; however, in all cases, those candidates recommended to me (i.e., who fit the description "excellent, inventive and creative work in the fields related to engineering"), were male. This may be due to a lack

of opportunities for women to pursue such areas of work in this generation. An alternative explanation may be a gender bias in the sample selection method: recall that I deferred to the professional judgement of a professor of mechanical engineering in selecting my sample. Other possibilities include Baron-Cohen's (2003) theory that the kinds of abilities that suit engineering work are found more frequently in males. I will return to these points in my discussion.

(2) Evidence of above-average general intelligence

There is ample evidence that the sample two participants were, as children, academically competent and possibly advanced compared to their peers. For example, all the participants mentioned early reading acquisition (with the exception of Mr. Bach, who was diagnosed with dyslexia), picking up concepts quickly, and excelling in academics:

> *The first couple of years did not really challenge me. My parents and encyclopaedias for kids had developed my mind and thoughts as well as my knowledge beyond what was required for the lower grades. . . I'm sure I could have squeezed grades 1-3 into one year or something like that. (Mr. Elgar)*
>
> *In grade 1 I think I was somewhat more advanced than the other kids . . . Up to the end of high school, I was good at pretty much everything . . . In hindsight, I was very under-challenged. (Mr. Chopin)*
>
> *I was interested and enjoyed (kindergarten and grade 1), but found it too easy and repetitive. I remember complaining to my parents that school was mostly 'review'. (Mr. Debussy)*
>
> *At the end of grade seven [age 12] Daniel won the top student award. We talked to the principal about this and he said "Daniel has been the top student of his class every year since grade one, but we did not tell him because we didn't want to change his wonderful personality." (DD)*

At times, various teachers commented to me upon his intelligence, expressing surprise on learning that he had a reading problem. (BB)

He was a deep thinker and you could reason with him. He displayed wisdom beyond his age (EE)

School came easy and I had lots of time to play. (Mr. Alberti)

Thus, similar to sample one, the sample two participants' passionate involvement with complex constructive activity as children did not appear to dampen their cognitive development in other academically-related domains.

(3) Interest in computers and games of strategy

Computers were not available to the participants when they were children as they were to the sample one participants. However, later in life, as this technology was developed and accessible, a similar connection between interest in "how-things-work", building, and computers was mentioned by Mr. Chopin and Mr. Debussy:

As I mentioned above, that [building, tinkering and exploring how-things-work] was my main interest. I always had, and always have to this day, many projects on the go. Most involve building things physical or in software. (CC)

When [Daniel] was about 15 and his brother, 19, I bought a Commodore 64 computer. On the first night that we had it set up these two boys sat up all night and figured how to program it. They made a picture of and airfield with a helicopter leaving a hangar (you could even see the craft move through a little window) then take off, fly around, then land and return to the hangar. (Understand that this required some dozens of written command lines to the computer in those early days of home computers.) (DD)

I find, in myself and my son, that building things on your own is a kind of control. When things get really stressful, there's nothing better to go to the shop and make something. Or play a strategy-based computer game in which you build up your forces and then

go and conquer something. Sometimes you just need to control something in your life. (CC)

This last insight makes an interesting point about the role that complex constructive activity and computer-based strategy games might play in the lives of people with this profile: i.e., as a source of stress relief. The comment is also interesting in the connection it draws between the two activities.

Games of strategy were not mentioned in any of the other sample two responses. It may be that current technological developments have given today's children access (via video games, Game-boy, and computer games) to a kind of strategy game denied to children of previous generations. Mr. Alberti did not necessarily view this as a good thing.

In an interview, Mr. Alberti expressed his concern that these days, children with a mechanical "bent" are substituting these electronic games for the kinds of hands-on technological activity that he feels is crucial for developing technological competence. If hours spent on the computer are taking the place of hours in the woodshop or under a car, then, he fears, tomorrow's engineers will not be entering university with the requisite hands-on skills. In addition to the computer problem, he said, children today do not have the exposure to mechanics they used to have. For example, when he was a boy, he said, families could not afford to buy a new toaster when the old one broke, so fixing things, tinkering and examining gadgets was a part of life that he grew up with.

Mr. Debussy expressed a similar point:

They [my father and grandfather] often repaired their own vehicles, did most home building and repaired objects themselves, rather than hire and buy. Remember, though, this was typical and

necessary at the time for working class families . . . For example, when I was 6 or 7 there was a bit of a coaster [soap box racer] craze in the neighbourhood. In those days, it would be too expensive to just run out and buy something like that for a seven year old, so my father (and I) made one from wood and wheels salvaged from an old wagon." (Mr. Debussy)

These are interesting points, both of which speak, I believe, to an environmental source of difference between the experiences and development of sample one and sample two.

(4) Interest in non-fiction rather than narrative

All participants wrote that they enjoyed reading as children, especially factual books related to their favourite subjects:

From grade 2, I was reading non-stop, from grade 4-5, books about science. (Mr. Alberti)

Science and making things were the primary interests. Reading was a close second, but I didn't have as much available to me as I could have read. . . I was voracious reader. As an adult, my parents and I have often mentioned that they should have done more to make books accessible to me. I probably spend 2-3 thousand on technical books a year (Mr. Chopin)

He liked stories about airplanes or trains or any kind of transportation . . . factual books were his favourites. (EE)

Daniel enjoyed the usual children's books that were read to him in his first few years. Later at age 6-7 [he] would mainly seek out car and aircraft related non-fiction. (DD)

Brian struggled with dyslexia, but when he did learn in grade 8: "he became – and is – an avid reader . . . once he did his own reading, he preferred factual books and/or science fiction." (BB)

Except for Mr. Debussy's "enjoying the usual children's books" (above), these accounts seem similar to the general preference for non-fiction described by the sample one participants.

(5) Disinterest In Pretend Play

> *[I engaged in pretend play] almost not at all . . . I wasn't big on make-believe or other group play involving such things . . . I was never really big on little cars (Hot Wheels, etc.), race sets, trains, etc. I wanted to make things. (CC)*

Similar to sample one results, Mr. Bach and Mr. Chopin seemed to have little interest in imaginative play: "He was willing to take part in imaginary play, but mostly in the interest of "getting along" with his peers . . . [he preferred] anything with moving parts . . . and dismantled as many of his mechanical toys as possible." (BB) Mr. Debussy enjoyed imaginative play with toy vehicles, but this was not the focus of his childhood activity; rather, "building things" occupied most of his time. Mr. Alberti reported imaginative play only in the context of building. The following description, however, is not one of pretend play in the narrative sense; rather, it describes suspension-of-belief in the technological sense:

> *My father and uncle used to give me things to take apart, sometimes I'd use the parts to try to build something. Whatever was lacking was filled in by imagination. Example: the wooden plane we built didn't have much chance to fly but we proceeded as true believers. (AA)*

Mr. Elgar's mother described her child engaging in more imaginative play than any of the children in sample one or sample two: "I can remember that he would pretend to be a taxi driver in Barbie's car. He made up stories with imaginary characters to entertain himself before he falls asleep." (EE) Mr. Elgar himself recalled:

I would usually build some vehicle or building and then take it on imaginary adventures through my house. . My mom never bought me any sophisticated LEGO as she wanted my imagination to do the work. So I played with simple objects but used my imagination to fill in the blanks. I never had any electronic or state-of-the-art toys as a child. (EE)

However, Mr. Elgar's mother pointed out that he engaged in imaginative play "not as much [as other children]".

With the exception of Mr. Elgar, who nonetheless engaged in less pretend play than other children, the disinterest in pretend play displayed by children in sample one seems to be similar to that displayed by the sample two adults when they were children.

(6) Lack of social orientation

Subtleties of social functioning were not well captured in these retrospective accounts. However, using the texts provided, it appears that the results are mixed: Mr. Alberti described himself as having been "very social" and "popular" as a child. Mr. Bach was described by his mother as "sociable." Mr. Chopin, on the other hand reported:

[I] was, generally, quiet and self-contained. [My brother] tended to socialize more and I tended to have more self-reliant projects I worked on . . . Most people could remember my brother's name and not mine. I was always called by his name. (CC)

Mr. Elgar wrote that he "fit well into groups . . . and got along well with the other kids . . . Throughout my school years I was noticeably different yet accepted for the most part by my peers." Mr. Debussy described himself as "not a popularity contest winner, but certainly not a loner. I always had one or two 'best friends' and we would typically do things together." Mr. Debussy's father wrote that he could "play and work on his own

for hours in his room and be quite happy". This reads like the description of a child who is not dependent upon the company of peers.

Interest in team sports

Four of the five sample two participants (all but Mr. Chopin) disliked team sports. Mr. Alberti specifically disliked all sport ("but this was normal where I grew up – Israel"); team sports were not "of particular interest" to Mr. Bach; Mr. Debussy specifically disliked contact sports and team sports unless he was the goaltender; Mr. Elgar, Mr. Bach and Mr. Debussy still, as adults, prefer individual sports to team sports. This is similar to sample one results, where seven of the ten participants described their child disliking team sports.

Mr. Chopin, on the other hand, grew to enjoy team sports, and became very involved in volleyball in high school, "mostly because of the excellent coach at our school . . . I think I learned a lot about teams and working with other people from him and others over that time." He added, in a response to the draft:

> *I played in national championships and on the university team through to 3rd [year] of undergrad. I still enjoy soccer and hockey. A big part of engineering, and something stressed in university and work is the idea of teamwork. A good team player is very valuable and I've tried always to be so. In fact, I get very frustrated by people who don't "try" [to be a team player]; just ask some of my team-mates on our 35+ hockey team! (CC)*

Peer relationships

Like sample one, there seems to have been a preference for peer relationships with one or two close, well known friends among the sample two participants. Mr.

Alberti typically played with "two close friends, one is still a close friend 50 years later"; Mr. Debussy always had "one or two 'best friends'; Mr. Chopin played:

> *. . . lots with my brother until I was 8 or so. After that, I had one older friend (a grade or two, I forget) . . . and a friend who was the eldest son of friends of my parents. He and I were very similar in many ways . . . he became a civil engineer . . . In general, I didn't and don't have many close friends and am usually pretty happy to be on my own. (CC)*

Although Mr. Bach "had a distinct preference for those who shared his passion for building", he was "generally very easy about playing with anyone – boys or girls – except that he disliked aggressive behaviour." (BB) Mr. Elgar on the other hand, recalled that he:

> *. . . had lots of friends in kindergarten . . . in grade 1, I made another best friend, and soon got a "girlfriend". As a result I spent most of my lunch breaks playing with her and her friends (all girls). The boys my age were mostly interested in playing rugby and other sports I wasn't interested in. (EE)*

Social skills; sensitivity to others; interpreting social situations

The questionnaire given to participants did not ask directly about social skills, sensitivity to others or interpreting social situations. Rather, this information was expected to emerge from the text if it were pertinent to the participants' childhood recollections. There was no mention in any of the second sample responses of clear weakness or strengths in these areas. However, Mr. Chopin commented in a response to the draft, that he "absolutely!" lacked motivation to conform to his peer group's or teachers' expectations. This might suggest a relatively weaker orientation to the thoughts and intentions of others.

Talkative about favourite topic but difficulty discussing feelings

Mr. Bach's mother reported that her son "doesn't always find it easy to communicate his feelings when things are not going well." Similarly, Mr. Chopin commented that he has "worked hard to communicate well", suggesting that communication was a weakness for him that he overcame through conscious effort. In a response to the draft he emphasized this point:

> *My parents were very encouraging in my development of my communication skills. I have worked hard at that all my life. In high school I won the award for English. At this point in my life, having been a professor, instructor, and having presented many talks and seminars, I feel like I'm a good communicator. I know I can be better and work to that end. (CC)*

Overcoming a possible weakness through conscious effort is a point to which I shall return in the discussion.

Naiveté

Mr. Bach was described as:

> *Very honest . . . until he became a young adult, he was very naïve. Then life taught him to be a little more "street smart" . . . he is still quite a trusting person and will usually give people the benefit of the doubt. (BB)*

This sounds similar to the naiveté reported in the sample one texts. Naiveté did not emerge from any of the other participants' texts, thus there is no notable pattern.

Remembering faces

All five participants described being good to average at remembering faces.

Summary

To summarize, there is only scant evidence that the sample two participants share some of the lack of social focus that emerged from the sample one texts. Mr. Alberti, according to his self-reports, displayed no lack of social focus other than avoiding team sports. Mr. Bach, in his difficulty talking about feelings and his naiveté, and Mr. Chopin, in his concerted effort to become a good communicator and his lack of motivation to conform to peer expectations might be considered, in these ways, to be less socially oriented. Mr. Debussy, disliking team sports and playing for hours on his own in his room, may demonstrate a slight lack of social focus. Mr. Elgar, although described "different" from the others in his peer group, appears to have fit in well, especially with the girls, whose play was less aggressive. The pattern of evidence regarding social focus is not clear.

(7) Aggression, conflict avoidance and bullying

Four of the five participants (Mr. Alberti, Mr. Bach, Mr. Debussy and Mr. Elgar) described a clear dislike of aggression, aggressive play and a tendency to avoid conflict rather than face it head on, for example:

> *I steered way way way clear of conflict. At the age of about five years, I was constantly bullied by my mother's friend's child, who was two years younger than I was. At around the same time, the two daughters (two horrible little girls) of another friend of my mom also treated me very poorly . . . [they] would always show off their new toys to me but prevent me from playing with them. I always obliged. (EE)*

Two participants (Mr. Bach and Mr. Elgar) reported incidents of being bullied. Mr. Debussy reported mild incidents occurring, and feeling "threatened" as a result of his strong academic performance.

From these accounts, and from the descriptions of Mr. Chopin's quiet, self-contained interests (described above), none of the five participants could be described as aggressive.

(8) Early development (temperament, speech, reading)

Speech

Like sample 1, the results for age of speech acquisition were mixed. Two participants (Mr. Chopin and Mr. Elgar) described late but immediate speech acquisition: "My Mom says I was a little over 2. I like to think that I waited until I really had something to say." (CC) "Eric did not say any words until 2 years and 6 months and then he started with five-word sentences. They were all saved up in his brain." (EE) Mr. Alberti reports speech acquisition as: "early . . . good vocabulary at 18 months." Mr. Bach and Mr. Debussy recall normal speech acquisition. There does not seem to be any pattern to these results.

Reading

There were no indications that any of the subjects in sample two began to read exceptionally early or immediately, as there were in sample one. Nevertheless, participants in all cases (except Mr. Bach) reported that reading came easily. Mr. Alberti remembers that "from grade 2 [he] was reading non-stop"; Mr. Chopin was reading easy books (Dr. Seuss) by 3 – 4 and *Childcraft* [a children's encyclopedia and do-it-yourself book for children aged 5 to 10] by age 5; Mr. Debussy learned to read at school with no difficulty; Mr. Elgar described a fairly normal, gradual process beginning at age 4-5.

Mr. Bach was diagnosed with dyslexia in kindergarten. Learning to read was a described by his mother as a long, hard struggle:

> *It was a gradual process—very gradual! Phonics became the key to his learning to read. . . . finally, when he was in grade eight, he was given a remedial reading class each day within the public school system – and at last he learned to read – a tremendous thrill for him! . . . During his high school years, he was fortunate in receiving extra remedial help in subjects that required reading and essays . . . Reading remained a challenge, but one that he has learned to master. (BB)*

(9) Scholastic preferences

Similar to sample one, math and science emerged as favourite school subjects for sample two. Mr. Alberti reported that he enjoyed "anything to do with science and building things"; Mr. Chopin " was good at pretty much everything" but disliked social science and language arts; Mr. Debussy was good at schoolwork and constructive activities; Mr. Elgar was really good at math and science. Mr. Elgar also enjoyed public speaking, provided the topic was "about being a pilot or building airplanes, of course."

BB struggled in school, due to his difficulty with reading:

> *Written assignments were particularly difficult for him . . . He usually managed math quite well but had trouble reading the instructions . . . in his early years, thanks to his very good memory, he excelled in taking part in class discussions. He was interested in all subjects . . . He played the trombone in the school jazz band and played acoustic guitar quite skillfully. (BB)*

Music was also mentioned by Mr. Chopin and Mr. Debussy as an enjoyable pursuit (hence my choice of music-related pseudonyms).

Social and language arts were described as least-liked school subjects by Mr. Chopin, and Mr. Bach. Mr. Chopin and Mr. Elgar described being not terribly interested

in art (Mr. Elgar "didn't like colouring and he didn't decorate his projects"). Mr. Bach, like Mr. Alberti and Mr. Debussy "did not enjoy nor do particularly well nor was he interested in sports programs or physical education". Mr. Chopin on the other hand, excelled at sports.

The general preference for math and science along with a lesser interest social and language arts is similar to that expressed by the sample one participants.

(10) The Visual-Spatial Learner

All participants described a good or average sense of direction. Presumably sensing reference to a visual-spatial construct, Mr. Chopin added: "I am very good with spatial manipulations. In undergrad, I got an A on my drafting course."

As mentioned above, two participants (Mr. Chopin and Mr. Elgar) described minimal interest in art; none of the other participants described any interest in drawing, painting or sculpting. When he did paint pictures, Mr. Elgar would "choose to paint the moon, planets or aircraft. Sometimes he would paint the airplane and the hanger it was in." (EE)

There does not seem to be sufficient evidence from the texts to support of refute whether Silverman's (2002) construct effectively captures these observations.

(11) Concrete Thinking

There was only one respondent who described a construct akin to concrete thinking:

> *I prized solving things logically. I like logical relationships and have had to learn how to be more random and abstract in my*

thinking. Even in that, I usually have a logical analogy in mind to help me think things through. I like making plans and carrying them out. That was true as a very small child . . . My character is a relatively strong and even mixture of a dominant and compliant character, concrete and sequential in my thinking." (CC)

Like comments made by sample one participants, the reference here to "concrete thinking" is unclear. I will return to this in the discussion.

(12) Tenacity, Focus and Intensity of Problems of attention

An ability to focus intently, described in sample one, was clearly present in four of the sample two responses:

I was focused and diligent compared to my peers, and not as impulsive. I recall being somewhat bewildered when my classmates asked me how I always seemed to know what to do and what the answer was; I said it was easy; all you have to do is listen to the teacher. So I must have had an above average ability to listen and retain what was being presented. I was also fairly obedient and rarely 'talked back' or made trouble which helped in school performance, but could also be viewed as a weakness. (Mr. Debussy)

In general, I was successful in school because I possess a great drive to finish things and understand them. I'm very curious about the world, and thirst for information and knowledge. That, coupled with an ability to concentrate for long periods, helped me to do well at school and in some way in sports. (Mr. Chopin)

Daniel had an excellent work ethic which he retains to this day. He did not go to university for the first year but worked at Canadian Tire changing tires and doing lube jobs and helping with other repairs. The repair shop manager told me later that he had 'worked his but off'. (DD)

[Brian was] very industrious . . . [he] had a lot of determination and perseverance when performing tasks . . . he never lost sight of his goal, which from the beginning of his schooling, was to go to university. As he put it – "there is a lot of stuff there that I want to learn about!" Though that looked like rather a dim possibility for a

rather long time, he did, by dint of hard work and determination, achieve it. (BB)

His attention span was well developed from all the stimulation. He can still work on a problem for hours until it is solved. He does not easily give up. (EE)

None of the argumentativeness that appeared in sample one (Edward, James, Henry and Ian) was mentioned in the sample two texts.

Unlike sample one, there were no descriptions of attention problems in the sample two texts. There was one mention, in Mr. Elgar's account, of "daydreaming" (see the quote in section 5.2); however, this occurred after he had finished his work. Aside from this, the kinds of "inattention to tasks not of interest" that appeared in the sample one texts was not described by sample two participants.

It appears that "attention difficulties" was an area where there was a notable difference between sample one descriptions and sample two recollections. Recall that six of the ten sample one children were described as having intense focus when engaged in a favourite activity alongside distractibility when not interested. It is possible that the recollections of sample two parents may have inadvertently screened out negative aspects of their child's behaviour in light of their child's present accomplishments. However, assuming the recollections are accurate, it does raise the question: are the sample one children fundamentally different from the sample two participants, or is the environment (e.g., the school context) adversely different for sample one children? I will return to this question in the discussion.

(13) School Experience

Unlike most of the sample one participants, sample two participants reported that they had enjoyed school. Mr. Alberti, Mr. Chopin, Mr. Debussy and Mr. Elgar found that elementary school lacked challenge, but nonetheless, described a positive experience overall:

> *In hindsight, I was very under-challenged. Schools with higher scholastic standards would have been better, perhaps. However, I feel I might have missed some of the team sports experiences that have helped me a lot. (Mr. Alberti)*
>
> *In grades 11 and 12 he was in an advanced program and I believe he started to enjoy school more (since he was not bored by reviews and "lowest common denominator" teaching). He made many good friends at this time and they still get together now and then. (DD)*
>
> *The first couple of years [in school] did not really challenge me . . . I don't recall being bored in elementary school either, however. I only did my homework if I knew it was going to be checked. I'm sure I could have squeezed grades 1-3 into one year or something like that, but then I would not have had so much spare time to play at home and learn things through my parents. I think my play shaped me as much as my studies did. I wouldn't change anything. (EE)*
>
> *Brian's school experience was affected by his struggle with dyslexia throughout his school years. His mother reported that "dyslexia was not well understood at that time" and that "there was no remedial help in the schools" before grade 8. This struggle certainly made the scholastic component of school difficult for Brian; [however, there is no mention of his being unhappy at school for reasons other than this]. (BB)*

Regarding the need expressed in sample one for self-directed work, there is no mention of this in the sample two responses. In fact, Brian's mother reported: "He responded best to a well structured educational environment." (BB)

Two of the sample one participants (James and Conrad, see above) described the positive influence that an individual teacher had had on their child's school experience. Similarly:

> *The teacher that Brian had in grade one had an enormous influence on his life, probably more than he is aware of. She recognized from the beginning that he was a child that showed a fine intelligence and was one of his first tutors when he was in grade 3. She gave me never ending encouragement to continue to pursue help for him within the public school system. She was convinced—and convinced me—that he was a talented child for whom the idea of a university education was by no means "pie in the sky". (BB)*

> *In high school, I . . . became very involved in volleyball, mostly because of the excellent coach at our school. It's safe to say that he was one of the top 5 coaches in all of Alberta for volleyball. Moreover, he was a great leader and mentor. I think I learned a lot about teams and working with other people from him and others over that time. (Mr. Chopin)*

Mr. Chopin added in the response to the draft:

> *There was also a teacher in Grade 3 that was exceptional. She, more than any one else, taught me about academic success. She took the time to work with the "brighter" kids in the class, giving us challenging things to do when we were finished early with other work. She kept me focused on accomplishment and success instead of getting bored. (Mr. Chopin)*

5.3 Summary

Sample two results are similar in many ways to the results from sample one: a strong interest in physical phenomena, how things work and constructive activity; little interest in pretend play; strong academic performance, expressed primarily in math and physical sciences; preference for individual sports; lack of aggression; a preference for one or two close friends; and an ability to focus intently on tasks of interest.

In both sample one and sample two there was some scant but certainly not conclusive evidence that the subjects lacked a social orientation. Evidence supporting a lack of social focus was much weaker in sample two than sample one, and in one case (Mr. Alberti), absent altogether.

Finally, school experience seems to have been mediated for some participants in both samples by individual teachers who seemed to understand, and provide for, their students' unique needs.

The main differences that emerged between the samples were in (1) attention problems and (2) school experience. Sample one texts contained descriptions of difficulties attending to tasks not of interest in seven of the ten cases. Sample two texts contained no such description. While mainstream school proved to be difficult for nine out of ten children in sample one, the adults in sample two recollected school as having been at least a benign experience.

6 CONCLUSIONS AND DISCUSSION

This study documented the interests, personality, cognitive style and early educational experiences of children who avidly engage in complex constructive activity, and compared these to the recollected accounts of adults who are exemplary, innovative and creative producers in the fields related to engineering. The main questions driving this research were: (a) in what ways are children who are highly interested in mechanical/physical thinking similar, (b) what theory best accounts for the pattern of results (if any) and (c) did adults who are highly successful by virtue of demonstrated work in a field related to engineering display these characteristics when they were children?

6.1 Gender; nature-nurture

All the children volunteered for sample one were boys; all the adults recommended to me for sample two were men. The term "buildy-boy" was supplied to me by one of the participants, in response to my comment that all the children volunteered for this study were boys. This term concisely captures the profile of a child with a passion for constructive play and figuring out "how things work"; given the gender of the subjects in this study, it seemed apt.

Obviously, this result does not suggest that there are no girls interested in complex constructive activity or women who are exemplary, innovative and creative producers in fields related to mechanical engineering. However, it may be that children

who are extraordinarily interested in "how things work" tend to be boys. Male over-representation in sample two may reflect similar causal agents as those acting on sample one; it may be the result of cultural expectations and gender bias in the field, possibly stronger in previous decades when the subjects were choosing their career path; or it may be the result of gender bias on the part of the people who made the participant recommendations to me. Additionally, given the small size of sample two (5) and sample one (10), chance factors could certainly be responsible.

Nevertheless, the over-representation of males in this study is consistent with Baron-Cohen's (2003) brain type theory, discussed below. It is also consistent with the large body of research that has found gender differences at the extreme high end of ability in mathematics (e.g., Benbow and Stanley, 1983; Feingold, 1992).

Discussion of gender differences dredges up the nature/nurture debate. Obviously the present study, with its reliance on subjective accounts, can lend no weight to either side. Nevertheless, parents in sample one appeared to believe, across all cases, that their child's intense interest in "how things work" and passion for complex constructive activity appeared extremely early, could not have been the result of parental coaching or teaching, and in cases where the child had siblings, was clearly unique to this child. Note that in every case, the child had a parent, grandparent or other close antecedent who was a scientist or engineer by profession, and/or had a "knack" for fixing/tinkering/inventing technology. The interests and tendencies of this relative would undoubtedly have affected the child's environment. At the same time, it would be foolish to ignore the possibility of some genetic influence on the intense interest these children displayed at such a young age in complex constructive activity.

While Babcock (2005) and Baron-Cohen (2003) suggested that orientation towards either mechanism or mentalism is primarily of genetic origin, Hunt's (1965) concept of intrinsic motivation can be applied to that model to include environmental influences. Hunt stated that a child's interest and attention are attracted to those aspects of the environment with which they are already somewhat acquainted. Thus, for example, a genetic foothold into an understanding of the physical environment begets further attention to and understanding of that environment, at the expense of attention to and understanding of other people's thoughts and intentions. In this way, early preference evolves into an entrenched cognitive style, even within quite similar environments. Recall the first anecdote related in this paper: two children on the same merry go round attending to different things: one attends to its technological aspects, the other child attends to the children around him and to the merry-go-round's symbolic potential. As the first child increases his folk physics knowledge, the second makes gains in folk psychology: this provides further grist for the preference mill, and so on, in iterative fashion. This might account for this study's finding that parents perceived their buildy-boys to have been "born that way" and the stability of the characteristics over the life span. Sample two accounts painted a picture of the buildly boy profile appearing early and remaining stable throughout life. To quote Mr. Chopin: "Once a buildy-boy, always a buildy-boy".

6.2 Visual/Spatial, Mechanism/Mentalism, and Hunter-Collector-Toolmaker theory

Results from both samples suggest that L.K. Silverman's (2002) visual-spatial cognitive style model does not adequately capture the cluster of characteristics that

emerged from this study. Although most of the subjects did posses visual-spatial strengths, there are commonalities not accounted for by the theory, such as the intense focus on tasks of interest and lack of motivation to attend to subtle social cues (in sample one). In addition, three characteristics emerged from the analysis that contraindicate L.K. Silverman's construct: 1) the prevalent weaknesses in the subjects' social intuition (in sample one), 2) no clear results regarding sense of direction, and 3) a fairly consistent lack of interest in drawing, painting and fine art across both samples.

I propose that Baron-Cohen's (2003) theory of brain types does a better job of explaining the findings of this study. Baron-Cohen's theory predicts that people with extraordinary interest in "understanding and building systems", (described by Babcock (2005) as "mechanism"), would be predominantly male, and would also present with somewhat weaker abilities in the folk psychology domain. This is, in part, what the present study may illustrate.

The results from the sample one analysis suggest that some buildy-boys present with weaker abilities to navigate in the social world. In most of the cases, the children in this study were described as preferring one or two close friends, preferring to work alone on projects, disliking team sports, and/or in some cases demonstrating difficulty "reading" social cues. At least one of these traits was described in varying degrees by every participant. Sample two results do not point as clearly to weak folk psychology as do sample one results; nevertheless, there is a weak suggestion of this in Mr. Bach's, Mr. Chopin's, and Mr. Elgar's accounts.

While Baron-Cohen's (2003) theory fits nicely with many of this study's descriptions, there remain two findings that his theory does not explain: 1) the high

occurrence of intense focus on tasks of interest (typically building activities, math problems, computer activities or reading factual material) alongside some degree of inattention to other tasks, noted in sample one; and 2) across both samples, evidence of a tendency towards conflict avoidance and a lack of aggression. Baron-Cohen's theory claims that the combination of strong orientations towards folk physics alongside weaker orientation towards folk psychology represents the "extreme male brain," his thesis being that this combination tends to occur more often in males. In my study however, "extreme maleness" in cognitive style seemed to be disassociated from, if not negatively correlated with, "extreme maleness" in aggression.

Hunter-Toolmaker-Collector (HTC) theory (Bonnycastle, 2004), an extension of Baron-Cohen's model, takes these two observations into account. HTC theory begins with the empirically supported theory of evolved sex differences in cognitive ability. In the Pliestocene era, the demands of child-bearing and lactation made women more suited to the work of gathering, leaving the hunting for men; selection thus developed gender specializations in cognitive abilities (alongside physical characteristics) favouring women for gathering, and men for hunting (e.g., I. Silverman & Eals, 1992). HTC theory posits a further division of labour among males into "hunters/traders" and "toolmakers". A toolmaker in our evolutionary environment would require highly mechanistic cognitive abilities, could easily have spared mentalistic capacity (as those involved in hunting in groups and trading with strangers could not), would need to be able to focus intently on the process of inventing and creating technology, and would not require the aggressive capacity needed for hunting or warring. That this cluster of traits occurs across the majority of cases in this study might be a contemporary illustration of this theory.

"Engineering and related folk physics skills have transformed the way in which our species lives, without question for the better. Indeed, without such skills, Homo sapiens would still be pre-industrial" (Babcock, 2005, p. 7). If the boys in this study do represent a "toolmaker" profile, it behooves us to value the ***entire*** cluster of traits, not just the folk physics, but also the accompanying intense focus alongside inattention, the conflict avoidance and the weaker folk psychology, as an important aspect of our species' make-up.

6.3 The Relationship Between Sample One and Sample Two

One of the purposes of comparing the childhood characteristics of today's successful adult engineers to those of young buildy-boys was to get a sense of whether the adults' success might have some predictive value for the children's futures. I hoped that this thesis might give the parents of buildy-boys the kind of inter-generational reassurance that might be offered by casual observations such as: "Don't worry if Tony plays with nobody and spends all his time building with Lego – that's what my Scotty did and now look at him: he's a successful inventor!" On the other hand, if today's successful inventors were clearly not like buildy-boys as children, then this kind of reassurance would not be warranted.

The adults from sample two reported recollections that were generally consistent with sample one in the following areas: lack of pretend play as young children, early interest in "how things work", a strong preference for complex constructive activity, lack of aggression, and intense focus (although none of the problems with inattention appear in sample two). A notable difference between sample one and sample two was in their

educational experience: sample two participants generally managed to get through school without the level of difficulty experienced by many of the sample one children.

School experience: sample one and sample two

Why would nine of the ten buildy-boys in sample one find main-stream school intolerable, while all of sample two found it to be at least a benign experience? Three explanations present themselves.

First, sample one and sample two may not represent a single cognitive profile. In this case, the factors that were common between the two samples were spurious, and sample two's career success depended on other variables (e.g., work ethic, family support, etc.). If this is the case, then there is no utility in predicting sample one's future based on sample two's career success.

A second possibility is that sample one and sample two do indeed represent a similar cognitive profile, but the adults in sample two, unlike much of sample one, possessed sufficient social interest and social ability to negotiate successfully through the school system, right through to university and to current levels of exemplary performance at work. In this case, it may be that the sample one children with a sufficiently weak folk psychology orientation will be unlikely to achieve the kinds of professional success demonstrated by sample two adults.

A third explanation may be that schools were different enough a generation or two ago such that social demands placed upon children then were not as overwhelming to weakly socially-oriented children as they are today. Although the playground jungle is arguably tamer now, I can think of a few reasons why schools of the past may have been

more accommodating to children like those in this study. First, embedded within the current curriculum there is a significant expectation that children be able to work in groups: in the past three decades, cooperative learning has become a widely used instructional procedure, in contrast to more traditional methods used a generation ago (Johnson, Johnson & Holubec, 1998). Second, there may be an unspoken expectation by contemporary teachers that children be successful both socially and academically, while a generation ago, teachers may have disregarded social abilities if a child's academic scores were high. Third, in the past, if a child was achieving academically, teachers were able to provide challenge by ability grouping within the classroom and differentiating the curriculum (e.g., the red group works out of the grade 5 math book, the blue group works out of the grade 3 math book)—a practice currently frowned upon. If these differences between past and present educational practices are responsible for the differences between sample one and sample two's experiences, then we might expect sample one children to achieve the kinds of successes enjoyed by sample two adults, provided they are spared the extreme social demands of the current mainstream school system.

Given the scope of this paper, I cannot speculate which, if any, of these three scenarios best fit this study's results. In any case, educational implications are significant (see discussion below).

6.4 Pretend Play

This paper summarized the body of literature that extols the benefits of pretend play, and the research, primarily by Smith (e.g., 1988), which casts doubt on pretend play being essential to child development. It is intriguing to note that while all of the subjects except Mr. Elgar were reported to have engaged in very little or no pretend play as young

children, there is no doubt that the children and adults in this study are highly able in many areas: they are all literate, functional and intelligent; some of the children have been tested and found to be intellectually gifted; the adults are all "exemplary producers" in their fields. This raises the question whether constructive activity is in some way able to fulfil similar functions afforded in the literature to pretend play, or whether the value of pretend play is, as Smith (1988; 2005) states, over-romanticized. In either case, pretend play cannot, as demonstrated by the examples documented in this study, be considered a necessary condition for the development of the kinds of cognitive abilities that are displayed by this study's subjects.

A weak finding of this study is that some subjects of this study were less socially oriented than their peers. This raises the question: is lack of pretend play in some way responsible? The pretend play literature does support the notion that pretend play assists in the development of perspective taking, that is, understanding another's mental states and affective experiences (e.g., Rubin, Fein & Vandenburg, 1983). However, there are no methodologically sound experimental studies that definitively support this claim (Smith, 1988). The best we have is correlational support for this notion.

I speculate that any association found between pretend play and social abilities is not directly causational, but rather, caused by a third variable: degree of orientation to folk psychology. An interesting observation from this thesis suggested this notion to me: the children in sample one (except James) and the adults in sample two tended to prefer factual books to fiction. Even when they do read narrative works, the books they gravitate towards tend to focus on solving problems of a logical nature (such as crime and

detective novels) or have a factual or scientific basis (science fiction, historical fiction), as opposed to a focus on human relationships.

Pinker (1997) posited that narrative evolved as a means for people to explore folk psychology. Reading (or writing) a novel gives us insight into another human's thoughts and intentions. People who are intrinsically motivated to understand others' thoughts and intentions (i.e., who are oriented towards folk psychology) will seek out novels and read them with relish (and perhaps write them).

Along these lines, I would like to suggest that pretend play is a child's means of accessing similar material. Pretend play is surely a medium for a child to explore human thoughts and intentions, by playing out stories, creating narrative, and trying on other persona. Motivation to engage in pretend play may be no more than the expression of a child's folk psychology orientation, similar to the motivation for an older person to read, tell or write stories. A desire to engage in pretend play, along with the desire to read stories, could be the result of an inherent desire to explore the domain of folk psychology. Rather than being a "leading activity" or essential ingredient in producing certain types of cognitive competencies, pretend play, like enjoying stories, may simply express a cognitive orientation. Similarly, complex constructive activity may be the expression of a child's folk physics orientation, the result of a mechanistic child's drive to experiment with physical phenomena.

Smith (1995) poses the question: "should we urgently foster socio-dramatic play in children who show little of it?" (p. 223). Perhaps we should, if our goal is to create future novelists, psychologists or other folk psychology specialists. Or, more reasonably, we should recognize that play choices result from a child's cognitive style, inherent

motivation and interests, rather than imbuing pretend play, or lack of it, with more significance than is due.

6.5 Concrete Thinking

I found it interesting that participants in both samples used the term "concrete thinking" to describe their children (or, in sample two, themselves). The term "concrete thinking" means the opposite of abstract thought. It typically refers to a failure to look beyond words to uncover the meaning behind them: taking metaphors literally is the example given in most explications (e.g., "GP notebook", 2006).

Two occurrences of the term "concrete" related to language use. James's mother wrote that James was a "concrete thinker;" her evidence was that he took the words "few" and "a couple" to mean exactly three and exactly two. Ian's mother described a similar tendency: Ian expected "I'll be a couple of minutes" to mean exactly two minutes. These examples may be better described as an expression of precision: that these children prefer to interpret language precicely rather than ambiguously may point to their preference for exactitude. The term "concrete," in these cases, may be a misnomer.

Another occurrence of the term "concrete" appeared in Daniel's mother's account. She reported that Daniel "sees the [social] world in terms of black and white," therefore, she believes, he is a "concrete thinker."

However, I would like raise the following question: if a person displays concrete thinking in his or her use of language (e.g., Ian and James), or in his understanding of social situations or his play choices (as in Daniel's case), does this necessarily mean the

person thinks concretely in all domains? Perhaps a framework of cognitive modularity (such as Baron-Cohen's folk phsyics/folk psychology domains) might be useful here.

I would like to suggest that while Ian might demonstrate "concrete thinking" in his language use—language being a component of folk psychology (Pinker, 1997)—he seems to have demonstrated abstract thinking in the folk physics domain when he "invented" negative numbers at age two (see the description of this event in section 4.1). Similarly, I would suggest that James, though possibly concrete in his language use, and Daniel, who uses "black and white thinking," both demonstrated the ability to abstract when they taught themselves to read (they were two of the sample who seems to have learned to read spontaneously—see the description in section 4.2). Self-taught readers have to figure out the "rules" of decoding by themselves: how letters form together to represent sounds, how sounds combine into words, etc. In other words, it requires abstracting a pattern from given examples.

Baron-Cohen's (2002) description of "systemizing" fits neatly with this idea: "systemizing" means trying to understand things according to laws or rules. This construct surely expresses the concept of "abstract thought" in the domain of folk physics. Thus, Edward was "systemizing" when, at age two, he abstracted from his experiments with pouring water a rule about water "flowing down" (see the quotation in section 4.1). Similarly, Felix's "popping out a theory about how something works" (see the quotation in section 4.1) clearly involves thought at an abstract level.

Thus, while the participants may have provided some evidence of "concrete thinking" in a particular domain (language, or possibly, folk psychology), there does not seem to be any reason to suggest that the subjects fail to exhibit abstract thought across

all domains. To suggest that someone is a "concrete thinker" because their language or social thinking tends to be somewhat literal seems, to me, to be an inappropriate use of the word "concrete".

What exactly did Mr. Chopin mean when he described himself as a "concrete thinker?" I would guess that he was referring to his preference for the folk physics domain, which requires logical, sequential, "systemizing" thought, over the domain of folk psychology, which requires a more intuitive ability to "mind-read" (Baron-Cohen, 1995). However, I speculate that within the folk physics domain, he does think very abstractly, in the sense of processing concepts separately from their specific referents, of generating laws and rules from observations, of understanding "how things work". I believe that Mr. Chopin could not have reached his high level of professional achievement otherwise.

6.6 Personality and Pathology

The kind of "pure social deficit" described by (Baron-Cohen, Wheelwright, Stone & Rutherfold, 1999) was not found among the children or adults in this study. Instead, any evidence of weakness in the "folk psychology" domain was subtle: difficulty talking about feelings, slight social discomfort, dislike of large groups, slight difficulty reading subtle social cues, and/or preference for one or two close friends was described by almost all participants.

These are not significant enough deficits to warrant a label or diagnosis along the autism spectrum. Instead, what I believe this study documents is a normal cognitive style that favours folk physics while possibly de-emphasizing folk psychology to some extent.

I posit that this is a normal orientation that does not yet have due representation in the child development literature. The result is the failure of academics, educators and parents to recognize its characteristics. The key example used in this paper was pretend play: as discussed, the "play ethos" literature would have us believe that because most children engage in pretend play, it must be a requirement for the development of a variety of cognitive, social and emotional competencies, and therefore a lack of it must be problematic.

Pretend play may well be a leading activity for the majority of children; however, a child whose attention is primarily oriented towards "how things work" may take an alternate route to attaining cognitive competencies. In fact, the entire developmental sequence may be different for mechanistic child: for example, s/he may grasp concepts such as negative numbers and the law of gravity years before s/he learns to interpret another child's body language. S/he may well learn to decode the written word years before s/he learns to appreciate a story line. This does not mean that s/he will never gain proficiency in these areas; however, it may take more time and a perhaps a different, more deliberate approach for these skills to develop. Recall the comments made by some of the children's parents that their child seemed to "improve with age".

Mr. Chopin's account illustrates this concept of deliberate skill development. He believed his success in life hinged upon his acquiring good communication and teamwork skills, skills he had to "work very hard" to develop. He attributed his skill development to the great deal of support and encouragement he received from parents and his volleyball coach, and to his playing team sports. Note that he developed these skills later in life: that is, during high school and university, whereas as a child, he had a tendency to

isolate himself from others. As an adult, he continued to work consciously on communication skills. His example seems to support the idea that an early relative weakness in social skills can be overcome later in life with conscious application and support—just as for another child, an early inability to grasp mathematical thinking can be overcome, with conscious effort, later than the age at which the children in this sample seemed to grasp it.

However, for parents of the children in sample one, there appeared to be an undercurrent of anxiety about their child's seeming deviation from "norms". As long as parents are led to expect children to develop according to a particular framework, then such anxiety is bound to occur when a child deviates from it. Participants from sample one reported to me a certain amount of relief in learning that their child wasn't the only one "like this". For example, James's mother wrote this comment in the margin of the draft: "Anne – thank you. This is so normalizing for me to see that Ian is like James!! None of his friends have this trait [extreme tenacity and argumentativeness]. I thought it was a parenting error!!"

If child development texts were to describe child development as it can present for a child with object-orientation (or mechanistic thinking style) as well as for children who are more people-oriented (who have a mentalistic thinking style) then perhaps parents would be spared the concern and the self-blame. Furthermore, if child development texts could show that an object-oriented child can later develop the skills required for success in the social arena, as did Mr. Chopin, then the parental anxiety might be further reduced. This clearly points to the need for longitudinal research that tracks the development of "buildy-boys" into adulthood.

6.7 Giftedness

Labels are useful when they can help with the identification and intervention of potential problems and/or opportunities. The label "gifted" is useful when it helps to identify children based on a set of common characteristics, and then aid in the development of beneficial educational interventions for those children.

At present, the single term "gifted" describes a heterogeneous population. Even among academics and educators defining the construct "gifted" causes much debate (Gagne, 1985): trait lists are long, subjective and too broadly encompassing; IQ-score cut offs are arbitrary and the testing itself, suspect (Freeman, 1979). Who is "gifted", who is not, and who should receive intervention, sits at the heart of the gifted literature (Rogers, 1998).

As there are numerous possible interventions for children labeled "gifted," appropriate prescription depends upon the extent of giftedness, the type of giftedness (e.g., gifted academically vs. gifted creatively), and the maturity and social development of the child, etc. (Stanley, 1995). Nevertheless, the term "gifted" continues to be construed as a single label, applied across the population. Some examples: there exist schools for "gifted" children; the Templeton Report (Colangelo, Assouline and Gross, 2004) recommends acceleration for "gifted" students; there are support groups for parents of "gifted" children. And yet, this study suggests that there may be at least one subpopulation within the "gifted" construct with identifiable characteristics and specific, unique needs.

A parent whose three-year-old discovers a siphon, grasps the concept of negative numbers and passionately explores the workings of the VCR, faces a very different set of

problems and possibilities than a parent whose child talks early and creates precociously imaginative puppet plays with his stuffed toys. As the two children mature, the first may become obsessive about building with Lego, demanding sets for children much older than he is, and may appear to be socially disinterested; the second may find himself unpopular at school for trying to lead the others in his complex socio-dramatic play ideas. Both children are gifted, both children present differently and have different needs. It would be foolish to assume that both would benefit from the same gifted program, or from attending the same gifted school. Similarly, we should not assume that the two children would find in each other, by virtue of the same label, an intellectual peer.

This study attempts to describe the characteristics, experiences and needs of children who are gifted in the mechanical/physics domain. The results point to a need for type-specific trait lists and accompanying interventions in the gifted literature. For example, the literature suggests that gifted children are precociously concerned about moral and ethical matters; yet in this study, of the ten children who are arguably gifted in the mechanical-physics domain, only one displayed this characteristic. Similarly, the expectation that gifted children are highly imaginative in their story telling was not met in this study. Of utmost concern is the claim that gifted children are socially mature for their age: many of the children in sample one are arguably counter-examples. I would like to suggest that interventions prescribed for children similar to those in this study should pertain to their buildy-boy profile, rather than be based on what we know about gifted children in general.

Finally, a comment made by Andrew's mother emphasized the following point (which was affirmed by the mothers of Gregory and Edward): she said she wished she

could connect her child with others "like him", in order to give her child validation, and to reduce both her and her child's sense of isolation. "Others like them" did not refer to other gifted children, but to other "buildy-boys".

6.8 Educational implications

The children in sample one are clearly intelligent; they appear to have great potential, possibly in an engineering-or physics-related capacity. It is possible, as discussed above, that they will mature into the kind of exemplary producers represented by sample two. It is also possible that they demonstrate an important variety of human cognitive style, a profile that has in the past and will in the future contribute to our species' development, according to HTC theory. Yet, among sample one, only one child demonstrated the ability to flourish within the mainstream school system. This raises the question: are changes needed in the school system in order to allow "buildy-boys" to thrive within a mainstream setting? The results from this study have revealed some aspects of a school environment that works for these boys: 1) small classes; 2) protection from aggression; 3) a curriculum that matches the child's ability level; 4) sympathetic, understanding teachers; and 5) less stringent demands on their social abilities. With the possible exception of the last item, it could be argued that all children would benefit from these educational enhancements. However, the fact that nine out of ten of the children in the sample were placed in alternative educational situations at significant financial cost to their parents suggests that their need was more extreme than is the average child's.

Comments made by Mr. Chopin in sample two suggest the kinds of interventions that might enable a "buildy-boy" to succeed in later life. Mr. Chopin worked very hard to become a good communicator, and consciously made the effort to engage in team sports

through his high school and university years. His parents and volleyball coach actively encouraged and supported him in this work. He attributes his success to his having developed, and continuing to develop, the capacity to work with and communicate with other people.

It is doubtful that these strategies would be equally effective in every case: a child without Mr. Chopin's resilience, drive and fundamental level of social skills might "sink" where Mr. Chopin was able to "swim." For example, pushing a child like Andrew (sample one) into team sports might result in utter frustration rather than in skill development. Future research is needed to inform the parents and educators who are faced with these kinds of decisions.

Future research could also look beyond current educational models to ones (if any) that have worked well for "buildy-boys" in the past and/or in other cultures. For example, the difference between the school experience of sample one and that of sample two warrants a closer look. Comparing school environments from a few generations ago to those of the present day, and the effect such differences might have on children with a "buildy-boy" profile, might be a starting point.

6.9 Conclusion

The value in this study may be in the documentation of a set of characteristics that seem to cluster together in ten particular children, rather than in any conclusion drawn from the results. The collection of descriptions will be, I hope, useful to parents and educators whose children demonstrate similar characteristics. In fact, a response made by a number of the sample one participants upon reading the draft copy of this thesis was

one of relief: relief that there are other children "like this," and that there are other parents whose children's development and school experiences are similar to theirs. Simply by ameliorating this sense of isolation, I believe, this study demonstrates its utility.

The comparison between the sample one texts and the sample two texts will provide, I hope, some further comfort. For example, because four of the adults in sample two showed disinterest in pretend play as children, yet nevertheless became successful and exemplary engineers, then perhaps this trait, on its own, will concern parents less. No doubt a study with a larger sample of "exemplary engineers" could address such parental concerns more effectively; hopefully my thesis will provide the impetus for future research in this direction.

Whether the descriptions gathered here can provide any support for one theory or another is, I feel, of secondary importance. Of primary importance is the well-being of children like the ones in this study, and their families. The better we can understand and acknowledge these talented, unique children, the better we will be able to support and cherish them.

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APPENDIXES

Appendix A: Diagnostic criteria

Diagnostic criteria for Asperger's Disorder from DSM IV (1994)

A. Qualitative impairment in social interaction, as manifested by at least two of the following:

1) marked impairment in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction.
2) failure to develop peer relationships appropriate to developmental level
3) a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing or pointing out objects of interest to other people)
4) lack of social or emotional reciprocity

B. Restricted repetitive and stereotyped patterns of behaviour, interests and activities as manifexted by at least one of the following:\

1) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
2) apparently inflexible adherence to specific, nonfunctional routines or rituals

3) stereotyped and repetitive motor mannerisms (e.g. hand or finger flapping or twisting, or complex whole-body movements)

4) persistent preoccupation with parts or objects

C. The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning

D. There is no clinically significant general delay in language (e.g., singl words used by age 2 years, communicative phrases used by age 3 years)

E. There is no significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behaviour (other than in social interaction), and curiosity about the environment in childhood

F. Criteria are not met for another specific Pervasive Developmental Disorder or Schizopherenia

Diagnostic criteria for Autistic Disorder from DSM-IV (1994)

A. A total of six (or more) items from (1), (2) and (3), with at least two from (1), and one each from (2) and (3):

1) qualitative impairment in social interaction , as manifested by at least two of the following:

a) marked impairment in the use of multiple nonverbal behaviours, such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction

b) failure to develop peer relationships appropriate to developmental level

c) lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest)

d) lack of social or emotional reciprocity

2) qualitative impairments in communication, as manifested by at least one of the following:

a) delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime)

b) in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others

c) stereotyped and repetitive use of language or idiosyncratic language

d) lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

3) restricted, repetitive, and stereotyped patterns of behaviour, interests, and activities as manifested by at least one of the following:

a) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus

b) apparently inflexible adherence to specific, nonfunctional routines or rituals

c) stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting or complex whole-body movements)

d) persistent preoccupation with parts of objects

B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: 1) social interaction, 2) language as used in social communication, or 3) symbolic or imaginative play.

C. The disturbance is not better accounted for by Rett's disorder or childhood disintegrative disorder.

Appendix B: Letter soliciting participants

Letter sent to parents of Tooltime[1] (summer engineering program for children aged 7 – 14). Similar letter sent to parents of children at St. Charles' School for Gifted Learners.

Dear parents of Tooltime participants, July 20, 2005

Do you have a child who loves to build? (Lego, K'nex, Tinker Toy . . .)

Is your child interested in how things work? (the vacuum cleaner, the CD player . . .)

Is your child fascinated by numbers?

Would you say your child has displayed this predilection from an early age?

Then I would love to have you participate in my research study. I am a graduate student in educational psychology at Simon Fraser University, and am enquiring into the unique cognitive and social development of kids who seem to be "born to build". As a participant, you would be asked to fill in a questionnaire that will document your child's developmental patterns, school experiences and learning style. The questionnaire takes about one half to two hours (depending on how much detail you choose to provide), and can be filled in on-line or by hand. The questionnaire has been approved by the SFU research ethics committee, and your and your child's identity will be kept confidential.

[1] pseudonym

I am hoping that this study will allow me to document the educational and emotional needs of these talented children, in order to facilitate the design of optimal educational experiences for them.

Please contact me by email (annebonnycastle@shaw.ca) or by phone (604-732-7804) if you are interested in participating, or if you have any questions about the study.

Sincerely,

Anne Bonnycastle

Graduate student, S.F.U.

Appendix C: Questionnaire sent to parent participants

Please answer these questions in **as much detail as you like**. The more detail the better – but please don't feel obliged to repeat information answered in previous questions. Please take as much space as you like to elaborate.

Most questions refer to your child **before age seven**, although please feel free to comment on later ages and grades. If you like, you may specify where your comments refer to specific ages.

1. What is your child's age currently? Gender?
2. Would you briefly describe your child's personality?
3. What is your child's preferred type of play (imaginative, group play, building, sport, etc.)?
4. Does she/he engage in pretend (imaginary) play more or less than other children? Exclusively? Not at all?
5. Does he/she engage in rough-and-tumble play more or less than other children? Exclusively? Not at all?
6. Does she/he engage in building, tinkering or exploring how-things-work more or less than other children? Exclusively? Not at all?
7. What kind of toys or objects does he/she like to play with?
8. With whom does she/he typically play?
9. What activities does he/she enjoy?
10. When did she/he learn to speak? (e.g., single words; sentences)

11. What things interest him/her?
12. Is he/she a sociable child? Please describe.
13. Does he/she prefer playing by her/himself or with other children?
14. Would you describe your child as tending to be honest/naïve or street-smart?
15. Is she/he good at remembering who people are?
16. In general, does your child tend towards either aggression or conflict-avoidance with his/her peers?
17. Does he/she have a good or poor sense of direction, compared to other children his/her age?
18. Does(did) she/he attend preschool? If yes, what kind (e.g., play-based, Montessori)? What has this experience been like?
19. What was your child's experience in kindergarten like? Grade 1?
20. When did your child learn to read? Was learning to read a gradual process, or instantaneous? Would you say your child relied on phonics to learn to read?
21. In school, what is your child really good at?
22. In school, what is your child not so good at?
23. Did/does your child display any behavioural or attentional problems? If so, please describe, and please note in what context you observe these problems.
24. Has your child experienced any problems with bullying or harassment? Please describe. If so, could you also describe what was done (or what ought to have been done) to alleviate the problem?
25. Does he/she enjoy sports? What kind of sports? Does she/he prefer team sports or individual sports?

26. What kind of books does your child read or have read to him/her? Does she/he enjoy stories? What kind? Does he/she you prefer stories or factual books?
27. What kind of things does your child find funny? Do other people appreciate your child's sense of humour?
28. In a group situation, is your child more likely to follow the lead of other children, or to "march to the beat of his/her own drummer"?
29. What would you say are your child's strengths and weaknesses compared to other children?
30. As a baby, would you say your child was easy or difficult (e.g., colicky, or regular sleeping and eating)?
31. Compared to other children, would you describe your child as more or less empathetic to the emotions of others (for example, if another child were crying, is your child likely to respond by trying to comfort her?)
32. Would you please describe what educational experiences/environment "works" for your child, and which do not?
33. What does your child's mother and father do professionally? Do you have any relatives who seem to display a "knack" for mechanical engineering, and/or for technical innovation? What is their relationship to your child? (e.g., maternal grandmother etc.)
34. Please add any other information that you think would be helpful for me to get a sense of the kind of person your child is, the way she/he developed, thinks, plays and learns.

Thank you so much for you assistance!

Please do not hesitate to call or email if you have any questions about this study.

Anne Bonnycastle

604-732-7804

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