The Design of a Therapy Garment for Preschool Children with Sensory Integration Dysfunction

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(ABSTRACT)

A design process developed by Joann Boles (Alexander, 1998; J. F. Boles, personal communication, 1996) was used to develop a therapy garment for three four-year-old boys with sensory integrative dysfunction who participated in occupational therapy using sensory integrative methods. The design process framework has four stages: (a) problem development, (b) needs assessment, (c) prototype development, and (d) evaluation. The problem was developed by observing children with sensory impairments; interviewing parents and professionals; experiencing sensory integrative methods; and reviewing literature.

The needs were assessed for the wearers, the activity, and the environment through four weeks of observations, interviews with the child and significant others, and document reviews. The research design was multiple case studies. The data collection and analyses followed the grounded theory procedures of open and axial coding outlined by Strauss and Corbin (1990).

The resulting needs of the wearers, the activities, and the environment were translated into garment specifications and criteria. The four garment specification categories were (a) movement, (b) sensory integration, (c) motor development, and (d) play.

Prototypes were generated to meet garment specifications in terms of structure, materials, and assembly. The process included writing ideas, coding and combining ideas, sketching ideas, constructing samples, and constructing a prototype solution. The resulting prototype consisted of a sleeveless pullover top, cape, and weights, and featured a bug superhero theme.

The prototype was evaluated against garment specification criteria through observations, interviews, and an evaluation form. The prototype allowed full body movement and provided safety features for full interaction in the environment. The prototype provided proprioceptive input and gross motor opportunities through the elastic band loops and bug weights, and promoted the use of vestibular integrating equipment with the cape. Tactile opportunities were provided through the variety of materials. Fine and perceptual motor skills were promoted by manipulatives on the cape and the opportunity to store fine motor activities in cape pockets. Storing activities in the cape promoted smooth transitions, motor planning, organization, follow through, and self discipline. The bug theme appealed to the wearers' play interests and promoted imaginative scenarios during therapy, thus aiding in self organization and attention to task.

DEDICATION

I am honored to recognize Judy, Mallory, and Ashley, the individuals that inspired this research. They have touched my life with their dedication to managing autism. Their willingness to meet challenges with creativity has been a source of inspiration and joy.

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CHAPTER 1

Introduction

Apparel design research proceeds from a specific population to the general population. The professional athletic running shoe preceded the running shoe available for all to use and the space suit for the astronaut has led to applications in recreational garments for the general public (Watkins, 1995). The purpose of this study was to design therapeutic clothing for children diagnosed with sensory integrative dysfunction, with the expanded belief that the discoveries will have future application to many larger populations.

Sensory integrative dysfunction is a developmental disorder defined by deficits in the central processing of vestibular, proprioceptive, and tactile sensory inputs that are not attributable to either peripheral or cortical central nervous system dysfunction (Fisher & Murray, 1991). Sensory integrative dysfunction makes it difficult to process and use sensory information for functional purposes (Ayres, 1979) and can interfere with the individual's learning and may cause behavioral problems (Stepp-Gilbert, 1988).

Individuals who have sensory integrative dysfunction are often impaired in their ability to carry out daily life activities (Koomar & Bundy, 1991). Common characteristics exhibited by preschool children with sensory integrative dysfunction are: clumsiness; poor balance; difficulty holding a prone position; gravitation insecurity (does not enjoy swinging, climbing, jumping); breaks toys easily; difficulty learning to tie shoes, ride bicycle, zip or button clothes; delayed language development; poor eye-hand coordination; poor motor planning; aversion to touch (especially light touch), certain odors, lights, or noises; dislikes getting hands dirty; dislikes going barefoot; and drops things frequently (Stepp-Gilbert, 1988). Individuals may vary in their sensory responses depending on their mood, the time of day, and other environmental factors (Koomar & Bundy, 1991).

Approximately 15% of all children experience some type of sensory integration problem (Stepp-Gilbert, 1988). This population includes children diagnosed only with sensory integration dysfunction and subgroups from populations with impaired motor development (developmental delay), learning disability, and central nervous system disorder (e.g., cerebral palsy, mental retardation, spina bifida, brain injury, and autism) (Fisher & Murray, 1991).

Sensory integration theory postulates that intervention through therapy provides enhanced sensory experience within the context of a meaningful, self-directed activity in order to elicit an adaptive behavior (Ayres, 1979; Fisher & Murray, 1991). The result is enhanced sensory integration and, in turn, enhanced learning (Ayres, 1979; Fisher & Murray, 1991). Sensory integration therapy programs are implemented primarily by occupational therapists (Densem, Nuthall, Bushnell, & Horn, 1989).

Clothing, primarily in the form of weighted vests, are being used to calm children with autism or other developmental disorders, who are distractible, hyperactive, and lack concentration (Haar & Giddings, 1997; Joe, 1998). Other weighted items available from companies are collars, quilts, and arm and ankle bands. The purpose of the present study was to design apparel products to aid in the integration of proprioceptive, vestibular, and tactile systems, as well as meet other needs of preschool children with sensory integration dysfunction.

Purpose of the Study

The purposes of this study were two fold:

1. To develop apparel products for preschool children diagnosed with sensory integrative dysfunction, for use with sensory integrative methods in the occupational therapy environment.

2. To use the Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996) to guide the research from conception through evaluation.

Objectives for the Study

The objectives of this study were structured according to the stages of the Boles framework:

1. Problem Development. To identify and define the problem of sensory integration dysfunction for young children with sensory integrative dysfunction through observation, interviews, and experiences.

2. Needs Assessment. To assess the needs of the wearer (i.e., child with sensory integrative dysfunction), the activity (i.e., occupational therapy with sensory integrative techniques), and the environment (i.e., rehabilitation center). Needs assessment includes data collection and analyses of observations, interviews, and documents.

3. Garment Specifications. To translate assessed needs to garment specifications.

4. Prototype Development. To develop garment prototypes based on garment specifications that meet assessed needs, through experimentation with structure, materials, and assembly.

5. Evaluation. To evaluate the prototype garment in the lab and in the field against assessed needs and garment specifications through observation, interviews, and an evaluation form.

Research Design

The design of the study was multiple case studies. Case studies are studies in which researchers concentrate on a single case or a few individual cases (Tesch, 1990). Case study research is "intensive and detailed study of one individual or of a group as an entity, through observation, self-reports and any other means" (Tesch, p. 39). Direct observation and systematic interviewing are two main sources of evidence for a case study (Yin, 1984). The cases were three four-year-old males with sensory integration dysfunction and impaired motor development. The sources of information for this study were observation, interview, and document review.

Design Process Framework

The Boles design process was the conceptual framework used for this study. The design process takes the designer from the initial idea through an evaluation of the final design (Dejonge, 1984; Watkins, 1995). Jones (1988) states "the basic concept for any design process is a controlled approach to translating the product specification into a working system that fulfills the need of the user" (p. x). Several scholars (J. F. Boles, personal communication, 1996; Dejonge, 1984; Lamb & Kallal, 1992; Watkins, 1984, 1995) in the field of clothing and textiles have developed or adapted design process frameworks to meet the needs of apparel design.

The design framework used in this study was developed by Boles (personal communication, 1996) and had its genesis in 1982, as a framework for design research to meet the criteria of other scholars in the field of clothing and textiles and is still evolving today. In 1982, the process included needs assessment, prototype development, and wear testing of the prototype men's indoor exercisewear (Boles, 1982). This process continued to develop and has been used in design course work and parts of the process have been used in research. Alexander (1998) used the problem development and needs assessment stage of the Boles design process framework to identify wearer preferences and garment criteria for female flight attendant uniforms. Mullet (1984) explored the needs assessment stage used by Boles (1982), in conjunction with the needs assessment model of Kaufman and English (1979) to develop garment criteria for kayakers' paddling jacket.

The Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996) has four stages: (a) problem development, (b) needs assessment, (c) prototype development, and (d) evaluation (see Figure 1). The problem development stage includes observations, interviews, and experiences. The problem development stage is the early identification and exploration of the problem through observing related activities, interviewing individuals about the problem, exploring the literature, and experiencing the problem through participation. Experience may also include professional and/or personal experience.

<u>Figure 1.</u> Boles design process framework (PDF, 31 KB, Fig1.pdf).

The needs assessment stage explores the problem developed in the first stage by identifying needs from the perspective of the wearer, the activity, and the environment. The needs are documented, analyzed, and translated into garment specifications.

Garment specifications guide development of prototype garment structures. Prototype development proceeds to materials, which is based on specifications and structures. Fastening systems are added and prototypes are assembled based on specifications, structures, and materials. This stage is three dimensional and utilizes manikins and live models. The final phase, evaluation, returns to the needs assessment and tests the prototypes in the field and in the lab for their ability to meet assessed needs.

Even though the design process is presented in stages, the process is a continuous feedback system. Stages are revisited along the design process continuum. This feedback system is indicated by the double-ended arrows in Figure 1.

<u>Benefits</u>

The benefits of the study are a collection of data that identify and analyze the clothing related therapy needs of preschool children with sensory integration dysfunction. There has been no previous study of this nature. The data will be used to create garments to aid in the sensory integration of children with sensory integration dysfunction. The garments will be designed for use in the therapy environment. The resulting products and findings can be applied in the child's other environments, such as home and school, and will enhance other populations with sensory problems, as well as populations with more normal sensory processing.

Another benefit of the study is the use of the Boles design process framework in its entirety. The process will provide researchers a framework for product design through problem development, needs assessment, prototype development, and evaluation.

Limitations

This study sample was limited to three children, four years of age. The three children were diagnosed with sensory integration dysfunction and impaired motor development with no overt muscular or neurological disorders. Limiting the number of cases, the types of cases, and the age of the cases does not provide generalizability. The resulting prototype garments will not address the needs of all children with sensory integration dysfunction and impaired motor development, but other cases with similar dysfunction profiles may benefit from the resulting garment product.

Definitions

Adaptive behavior--a purposeful and goal-directed behavior that enables the individual to successfully meet the "just right" challenge and learn something new (Ayres, 1979)

Anticipatory play roles--play roles that the child might realistically enact or encounter in later life (Stone, 1965).

Bilateral integration--integrating sensorimotor function of the two sides of the body (Ayres, 1972b).

Bolster swing--piece of equipment with a strong inner core, covered with foam padding and a cloth cover, and is six feet long and three feet around. Ropes attached to each end of the bolster are suspended from overhead hooks. (Ayres, 1979)

Cocontraction--the simultaneous contraction of all muscles around a joint to stabilize it (Ayres, 1979).

Crossing the midline--the movement of the eyes, a hand and forearm, or a foot and leg across the midsection of the body without involving any other part of the body (i.e., without turning the head, twisting or swaying the trunk, or innervating the opposite limb) (Ayres, 1979).

Crab walking--movement using all limbs while in a supine position, where the feet and hands move the body.

Dyspraxia--difficulty with motor planning that results in clumsiness, associated with poor tactile discrimination (Fisher & Murray, 1991).

Fantasy play roles--play roles that a child will seldom, if ever, enact in real life (Stone, 1965).

Fine motor function--functioning that requires precise movement of the small muscles of the body (Folio & Fewell, 1983).

Form perception--the ability to perceive an arrangement or pattern of elements or parts constituting a unitary whole, wherein the elements are in specific relationships with each other (Ayres, 1979).

Frog swing--suspended swing with a flexible seat and elasticized support ropes to allow for bouncing.

Gravitational insecurity--unusual degree of anxiety or fear in response to movement or change in head position; related to poor processing of vestibular and proprioceptive information (Ayres, 1979).

Gross motor function--functioning that requires precise movement of the large muscles of the body (Folio & Fewell, 1983).

Motor planning (or praxis)--ability to plan and execute a sequence of motor tasks (Ayres, 1979).

Occupational therapy--a profession that employs purposeful activity to help the client form adaptive responses that enable the nervous system to work more efficiently (Ayres, 1979).

Perceptual motor--a process that includes input in the form of sensory or perceptual activities and output in the form of motor or muscular activities (Folio & Fewell, 1983).

Postural balance--refers to skill and performance in developing and maintaining body posture while sitting, standing, or engaging in activity.

Postural reflex--changes in body position in response to head and body movement and/or the pull of gravity.

Prone--horizontal body position with the face and stomach downward (Ayres, 1979).

Proprioception--The sensations from the joints, tendons and muscles, which provides an understanding of movement or position of body parts and judgement of weight, shape and force. This information allows the brain to know where each part of the body is and how it is moving. (Ayres, 1979).

Proprioreceptors–receptors of the muscles, joints, and skin that are stimulated by active movement of the muscles and joints (Fisher, 1991).

Range of motion--the skill and performance in using maximum span of joint movement in activities with and without assistance to enhance functional performance.

Reflex--an innate and automatic response to sensory input (Ayres, 1979).

Reflex integration--skill and performance in enhancing and supporting functional neuromuscular development through eliciting and/or inhibiting stereotyped, patterned, and/or involuntary responses coordinated at conscious and unconscious levels (Fisher & Murray, 1991).

Sensorimotor skill--a skill in which muscular movement is prominent but under sensory control.

Sensory integration--neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment. The spatial and temporal aspects of inputs from different sensory modalities are interpreted, associated, and unified. (Ayres, 1989).

Sensory integration dysfunction--developmental disorder defined by deficits in the central processing of vestibular, proprioceptive, and tactile sensory inputs, that are not attributable to either peripheral or cortical central nervous system dysfunction (Fisher & Murray, 1991).

Sensory overload (overstimulation)--observed signs of over stimulation which can include pupil dilation, sweaty palms, changes in rate of respiration, flushing or pallor (Koomar & Bundy, 1991).

Sensory stimulation--sensory input techniques that are passively provided to the client. Murray & Anzalone,1991).

Scooter board--consists of a piece of wood or hard plastic mounted on four wheels that can roll freely and spin in any direction (Ayres, 1979).

Somatosensory processing--combination of tactile and proprioceptive inputs (Ayres, 1989).

Supine--horizontal body position with the face and stomach upward (A parent's, 1991).

Tactile defensiveness--negative or averse response to certain types of tactile stimuli (Royeen & Lane, 1991).

Tactile discrimination--impairment of tactile and haptic perception (Royeen & Lane, 1991).

Vestibular system--contributes to the subjective awareness of body position and movement in space, postural tone and equilibrium, and stabilization of the eyes in space during head movements (Fisher, 1991).

Vestibular receptors--the semicircular canals, the utricle, and the saccule, which are stimulated by movement of the head and by gravity (Fisher, 1991).

CHAPTER 2

Problem Development

Problem development is the first stage of the Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996). This stage is the early identification and exploration of the problem through observing related activities, interviewing individuals about the problem, exploring the literature, and experiencing the problem through participation. Experience may also include professional and/or personal experience. This chapter will present the development of the problem through observations, interviews, and experiences, and present literature related to each of these phases.

Observations

The initial interest for this study began through a friendship with a five-year-old girl who is autistic. Through this relationship, I became interested in issues of autism, particularly sensory issues. The child exhibited characteristics of autism cited in the literature, she walked on her tip toes, avoided eye contact, did not interact with other children, and was non-verbal. She craved deep pressure and was observed hugging her mother with strong, firm hugs. She had a heightened sensory awareness. When on a walk, I observed that she used her senses to explore her environment. She spent time looking intensely at weeds, flowers, and rocks, and touched anything within reach; or if not within reach, she would find a way to reach what interested her. She was known to spend long amounts of time climbing trees. She found bugs and a lizard that the other children walked past. She liked the feel of mud on her feet as she walked into a small pond. She favored clothing that covered her limbs and was made from cotton knit fabric. Her mother would often dress her in a jumper or skirt over cotton knit, flowered long-johns. The need to cover the limbs with fabric that hugs the body is characteristic of the child who needs continuous tactile input (Cook, 1990).

In contrast, a four-year-old male with autism was observed who did not like clothing. He would remove his shirt, socks, and shoes, and pull his pant legs up as far as possible. These are characteristics of tactile defensiveness (Larson, 1982). Dr. Temple Grandin (1988, 1994) who has autism, shared several sensory issues related to clothing. The tags sewn onto clothing were not just irritating to Grandin but felt like sandpaper. Grandin found it difficult to adapt to changes in seasonal clothing; for example, changing from pants in the cold season to wearing shorts in the warm season. She had to wash new underwear about twenty times before she could tolerate it against her skin.

While individuals with autism spurred this research interest, they were not included in the study. Often children with autism do not use verbal communication. The verbal communication of subjects was important in this study as wearer response to needs, to prototype development, and to field testing evaluation. In addition, the literature revealed that while there are many sensory issues with individuals with autism, brain abnormalities may be an overriding factor (Bauman & Kemper, 1985; Courchesne, Yeung-Courchesne, Press, Hesselink, & Jemigan, 1988). Therefore, children with verbal skills and sensory integrative dysfunction but with no overriding central nervous system damage were included in the study.

To further develop the problem, possible sites for data collection were visited. During site visits I observed occupational therapy sessions of children diagnosed with sensory integration dysfunction, talked with therapists, and experienced the activities and equipment used during therapy. Two sites were visited on six days. The site visits were essential in selecting the population, preschool children with sensory integrative dysfunction, and the occupational therapy environment for this study.

Sensory Integrative Populations

The site visits provided opportunity to observe children with sensory integrative dysfunction. Children with sensory integrative dysfunction are described as children having normal intelligence who are experiencing sensory motor delays or sensory integrative dysfunction in the absence of any overt physical or neurological disorders (Yack, 1989). In addition the children may have mild-to-moderate problems in learning and behavior, especially those problems associated with motor incoordination and poor sensory processing that cannot be attributed directly to central nervous system damage or abnormalities (Fisher & Murray, 1991). Sensory integrative dysfunction is a developmental disorder that is hypothesized to result in disruption of the integration of sensory input (Fisher & Murray, 1991). The diagnosis of sensory integrative dysfunction requires that evidence of the hypothesized underlying basis (deficits in the central processing of vestibular, proprioceptive, or tactile sensory inputs) be present and not attributable to either peripheral or cortical central nervous system dysfunction (Fisher & Murray). When individuals have deficits in processing and integrating sensory inputs, deficits in planning and producing behavior occur that interfere with conceptual and motor learning (Ayres, 1989).

Approximately 15% of all children experience some type of sensory integration problem (Stepp-Gilbert, 1988). A sub-group of the population with sensory integration dysfunction is children with learning disabilities, whose sensory deficits are without other apparent cause (e.g., emotional problems, mental retardation, peripheral sensory loss, and neurological damage or abnormalities) (Fisher & Murray, 1991). Approximately 10% of school age children have a disability; most (over 50%) of the children with a disability have a learning disability. Of these 50%, over two-thirds of the children have sensory processing problems (Schaffer, Law, Polatajko, & Miller, 1989; Yack, 1989).

Children with mental retardation, cerebral palsy, spina bifida, brain injury, autism, or other developmental disorders attributable to central nervous system pathology may have concurrent deficits in sensory integration. Symptoms that look like sensory integration dysfunction are probably not due to deficits in integrating the sensory inputs per se, rather, both their impairments in sensory processing and their other deficits can be attributed to the brain pathology (Fisher & Murray, 1991). However, sensory integration methods have been used with these populations to enhance sensory processing.

To assist in the definition of the population of children with learning disability and sensory integration dysfunction, Schaffer et al., (1989) did a descriptive analysis. Results indicated that children with learning disability and sensory integration dysfunction were similar to other children with learning disability in terms of gender and IQ distribution, developmental history, and academic achievement. That is, the group had a greater proportion of males than females; a fairly large percentage of IQ scores in the lower end of the normal range; particular developmental delay in the area of speech development; and the greatest academic deficits in language and reading. Differences between the groups of children with learning disability and the children with learning disability and sensory integration dysfunction (LD/SD) was the LD/SD children had increased emotional/behavioral disorders evident in attention and concentration problems, poorly developed speech, a lack of social relationships, and immaturity of behavior. The LD/SD sample also had deficits in gross and fine motor performance.

In an effort to identify patterns of sensory dysfunction, Ayres (1965, 1966, 1972d, 1977a) completed factor-analytic studies using the Southern California Sensory Integration Test data from children with learning disability or perceptual motor disability and children without disability. The patterns of dysfunction included: dyspraxia (somatosensory-based dyspraxia), poor bilateral integration associated with vestibular-proprioceptive dysfunction, poor post-ocular mechanisms (vestibular bilateral integration disorder), tactile defensiveness, poor form and space perception, auditory-language dysfunction, and poor eye-hand coordination. In 1989, using the Sensory Integration and Praxis Test, Ayres presented the following patterns of dysfunction: somatosensory processing deficits, poor bilateral integration and sequencing, impaired somatopraxis, poor praxis on verbal command, visuopraxis factor (poor form and space perception, visual construction deficits, visuomotor coordination deficits), and generalized sensory integration dysfunction.

Behaviors of Children with Sensory Integrative Dysfunction

A child with sensory integrative dysfunction will typically exhibit more than one of the following behaviors. In addition, individuals may vary in their sensory responses depending on their mood, the time of day, and other environmental factors (Koomar & Bundy, 1991).

1. Overly sensitive to touch, movement, sights, sounds, or smells. This sensitivity may be manifested in behaviors such as irritability or withdrawal when touched; avoidance of certain textures of clothes or foods; drops things frequently; distractibility; fearful reaction to ordinary movement activities, such as those typically found on a playground; dislike of certain odors, lights, and noises; dislike of getting hands dirty; and dislike of going barefoot (Ayres, 1979; Stepp-Gilbert, 1988).

2. Under-reactive to sensory stimulation. In contrast to the overly sensitive child, an under-responsive child may seek out intense sensory experience such as body whirling or crashing into objects (Ayres, 1979). The child may seem oblivious to pain or to body position. Some children fluctuate between the extremes of over- and under-responsiveness.

3. Activity level that is unusually high or unusually low. The child may be constantly on the move or may be slow to activate and fatigue easily (Ayres, 1979). Again, some children may fluctuate from one extreme to the other.

4. Coordination problems. Coordination problems can be seen in gross or fine motor activities. Some children may have unusually poor balance; appear clumsy; fall frequently; bump into objects; have difficulty holding a prone position, airplane posture, and riding a bicycle; have poor eye-hand coordination; poor motor planning; difficulty coloring between lines, putting puzzles together, cutting with scissors, tying shoes, zipping, and buttoning clothes; break toys easily; and

drops things (Ayres, 1979).

5. Delays in speech, language, motor skills, or academic achievement. These delays may be evident in a preschooler along with other signs of poor sensory integration. In a school-aged child, there may be problems in some academic areas despite normal intelligence. (A parent's, 1991).

6. Poor organization of behavior and poor self-concept. The child may be impulsive or distractible and show a lack of planning in approach to tasks. Some children have difficulty adjusting to a new situation. Others may react with frustration, aggression, or withdrawal when they encounter failure. (A parent's, 1991).

Sensory Integration Theory

Sensory integration theory postulates that learning is dependent on the ability of normal individuals to take in sensory information derived from the environment and from movement of their bodies, to process and integrate these sensory inputs within the central nervous system, and to use this sensory information to plan and organize behavior (Ayres, 1989; Fisher & Murray, 1991). Sensory integration theory was developed to explain an observed relationship between (a) deficits in interpreting sensory information from the body and the environment and (b) deficits in academic or neuromotor learning in some individuals who demonstrate learning disabilities or clumsiness (Fisher & Murray, 1991).

Sensory integration is the ability of the brain to organize and interpret sensory information for appropriate use (Ayres, 1972b; Scardina, 1981). Sensory integration is in part responsible for the development of adequate perception, language, cognition, academic skills, emotional maturation, behavior control, the ability to cope with stress, to move freely without fear, and to perform without an aversiveness to movement or touch (Scardina, 1981). Sensory integration and the corresponding adaptive behaviors lead to organized and appropriate occupational behavior, including self-care and self-management, play, and academic skills (Fisher & Murray).

Assumptions of Sensory Integration Theory

Fisher and Murray (1991) identify five assumptions of sensory integration theory largely based on the work of Ayres (1972b, 1979, 1989).

1. Neural plasticity. Intervention procedures derived from sensory integration theory are hypothesized effect changes in the brain. These changes are based on the assumptions of sensory integration theory that there is plasticity within the central nervous system. Plasticity refers to the ability of brain structures to change or to be modified.

2. Developmental sequence. A second assumption is that the sensory integrative process occurs in a developmental sequence.

3. Nervous system hierarchy. The brain functions as an integrated whole but is comprised of systems that are hierarchically organized. Higher-level integrative functions evolved from and are dependent on the integrity of lower-level structures and on sensorimotor experience. Higher

(cortical) centers of the brain are viewed as those that are responsible for abstraction, perception, reasoning, language, and learning. Sensory intake, integration, and intersensory association, in contrast, are viewed as occurring mainly within lower (subcortical) centers. Further, lower parts of the brain are conceptualized as developing and maturing before higher-level structures, which are thought to be dependent, in part, on the development and optimal functioning of lower-level structures.

4. Adaptive behavior. The fourth assumption of sensory integration theory is that an adaptive behavior promotes sensory integration, and, in turn, the ability to produce an adaptive behavior reflects sensory integration. Adaptive behavior is one that is purposeful and goal-directed. It is a behavior that enables the individual to successfully meet the just right challenge and learn something new.

5. Inner drive. The final assumption is that individuals have an inner drive to develop sensory integration through participation in sensorimotor activities.

Dysfunction of the Senses

Sensory integration focuses primarily on three basic senses: proprioceptive, tactile, and vestibular. The inter-relationship among these three senses is complex, as they allow individuals to experience, interpret, and respond to different stimuli in their environment (Hatch-Rasmussen, 1996). The three sensory systems are discussed below.

Proprioceptive sense. The proprioceptive sense refers to components of muscles, joints, and tendons that provide a person with a subconscious awareness of body position and movement (Matlin & Foley, 1997). Proprioceptive feedback comes primarily from receptors in muscle spindles, mechanoreceptors of the skin, and motor signals which are stimulated by active movement of muscles and joints (Fisher, 1991; Matlin & Foley). Fisher postulates that producing an adaptive behavior against resistance may be the most effective means available for generating proprioceptive feedback. Activities that provide proprioceptive feedback are extending the head and upper trunk against gravity from the prone-lying position, extending weight-bearing limbs while jumping on a trampoline, or flexing arms to swing on a suspended trapeze (Ayres, 1979; Fisher). A vestibular receptor, the labyrinth, also provides proprioceptive feedback. When proprioception is functioning efficiently, an individual's body position is automatically adjusted in different situations; for example, sitting properly in a chair and stepping off a curb smoothly (Ayres, 1979). It also allows individuals to manipulate objects using fine motor movements, such as writing with a pencil, using a spoon to drink soup, and buttoning one's shirt (Ayres).

Vestibular sense. The vestibular system has three major functions: (a) subjective awareness of body position and movement in space (Matlin & Foley, 1997), (b) postural tone and equilibrium, and (c) stabilization of the eyes in space during head movements (Fisher, 1991). The vestibular receptors are the hair cells (cristae) located within the semicircular canals, the utricle, and the saccule of the vestibular labyrinth, which are stimulated by movement of the head and by gravity (Fisher).

Dysfunction within this system may be hypersensitivity to vestibular stimulation and fearful reactions to ordinary movement activities (e.g., swings, slides, inclines, ramps). It may be difficult to maintain balance, climb or descend stairs or hills. It may also be impossible for a student to look up at the blackboard and back down at the paper without losing their place (A parent's, 1991). On the other extreme, the children may actively seek very intense sensory experiences, such as excessive body whirling, jumping, and spinning (Cook, 1990).

Activities that provide semicircular canal stimulation are rotation or spinning in a suspended net hammock. Utricular stimulation is provided by lying prone over a stationary therapy ball or barrel. (Ayres, 1979; Fisher, 1991).

Tactile sense. Tactile receptors are found throughout the skin and are activated by externally applied stimuli such as touch, pressure, pain, and temperature (Royeen & Lane, 1991). These receptors carry information to the somatosensory cortex in the brain (Matlin & Foley, 1997).

Two patterns of tactile dysfunction, tactile defensiveness and poor tactile discrimination, have been identified. These two types of dysfunction may or may not occur concomitantly. Moreover, the behavioral manifestations of tactile dysfunction can vary between individuals and even within a particular individual over time (Royeen & Lane, 1991).

Tactile defensiveness. Tactile defensiveness refers to observable aversive or negative behavioral responses to certain types of tactile stimuli that most people would find to be non-noxious (Royeen & Lane, 1991). It is characterized by a collection of the following behaviors:

1. Avoidance of touch. Avoids certain styles or textures of clothing, or conversely, an unusual preference for certain styles or textures of clothing. Preference for standing at the end of a line to avoid contact with other children. Tendency to pull away from anticipated touch or from interactions involving touch, including avoidance of touch to the face. Avoidance of play activities that involve body contact, sometimes manifested by a tendency to prefer solitary play.

2. Aversive responses to non-noxious touch. Aversion or struggle when picked up, hugged, or cuddled. Aversion to certain daily living tasks, including baths or showers, cutting of fingernails and hair, and face washing. Aversion to dental care.

3. Atypical affective responses to non-noxious tactile stimuli. Responding with aggression to light touch to arms, face, or legs. Increased stress in response to being physically close to people. Objection, withdrawal, or negative responses to touch contact, including those encountered in the context of intimate relationships.

Poor tactile discrimination. Poor tactile discrimination is the inability to identify the temporal and spatial qualities of tactile stimuli (Royeen & Lane, 1991). It is the inability to optimally perceive and organize incoming discriminative touch information for use. Poor tactile discrimination or perception may include difficulty in discriminating where and how many times one is being touched, as in tactile localization, two-point discrimination, and finger identification; impaired ability to recognize the shape of an object though active manipulation, as in haptic perception; and inefficiency in how one tactually explores an object or environment to solicit additional cues which give meaning about that object or environment, as in active touch. Poor tactile discrimination may also contribute to an impaired awareness of self.

Treatment for tactile defensiveness may include covering swings and other equipment with various textured materials (e.g., carpeting, corduroy, sheepskin). When the individual lies on, sits on, or firmly hugs the equipment, during an activity, he/she receives deep touch-pressure (Koomar & Bundy, 1991).

Linkous and Stutts (1990) used electromyographic (EMG) readings to assess whether surface textures other than the usual slick vinyl or naugahide coverings of frequently used apparatus would increase muscle tone for hypotonic and developmentally delayed children. The sample included thirteen children, one through four years of age. Six children were diagnosed with Down Syndrome, the other children were cited as having "rare conditions." The experimental surfaces included (a) slick: uncovered vinyl, (b) covered: vinyl covered with high grade cotton sheeting, (c) fuzzy: soft plush bath mat of high luster velvet pile made with two-ply nylon yarn with latex backing, (d) covered rough: rubber doormats covered with high grade cotton sheeting, and (e) rough: a rubber doormat. As the surfaces upon which the children lay became more textured, the muscle tone increased significantly. The surfaces with the least texture, covered-slick and slick, had the lowest EMG reading. The covered rough and rough surfaces had the highest readings.

Enhanced tactile information can be provided by brushing the skin with wide paint brushes, surgical brushes and textured mitts, playing in containers of plastic balls, finding objects hidden in containers of dried beans or rice, burying the body under large pillows, rolling over therapy balls, having the therapist roll a large ball over the back and limbs, and vibration from vibrators (Koomar & Bundy, 1991). Individuals usually find deep touch-pressure (or other forms of enhanced tactile intake) to be most acceptable when applied to their arms and legs rather than to their faces or other body areas (Koomar & Bundy, 1991).

Koomar and Bundy (1991) suggest that the child, rather than the therapist, administer the stimulation (vibrator). In this way, the child is in control and can select the areas of the body on which to apply vibration, the type of intake desired, the relative pressure with which it is administered, and the length of time it will be applied (Koomar & Bundy).

While deep touch-pressure usually is the type of enhanced tactile intake most commonly recommended for decreasing tactile defensiveness, some children may prefer light, rapid stimulation (Koomar & Bundy, 1991). Ayres (1972b) hypothesized that some individuals may perceive light touch as deep touch-pressure.

Senses Summary

Dysfunctions in one or more of the senses is a disorder in which sensory input is not integrated or organized appropriately in the brain and may produce varying degrees of problems in development, information processing, and behavior. An individual may be hyper- or hypo-responsive to sensory input, activity level may be either high or unusually low, a child may be in constant motion or fatigue easily, and some children fluctuate between these extremes.

Play and Therapy

The observations at the rehabilitation centers brought out the importance of play in the therapy environment. Often the activities revolved around a play theme. Michelman (1974) in her chapter "Play and the deficit child," identified play as a crucial part of a child's treatment that influences behavior, thinking, and performance of the child, as well as provides the child with a sense of control over his or her world. The child's environment should engage the senses but neither overstimulate nor underestimate the child's potential (Michelman, 1974). Michelman identified four criteria for structuring play experiences for children with disabilities: (a) tasks that gain and hold interests, (b) children and adult role models, (c) time for quiet reflection, and (d) opportunity to pace him/herself.

Play is the transaction between an individual and the environment that is intrinsically motivated, internally controlled, and free of many of the constraints of objective reality (Bundy, 1991). Bundy states a balance between the three play factors must be established by the therapist. The neurophysiological principles of sensory integration theory need to be integrated into natural play activities with an appreciation for the proper adaptive behavioral responses (Scardina, 1981). Equipment design should allow for maximum play, while involving full body movement (Scardina).

Research comparing the play of normal boys and boys with sensory integrative dysfunction indicate that the dysfunction does not always result in play deficits (Bundy, 1989; Clifford & Bundy, 1989). Bundy compared the play skills of 31 preschool aged boys with sensory integrative dysfunction and 30 preschool aged boys with normal sensory processing. The Preschool Play Scale was used to test four components: (a) Space Management, which is play involving large muscles; (b) Material Management, which is fine motor play skills; (c) Imitation, which involves imitation, imagination, and dramatization; and (d) Participation, which is social interaction, cooperation, and communication. The group of boys with sensory integration dysfunction scored significantly lower than the boys with normal sensory processing on the Space Management, Material Management, and the Participation components of the play scale. The groups did not differ on the Imitation component. Although the boys with sensory integrative dysfunction scored significantly lower than the boys with normal sensory processing on three components of the play scale, many of the boys with sensory integrative dysfunction had age-appropriate skills in one or more areas of play.

Clifford and Bundy (1989) compared the play preferences of boys with sensory integrative dysfunction and boys with normal sensory processing. There was no difference between the groups with regard to play preference. Both the normal and the sensory integrative dysfunction groups preferred toys representing sensorimotor play over construction and symbolic toys.

Imaginative play is an important stage in the child's (two through seven years of age) mental development as he/she assimilates reality at his/her own level of understanding through imitative and make-believe play (Piaget, 1962). Stone (1965) elaborated on the roles or identities that children assume during make-believe or dramatic play. The roles are generally anticipatory and fantastic. Anticipatory roles are those that the child might realistically enact or encounter in later life. Fantastic roles are those that the child will seldom, if ever, enact or encounter in real life. Stone suggests that fantasy play serves to retain past myths, legends, villains, and heroes of the society, whereas anticipatory play provides a context for rehearsal for adult roles. By acting out roles, the child develops a conception of their own attitude or role as differentiated from and related to the adopted role (Stone). Stone noted the importance of costume during fantasy play, by stating "this phase of play in the development of the self cannot be accomplished without costume. . . costume is a kind of magical instrument" (p. 237).

Davis (1983) found that clothing influenced the play behaviors of preschool females without disability. Two garments, called the Make-believe Concept and the Manipulative Concept, were designed to test for make-believe play and creativity with 36 preschool (4- to 6-year-old) females. The garments were overalls, where the Make-believe Concept garment featured abstract surface designs, and the Manipulative garment featured a removable apron pocket filled with shapes. There was an increase in imagination scores and an increase in the amount of time spent in make-believe play while wearing the garments.

Interviews

Talking about sensory issues with a parent whose child is autistic and several therapists helped to direct and develop the problem of the study. The conversations brought out issues on how textiles and apparel can aid or hinder the development of children with sensory impairments. Talking with the therapists aided in site selection and sample selection criteria.
The mother of the child with autism shared an idea to promote peer interaction and provide proprioceptive and tactile input. The mother constructed a "human hamburger," where the hamburger, bun, lettuce, cheese, pickles, etc., were constructed of a variety of fabrics (fur, lace, vinyl, corduroy, etc.) and stuffed with fiberfill, foam rubber, and bean bag pellets (Green, personal communication, September 1996). In this way, the child with autism and the other children could experience several textures on the external and internal areas of the objects. The human hamburger promoted the idea of stacking the hamburger parts and physically stacking the children. This provided an opportunity for the child with autism to interact with peers while gaining tactile and proprioceptive (deep pressure) input.

In an effort to decrease toe walking, Green (personal communication, May 1998) had her daughter wear tap shoes on walks. The heel to toe walk was reinforced by the auditory sound created by the tap. Green stated the importance of allowing her daughter choices and believed that the toe walking did provide needed input. Therefore, the tap shoes allowed the child the option to toe walk or heel to toe walk.

Parents have adapted or created products to protect their children with autism from self-injurious behavior and thus have also eliminated the attention that the parent gave to the behavior. For wrist biting, a leather oval with thumb hole attached to ribbing and buckled around the wrist helped to stop one child's self-injurious behavior (Schopler, 1995). Thickly padded gloves were created for a child who was preoccupied with extreme squeezing of his knuckles (Schopler, 1995). Similarly, padded mittens were used to protect the hands of a child who banged his hands on hard surfaces (Tustin, 1992).

White (personal communication, April 1996), a special education instructor, found she should wear cotton clothing when working with one of her students with autism. The child could not tolerate fabrics that contained other fibers, especially polyester. The child would physically withdraw from White and was not able to finish sessions. This example brought out the importance of not only considering clothing for the child with sensory issues but also clothing of significant others.

Talking with individuals at the occupational therapy centers helped to develop the problem in terms of site selection, negotiating access, and selecting subjects. The site selected was a teaching center where students working on therapist degrees serve practicum hours. Therefore, the children were accustomed to new people working with them or observing them. Another reason for selecting the site was the higher number of children who matched the sample criteria in the selected program over the non-selected program. Early site visits were used to arrange a plan of action and access. Three therapists and seven child subjects were selected based on sample criteria and schedule coordination. Consent forms were presented to the therapists involved who shared the information with the supervising therapist. The forms explained the protocol for research, consent forms for all involved in research, and steps taken to maintain confidentiality. Permission forms from the Center and from the Institutional Review Board were given to the parents of the child subjects by sending the forms home in the child's back pack.

The support of the family was identified as a factor in the success of children in occupational therapy (Case-Smith, 1997). "When students were successful, the parents were described to be part of the team. Parental support of the child was always identified to be a foundation for the child's performance" (Case-Smith, p. 149). Avenues for parental support and child success were regular communication between the occupational therapist and parents, working as a team, making families feel welcome, and a carryover of occupational therapy activities in the home environment (Case-Smith).

Experiences

The idea that pressure and weight could provide calming and improve behavior in children with sensory issues (Grandin, 1992; Imamura, Wiess, & Parham, 1990) especially from apparel products (Joe, 1998; Occupational, 1996), led me to experience this pressure. A two-pound weighted sleeve was experienced on different parts of my body. When placed around the neck and on the body, I found it to be calming. However, when I constructed a ten-pound sleeve and placed it around my neck, I became nauseous, dizzy, and got a headache. When the ten-pound sleeve was placed on my legs it felt relaxing.

During site visits I experienced the vestibular integrating equipment of the platform swing, frog swing, bolster swing, and cargo net swing. Any spinning made me nauseous and dizzy, but slow swaying was tolerated. I also explored therapy balls, foam shapes, games, scooters, vibrators, and brushing with a surgical brush.

Deep Pressure and Tactile Stimulation

One method of proprioceptive and tactile sensory stimulation is deep pressure or deep touch pressure. Deep touch pressure is the type of surface pressure that is exerted in most types of firm touching, holding, and stroking (Grandin, 1992). Temple Grandin, an adult with autism, has reported that deep pressure applied to her body provides a calming effect. As a child, Temple would lay under the sofa cushions and have her siblings sit atop the cushions. As an adult, Temple designed a squeeze machine to provide great amounts of pressure over her body (Grandin, 1992).

The squeeze machine consists of two padded side boards which are hinged at the bottom to form a V-shape. The user steps into the machine and lies down on the inside in the V-shaped space. Deep touch pressure stimulation is applied along both sides of the person's body, with lateral pressure pushing inward onto the body. The user has control over the amount of pressure applied. A lever-operated pneumatic valve, which is connected to an air cylinder that pulls the side boards together, allows the user to self-regulate the amount of pressure applied. For adults, up to 95 pounds of pressure can be applied and for children under the age of nine, the pressure is set for 40 to 50 pounds.

The squeeze machine reduced anxiety and nervousness and increased the tolerance of touch for Grandin. In addition, the use of the squeeze machine allowed Grandin to reduce the amount of medication she had been taking. The squeeze machine's pressure also had a relaxing effect on adults without disability (Grandin, 1992). The squeeze machine has been used as therapy for children with autism, attention-deficit hyperactivity disorder, learning disability, pervasive developmental disorder, and Tourette's disorder. Anecdotal reports find the machine is calming, inhibits tantrums, and reduces stereotypical behavior (Grandin, 1992). Imamura et al., (1990) found a reduction in hyperactivity in four of nine children using the squeeze machine. The children were diagnosed with either autism or pervasive developmental disorder. The squeeze machine in available for approximately $2000 (Grandin, 1992).

After reading about the effects of deep pressure, I recalled incidences of pressure that provided relaxation. To relax in bed, I would often place an additional blanket on my body, not for the warmth, but for the weight. My son often requested an adult to sit on him before he played soccer. He said this helped him relax before a soccer game.

The effects of deep pressure on normal adults were analyzed by Krauss (1987) using an air mattress apparatus that applied squeezing pressure to the body. The subjects reported mild subjective reductions in anxiety and were found to have mildly increased heart rate, but neither finding reached statistical significance. However, subjective responses showed an increase in relaxation.

Zissermann (1992) studied the effects of wearing an anti-burn scar pressure garment in reducing self-stimulatory behaviors (hitting hands together and hitting surfaces) in an eight-year-old girl with autism. The idea to use a pressure garment to consistently "hug" the child, resulted from observations that the child became calm and occasionally smiled when deep pressure was applied in the forms of firm hugs and back rubs. A pilot test using arm length gloves constructed from support pantyhose, indicated that while wearing the gloves self-stimulating behaviors decreased. When wearing the anti-burn scar pressure vest with sleeves, hand slaps decreased by 54.5% while the frequencies of hitting a tabletop surface increased by 2.5% (right hand) and 9.6% (left hand). The results of the study were inconclusive and Zissermann did not recommend the wearing of an anti-burn scar pressure garment.

Padded arm splints and woven elastic bandages wrapped around the upper and lower extremities were used to provide deep pressure and tactile input for a 13-year-old nonverbal autistic boy with severe mental retardation (McClure & Holtz-Yotz, 1991). While wearing the splints and wraps the boy's self-stimulation and self-injurious behavior decreased, and his ability to interact with others increased, along with a strong desire to wear the splints.

In anecdotal reports, various types of pressure-seeking behavior, such as wrapping arms and legs in elastic bandages, sleeping under many blankets, getting under mattresses, rolling up in a gym mat, and crawling under cushions have been described to produce a calming effect in children with autism (Ayres, 1979; Grandin, 1992; Imamura, et al, 1990) and children with attention-deficit hyperactivity disorder (Ayres, 1979).

Products to wear that provide deep pressure are weighted vests, weighted collars, weighted arm and leg bands, lap and shoulder weights, and weighted quilts. These products are available through therapy product magazines. They have also been constructed by parents and therapists or ready-made apparel (fishing vest) has been adapted. A course assignment in the class Apparel Product Evaluation provided the opportunity to evaluate a product currently on the market and, based on the evaluation, design an improved product. A survey of the use of weighted vests by regional occupational and physical therapists was conducted. The therapists surveyed reported using the weighted vest on children with developmental disabilities to provide calming and sensory input. While wearing the vest some children had reduction in hyperactivity and a longer attention span. No long-term effects were reported from wearing the weighted vest. Based on the survey, several components of dissatisfaction with the vest were noted as: distraction caused by the zipper closure, no means to adjust the fit of the vest, uneven distribution of weights when increasing or decreasing weights due to the weights available and the four pocket placement, high expense of the product, and the lack of prolonged effect. Satisfactory components of the vest were: the denim fabric because it was sturdy, easy care, and was a "good, calming color," easy to use in the classroom, and easy to don and doff. The HAARVEST was created to incorporate the satisfactory features of the current product, adapt or change the unsatisfactory feature, and incorporate new features (Haar & Giddings, 1997). The product was not evaluated.

Liotta-Kleinfeld (as cited in Joe, 1998) conducted a pilot study applying weighted vests to children with and without autism. The children without autism reported that wearing the vest made them feel sleepy but showed no appreciable change in pulse nor blood pressure; whereas, the children with autism had measurable drops in both pulse rate and blood pressure reading.

While the wearing of weighted vests are increasing in elementary schools and therapy treatment programs, the outcomes of wearing weighted vests are largely anecdotal and few parameters exist to guide the use of the vests (Joe, 1998). Liotta-Kleinfeld (as cited in Joe, 1998) reported that for children with autism, the vest initially increases a child's arousal and therefore should be put on several minutes before beginning a scheduled activity and, if left on more than 45 minutes, the vest may produce a rebound effect. Another therapist Blanchard recommended that the vest be removed after 10 to 15 minutes of use (Joe, 1998). The amount of weight used in the vest began at one pound for preschoolers and three pounds for teens (Liotta-Kleinfeld). Blanchard initially weights the child with 5% of child's body weight and increased or decreased the amount of weight as the situation warranted (Joe, 1998).

Sensory Evaluation

Sensory evaluation consists of both standardized testing and structured observations of responses to sensory stimulation, posture, balance, coordination, and eye movements. The occupational or physical therapist may also informally observe spontaneous play and may ask parents to provide information about the child's development and typical behavior patterns. Four of the tests available for evaluating young children are the DeGangi-Berk Test of Sensory Integration (Berk & Degangi, 1983), the Sensory Integration and Praxis Tests (Ayres, 1989), or the earlier version the Southern California Sensory Integration Tests (Ayres, 1972c) and the Southern California Postrotary Nystagmus Tests (Ayres, 1975). The Ayres' battery of tests were designed to contribute to the clinical understanding of children four through eight years of age with mild to moderate learning, behavioral, or developmental irregularities. The tests assess the child's functioning in visual perception, somatosensory processing (touch and proprioception), vestibular processing, eye-hand coordination, and motor planning or praxis. The DeGangi-Berk test provides an overall measure of sensory integration for preschool children ages three to five, and measures postural control, bilateral motor integration, and reflex integration.

Intervention

The goal of therapy for treatment of sensory integration dysfunction is direct intervention to enhance the function of the individual's nervous system and thereby lay foundations for improved motor or academic learning by providing the individual with opportunities to take in enhanced sensory information in the context of active participation in activities that are meaningful to the individual and elicit adaptive behaviors (Koomar & Bundy, 1991). Progress is monitored at 3 to 6 month intervals. Monitoring may involve testing on a number of different types of tests, or it may involve objective documentation of behavioral changes. The duration of therapy typically ranges from six months to two years, depending on the severity and type of problem as well as on the rate and degree of progress (A parent's, 1991). There are no rules about how many activities should be done in a treatment session or how long each activity should last. Activities should be allowed to continue until they are no longer motivating for the client or until the client has mastered the challenge (Bundy, 1991).

Yack (1989) surveyed therapists practicing sensory integration in southern Ontario. Survey results indicated that the sensory integration framework was only one of the strategies used by occupational therapists in southern Ontario in programs for children with sensory integrative dysfunction. The intervention treatments were comprised of varying treatment strategies necessary to meet the needs of individual clients.

The use of sensory integration methods have been tested against other treatment programs. Polatajko, Lay, Miller, Schaffer, and Macnab (1991) evaluated the effect of sensory integration versus perceptual motor treatment on academic achievement, motor performance, and self-esteem of children who have learning disability and sensory integration dysfunction. Both the sensory integration and perceptual motor groups improved on academic and motor measures. Implications suggest that either therapy is equally effective in improving academic and motor performance in children with learning disability and sensory integrative dysfunction, and that therapists may choose the approach they prefer, or use the techniques in combination.

Similarly, Kaplan, Polatajko, Wilson, and Faris (1993) analyzed the effect of sensory integration, perceptual motor treatment, and tutoring on individuals with sensory integration dysfunction and learning disability. There was no statistical difference between the methods. In addition, when comparing tutoring and sensory integration treatments for children with learning disability and sensory integrative dysfunction, Wilson, Kaplan, Fellowes, Gruchy, and Faris (1992) found no significant difference between the two treatment groups. The finding that the sensory integration group improved as much in reading and other academic measures as the tutoring group who received extensive work in those areas supports the theory that sensory integration may be as effective as tutoring in improving academic functioning. Tutoring, however, was as effective as sensory integration in improving motor functioning, which was unexpected.

In three studies, Humphries, Wright, McDougall, and Vertez (1990), Humphries, Wright, Snider, and McDougall (1992), and Humphries, Snider, and McDougall (1993) investigated the efficacy of sensory integration therapy in treating children with sensory integrative dysfunction and learning disabilities. The Humphries et al., (1990) study found one hour of sensory integration therapy per week was superior to a comparable trial of perceptual motor training or no treatment in improving certain aspects of gross motor functioning and motor accuracy in a sample where the majority of children exhibited vestibular dysfunction. The second study (Humphries et al., 1992), which tripled the amount of treatment provided, indicated sensory integration therapy showed an advantage on a measure of motor planning while perceptual motor training was significantly more effective in improving gross motor functioning. Neither study indicated improvement for either type of therapy in cognition, attention, language, self-concept, or academic performance. The third study (Humphries et al., 1993) indicated improvements in sensory integrative functioning from the group receiving sensory integration therapy and the group receiving perceptual motor training. The no treatment group did not show significant sensory integrative improvements.

Ayres' research indicated positive effects from sensory integration therapy for children with learning disability on academic achievement (Ayres, 1972a, 1978), eye-hand coordination (Ayres, 1977b), and language comprehension and language expression (Ayres & Mailloux, 1981). While Ayres' work was recognized as an important influence in the field of occupational therapy (Schaffer, 1984), her work has been criticized (Cummins, 1991; Polatajko, Kaplan, & Wilson, 1992; Schaffer, 1984) for methodological errors.

<u>Summary of Intervention</u>

The ultimate goal of intervention is to facilitate the child's development, self-actualization, and occupational performance. The therapist and the child design and create activities that are motivating to the child, provide controlled opportunities to take in appropriate types and amounts of enhanced sensory information, involve active participation, and require that the client respond adaptively to the challenge (Koomar and Bundy, 1991).

The problem development stage explored the problem and set the parameters for the study. The problem that emerged was to design apparel products that would aid in the integration of proprioceptive, vestibular, and tactile inputs. The parameters for the study included a sample of preschool children with sensory integration dysfunction, who participated in occupational therapy at a rehabilitation center in Virginia. Problem development began with an interest in sensory issues, continued by reviewing the literature, observing and interviewing individuals involved with sensory issues, and through experiences in the environment.

CHAPTER 3

Needs Assessment

The purpose of this study was to use the Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996) to design therapeutic apparel products for children with sensory integrative dysfunction. This chapter presents the needs assessment process of exploring the problem developed in the previous chapter. The needs are assessed for the wearer, the activity, and the environment. That is, three children with sensory integrative dysfunction, who participate in occupational therapy using sensory integrative methods at a rehabilitation center in Virginia. The analyzed needs are then translated into garment specifications. This chapter presents the sample cases; the data collection methods and analysis procedures; the analyses of the environment, the wearer, and the activity; the needs of the environment, the wearer, and the activity; and the resulting garment specifications.

Procedures

The Sample Cases

The wearer participants were three black male children, Matthew (4.6 years of age), Aaron (4.3 years of age), and Bryan (4.5 years of age), whose names have been changed to protect their identity. Occupational therapists at the selected rehabilitation center aided in the child participant selection process. The participant selection criteria was as follows:

1. The children will be professionally diagnosed with sensory integrative dysfunction and receiving occupational therapy that incorporates sensory integrative methods at the selected rehabilitation center.

2. The children will be males and females between the ages of four and six years.

3. The children will not have an overt physical or neurological disorder.

4. The parents or guardians of the child participant will provide permission by reading and signing the informed consent forms.

The wearer sample initially included seven children, six males and one female, participating in occupational therapy at a rehabilitation center in Virginia. The final sample was three males. Reasons for exclusion in the sample were: one white male moved; one black male discontinued therapy; one white male was older than the specified age criteria; and the black female had an overriding central nervous system disorder.

Significant Other Respondents

Interviews were conducted with each child's occupational therapist and a parent. Names of the respondents have been changed to protect their identity. Additional significant others, including a grandparent, a sibling, physical therapists, Primary Care Room instructors, and speech therapists, were also interviewed during the data collection period. The number of interview respondents was eighteen. The interview respondents were females between the ages of twenty-three through fifty years of age, with the exception of a male respondent who was age seven.

Data Collection

The needs of the wearer, the activity, and the environment were developed from the data collected by qualitative methods of observation, interview, and document review. The use of observation, interview, and documents provided data source triangulation (Denzin, 1984; Stake, 1995).

Observations. Each child was observed three half days per week for four weeks. The child was observed during his 40 minute occupational therapy session, and in the Primary Care Room for approximately 10 minutes before and after the therapy session. In addition, some physical therapy sessions were observed, as well as speech therapy if it was a co-treatment with occupational therapy.

I made an effort to be unobtrusive in the environment. The child and therapist were observed from locations where the child's facial expressions could be observed. No interaction occurred unless the therapist requested assistance. The children became accustomed to my presence after one week, as explained in the following field note. "Last week M [Matthew] was interested in me. Since I have been basically ignoring his pleas ('Help me Sherry'), looks, and fits, he is willing to just let me be there. It's sad, I feel like he is disappointed in me because I won't play with him" (field note, March 4, 1998).

I took notes during each observation session, and recorded events as they changed or if there was no change, at five minute intervals. These notes were in the form of lists, documenting what was going on and for how long in relation to the child, the therapist, the activity, and the environment. The notes were hand-written in an observation journal. After each observation session I wrote out descriptive field notes in narrative form. Morning observation descriptive field notes were written at a library near the site during the one and one-half hour noon break. Afternoon descriptive observation field notes were written each evening at my home. I discussed the field notes with the occupational therapist to validate the observations.

Interviews. Structured interviews were conducted with each child's occupational therapist and a parent. Open-ended interview questions sought insight to the child's sensory needs and practices, therapy goals, clothing practices, preferences, and behaviors, and play practices and preferences. Each interview lasted approximately 40 minutes. The interviews took place at a convenient time and location specified by the interview respondent. The locations included the child participant's home, the therapy site, a restaurant, and one telephone interview. The structured interviews were audio recorded using a Sony® micro cassette recorder and transcribed by me. A summary of the interview was verbally presented to informants to enhance validity. (See Appendix A for the list of questions used to guide the interview).

Informal interviews or natural dialogue (Fetterman, 1989) occurred during data collection. They were part of the interaction between the child, the child's occupational therapist, speech therapist, physical therapist, instructors, and myself. Informal interviews with the child participants sought insight to the child's preferences and dislikes for clothing, play, and therapy activities (see

Appendix B). Informal interviews with the instructors and therapists sought perspectives on the child, served to form and validate observation categories, and provided triangulation of information. The informal interviews were recorded as notes during observation sessions and written into field notes as described in the observation section.

Documents. Two types of documents, the Patient Plan of Care: Occupational Therapy and each yearly Occupational Therapy Re-Evaluation, were provided by the rehabilitation center. The Patient Plan of Care: Occupational Therapy document described the child's diagnostic history, therapy needs, and therapy plan. The Occupational Therapy Re-Evaluation document described the long term and short term therapy goals and therapy assessment. The short term therapy goals were evaluated every eight to twelve weeks. The long term goals were normally assessed at one year intervals. Documents for the Patient Plan of Care for physical therapy and speech therapy were not viewed.

Analyses

Analysis of qualitative data is the process of making sense of narrative data (Tesch, 1990). The narrative data included the written descriptive field notes from the observations and interviews, and the information from the documents. Analyses was concurrent with the data collection as recommended by Strauss and Corbin (1990). The aim of the analyses was to divide the data into relevant and meaningful units, yet maintain the connection of data to the overall circumstances under investigation (Tesch, 1990). The units were used to establish needs of the environment, wearers, and activities, and these needs were translated into specifications for garment development.

Analyses of observations, interviews, and documents for each case included the grounded theory procedures of open coding and axial coding as outlined by Strauss and Corbin (1990). Open coding is the "process of breaking down, examining, comparing, conceptualizing, and categorizing data" (Strauss & Corbin, 1990, p. 61). The open coding procedures included assigning concepts to discrete events and then grouping like concepts into categories. The observation categories were guided by the following questions: Where is the child? What is the child doing? What equipment is being used? How is the equipment being used? Why was the activity/equipment selected? What types of sensory input are occurring? Who is interacting with the child? What is the behavior of the child and interacting individuals? What is the dress of the child and interacting individuals? What is going on in the environment?

A dimensional profile or continuum of intensity, duration, and behavior reaction was created for each property of the category. Therefore, each category had several properties, which were then dimensionalized to provide specificity. The dimensional profile was guided by the following questions: What is the duration (in minutes) of the activity? What is the intensity (high, medium, or low, based on the child's concentration, attention, facial expressions, and body language) of the child participating in the activity? What is the behavior (positive to negative, based on child's actions, facial expressions, and verbal comments) of the child participating in the activity?

Axial coding is the "procedures whereby the data are put back together in new ways after open coding, by making connections between a category and its subcategories" (Strauss & Corbin, 1990, p. 97). The analyses of data are presented in the categories of environment, wearers, and activities. Needs for each category are presented and then translated into garment specifications.

Needs

The needs were developed from the data collected about the environment, the wearers, and the wearer's activities, and are presented in the following sections. The environment section presents the facility where the study was conducted. The environment assessment was the result of observations, unstructured interviews, and literature provided by the rehabilitation center. The wearer section describes the wearer through diagnoses, therapy history and goals, sensory systems, motor development levels, self organization and attention to task, play, and clothing practices and preferences. The wearer assessment was developed from observations, parent interviews, therapist interviews, unstructured interviews with the child, instructors, and therapists, and document reviews. The activity section presents the occupational therapy activities used to integrate the sensory systems and increase motor development. The activity assessment was developed from observations, therapist interviews, unstructured interviews with the child, instructors, and therapists, and literature about the Center. The chapter concludes by translating the needs assessment of the environment, wearers, and activities into garment specifications.

Environment

The environment of this study was a rehabilitation center in Virginia. The center used an early intervention program called Focus On Children Using Special Skills (FOCUSS). The goal of the FOCUSS program was to enhance the total development of young children through a combination of multi-disciplinary therapies within a Montessori environment (Center, n.d.). The children were guided in activities using materials that promote communication, refine motor skills, and encourage social interaction and independence (Center, n.d.). An overriding philosophy of the therapy programs is that a child's play is a child's work (F. Pink, personal communication, November 17, 1997; Bundy, 1991). Therefore, the therapy work is a form of play for the child.

FOCUSS is designed for children aged eighteen months to five years, with a wide range of speech, language, and auditory disorders, sensory and motor delays, and other developmental disorders (i.e., autism, pervasive developmental disorder). The children enrolled in FOCUSS may receive therapy services including occupational therapy, physical therapy, and speech therapy while attending the program. When the children were not in therapy they interacted in the Primary Care Room with instructors and children enrolled in the program. The children in the FOCUSS program attended one half day, either two or three days per week. In addition to the FOCUSS program, the rehabilitation center offered therapy services to individuals of all ages and disability diagnoses.

The layout of the rehabilitation center had a reception area, Primary Care Room for preschoolers, Primary Care Room for toddlers, Fine Motor Room, Occupational/Physical Therapy Room, and Speech Therapy Room. In addition, there were various offices for the therapists, instructors, clerical staff, and supplies storage. The children in this study divided their time between the preschool Primary Care Room, the Occupational/Physical Therapy Room, the Fine Motor Room, and the Speech Therapy Room.

The Primary Care Room was a preschool environment based on the Montessori philosophy. The children participated in preschool activities in the Primary Care Room when they were not participating in therapy. The Fine Motor Room had two table and chair areas, where the children worked on fine motor activities. In addition, the Fine Motor Room housed a computer. The Occupational/Physical Therapy Room contained equipment to engage the child's large muscles, including suspended equipment (swings and bolsters), large foam shapes, large balls, balance beams, and scooters.

There were typically six children in each toddler and preschool FOCUSS program session. There were four instructors in the preschool Primary Care Room and each child had an occupational therapist, speech therapist, and physical therapist. There were twelve full-time therapists at the rehabilitation center. The children played in the Primary Care Room with the four instructors and five other children between therapy sessions. The therapy sessions took place in the appropriate therapy room. Several children from both the preschool and toddler group received therapy simultaneously. Each child had his/her own therapist and often an assistant. Therefore, the Occupational/Physical Therapy Room may have five children and eight adults in the room at one time. However, it was more typical to have three children and four adults in the Occupational/Physical Therapy Room.

Summary. The environmental needs for product development are to support the program's goals and therapy philosophy. The categories that emerged from the analysis of the environment were that the product should promote communication between the wearer and the therapist, refine motor skills, encourage social interaction between the wearer and other children, promote independence when interacting in the environment, and be a form of play.

Wearers

The wearer participants in the study, Matthew (4.6 years of age), Aaron (4.3 years of age), and Bryan (4.5 years of age), are black males enrolled in the FOCUSS program at a rehabilitation center in Virginia. They each attended the program three half days per week. Matthew and Aaron attended the morning program and Bryan attended the afternoon program.

All three boys have been diagnosed with Sensory Integrative Dysfunction and Impaired Motor Development. In addition, Aaron and Bryan have Chronic Otitis Media (chronic ear infection). Aaron was also diagnosed with language delay. Sensory motor integration was assessed by professional observation and therapeutic handling. Impaired motor development was assessed with the Peabody Developmental Motor Scales (Folio & Fewell, 1983). The diagnostic descriptions presented above and the therapy history presented below were obtained from the Patient Plan of Care: Occupational Therapy and Occupational Therapy Re-Evaluation documents.

Matthew had participated in occupational therapy and physical therapy since 2.9 years of age (June 1996) and in speech therapy since two years of age. Aaron participated in occupational therapy, physical therapy, and speech therapy from March 1997 (3.2 years of age) until November 1997 and from January 1998 to June 1998. During Aaron's break from therapy he was prescribed methylphenidate (ritalin) to assist his behavior organization. Bryan had been receiving occupational therapy, physical therapy, and speech therapy since 1.11 years of age (October 1995). (See Table 1).

The long term occupational therapy goals of Matthew, Aaron, and Bryan as recorded on the Patient Plan of Care: Occupational Therapy documents were to:

1. Improve motor planning and reflex integration. Motor planning is the ability to plan and execute motor tasks (Ayres, 1979). Reflex integration is the skill and performance in enhancing and supporting functional neuromuscular development through eliciting and/or inhibiting stereotyped, patterned, and/or involuntary responses coordinated at conscious and unconscious levels (Fisher & Murray, 1991) as seen in postural reactions, righting and equilibrium reactions, and grasp reflex (Folio & Fewell, 1983).

2. Improve self organization and attention to task.

3. Improve hand strength and fine motor skills. Fine motor skills consist of tasks that require precise movements of the small muscles of the body, that include skills in grasping, hand use, eye-hand coordination, and manual dexterity (Folio & Fewell, 1983).

4. Improve perceptual motor skills. Perceptual motor skill is the ability to interpret sensory input through motor experiences as opposed to abstract concepts (Folio & Fewell, 1983). Perceptual motor activities include stationary and dynamic balance, coordination of perception and movement (catching, bouncing, or kicking a ball), and fine motor skills of constructing with objects and copying (Folio & Fewell, 1983).

5. Improve overall sensory integration. Sensory integration is the integration and interpretation of sensory stimulation from the environment by the brain, that focuses primarily on the tactile, vestibular, and proprioceptive senses (Ayres, 1979).

Sensory systems. The proprioceptive systems of Matthew and Aaron were documented as under-reactive and observed through their impaired position sense, poor body awareness, poor posture, low muscle tone, poor muscle co-contraction, and poor motor planning. Matthew was observed walking on his toes on a regular basis. Matthew's therapist noted that he often laid his head on tables and equipment, indicating low neck muscle tone (B. Blue, personal communication, March 18, 1998). Bryan's proprioceptive system was documented as modulated or functioning at his age level, as observed through good balance, good muscle co-contraction, and joint position sense. Even through Bryan's proprioceptive system was modulated, he participated in activities to maintain his proprioceptive system and integrate his vestibular system and improve motor skills.

The vestibular systems of all three boys were poorly modulated. The documents indicated that Matthew's, Aaron's, and Bryan's ocular motor control, muscle tone, balance and movement perception were affected causing problems with motor planning, eye-hand coordination, motor skill development, postural security, and reflex integration. Bryan's mother (personal communication, April 1, 1998) noted improvement in Bryan's vestibular system. When Bryan

Table 1

Wearer Profile of Therapy History and System Evaluation

	Matthew	Aaron	Bryan
Age	4.6 years	4.3 years	4.5 years
Diagnosis	Sensory Integrative Dysfunction; Impaired Motor Development	Sensory Integrative Dysfunction; Impaired Motor Development; Chronic Otitis Media; Language Delay	Sensory Integrative Dysfunction; Impaired Motor Development; Chronic Otitis Media
Therapy Attendance	June 1996-June 1998	March 1997-November 1997; January 1998-June 1998	October 1995-June 1998
Medication	None	Methylphenidate (ritalin)	None
Proprioceptive System	Under-reactive	Under-reactive	Modulated
Vestibular System	Poorly modulated	Poorly modulated	Poorly modulated
Tactile System	Poorly modulated	Fairly modulated	Modulated
Gross Motor	12 month delay	10 month delay	5 month delay
Fine Motor	19 month delay	12 month delay	11 month delay

first began therapy he was unable to tolerate swinging or spinning. His system now tolerates swinging and spinning.

The tactile systems of the three boys were diverse. The systems ranged from poorly modulated to modulated. Matthew's tactile system was documented as poorly modulated. Matthew craved tactile inputs, he frequently touched objects, pressed objects against his body, and requested water play when in the Primary Care Room (B. Blue, personal communication, March 18, 1998; observation). Tactile experiences were calming and had an inhibitory affect on him. When a vibrator was pressed against Matthew (generally his back, arms, legs, and cheek), he responded by relaxing his body (observation). His cheek and jaw were a favored area to place the vibrator. Aaron's tactile system was documented as fairly modulated. Aaron explored his environment through touching; however, he was easily overstimulated and when this occurred he did not allow enough time to take in the information because he moved quickly on to the next activity (R. Gray, personal communication, March 18, 1998; document review). Bryan's tactile system was documented as modulated. Even though his tactile system was modulated, Bryan still participated in tactile integration activities to maintain his level of tactile integration and aid in the integration of his vestibular system and improve his motor skills.

Olfactory, gustatory, and auditory systems were not evaluated on the diagnostic evaluations. However, the therapists commented on the systems. Blue (personal communication, March 18, 1998) and I noted that Matthew smelled his environment and also put objects in his mouth. While Blue recognized a need to integrate the olfactory and gustatory senses, no integration activities were being used. Pink (personal communication, March 23, 1998) also recognized the need for olfactory integration, as well as auditory integration, for Bryan and other children at the rehabilitation center. Aaron's therapist did not recognize any olfactory, gustatory, or auditory needs for Aaron.

The olfactory, gustatory, and auditory needs were not being addressed because they were not part of the therapy goals stated on the Patient Plan of Care documents. Matthew's therapist (B. Blue, personal communication, March 18, 1998) mentioned the center had a smell box in the past, but the smells dried out and it was not replaced. Scented markers had also been used in the past to stimulate the olfactory sense (B. Blue, personal communication, March 18, 1998).

Motor development. Matthew, Aaron, and Bryan were documented with impaired motor development. They had delays in gross motor skills and perceptual and fine motor skills. Matthew had a 12 month delay in gross motor skills and a 19 month delay in fine and perceptual motor skills. Aaron had a 10 month delay in gross motor skills and a 12 month delay in fine and perceptual motor skills. Bryan demonstrated a 5 month delay in gross motor skills and an 11 month delay in fine and perceptual motor skills. The motor development delays were obtained from the Occupational Therapy Re-evaluation documents. Refer to Table 1 for a summary of the wearers' motor delays.

Self organization and behavior. Matthew displayed hyperactivity, distractibility, had trouble structuring activities, had a short attention span, and had poor overall self organization (Occupational Therapy Re-evaluation; observation; B. Blue, personal communication, March 18, 1998; parent interview, March 17, 1998; instructor dialogue, March 1998). Managing Matthew's negative behavior was a daily challenge. It was difficult for Matthew to stay on task during therapy. He would often leave the activity and run the room. He often had to be controlled with time-out or keep focused by promises/threats of, "If you do good, you can go outside; if you are not good, you will not be able to go outside". Matthew would tantrum when he didn't get his way. His behavior in the Primary Care Room was positive when he was involved in water play; otherwise, he had trouble selecting an activity and staying on task with that activity. When he was having bad days, he would kick and yell at the other children. As a consequence, he would have to spend time-out in the hall with an instructor, then return to the care room, apologize, and pick an activity.

Aaron's observed behaviors were inconsistent with the documents reviewed. The documents described Aaron as an outgoing and active child. Aaron was observed to be shy and reserved. Aaron's therapist hypothesized that the behavior discrepancies may reflect Aaron's use of methylphenidate (ritalin), which began during Aaron's three month absence from therapy. In the Primary Care Room Aaron played by himself, did not seek out playmates, and rarely participated in group activities. His attention span at each play area was good, and he played with a variety of items. A Primary Care Room instructor said he is the only child who has tried everything in the Primary Care Room.

Throughout the first two weeks of observation Aaron did not transition to the Occupation/Physical Therapy Room (OT/PT room). He became overstimulated and out of control when trying to make the physical transition to the OT/PT room. Two weeks into the observations, methylphenidate (ritalin) was given to Aaron 60 minutes later than usual. On this day he was able to make a smooth transition to the OT/PT room. His medication continued at the later time, and he was able to participate in the OT/PT room for the remaining two weeks of observation. Due to previous violent outbursts, the therapists were cautious with Aaron and avoided overstimulation.

Bryan was observed as having a positive relationship with the children and readily participated in his afternoon program. Bryan was an active child with an impulsive nature, which placed he and others in unsafe situations (F. Pink, personal communication, March 23, 1998; parent interview, April 1, 1998; Patient Plan of Care document). Bryan's mother shared a story where Bryan saw a bird and wanted to be like a bird and consequently "flew" into the street (April 1, 1998). These impulsive behaviors concerned his mother for his safety and the safety of his siblings.

<u>Play.</u> A strength of Matthew's play was his active imagination (observation; B. Blue, personal communication, March 18, 1998; parent interview, March 17, 1998; Patient Plan of Care document; instructor dialogue). He participated in anticipatory and fantasy play and changed his voice for different characters. His favored anticipatory role was playing his father ("Big Matthew") while caring for a doll he referred to as "Little Matthew.” He enjoyed action figures and superheroes, such as Batman, Robin, Superman, Beetle Borgs, Spiderman, and Power Rangers. His mother said he was very rough with his toys and often broke them. Matthew did not participate in costume holidays but had used household linens as a cape in order to "fly" around the house acting like a superhero. Matthew enjoyed attention and was often asked to sing and dance at the Center. His favorite song to sing was "Do you love me?.” He craved water activities and selected this activity in the Primary Care Room on a regular basis.

Matthew had limited opportunities at his home to participate in gross motor and fine motor activities. His home play was limited to play in his bedroom with action figures and watching television. In addition to the rehabilitation center three mornings per week, Matthew participated in a pre-school program five afternoons each week.

Aaron was observed to be non-social and usually played by himself in the Primary Care Room. In contrast, his mother said he played well with the children at church and at daycare. Aaron's therapist was not aware of any favorite play interests. At home he enjoyed playing with action figures, such as Batman, Superman, Power Rangers, and Beetle Borgs. He also played with stuffed animals, cars, and trucks. His mother said he was rough and often broke his toys. He enjoyed gross motor activities and did these activities at daycare and at his grandmothers. Aaron's mother said he did not like quiet activities but colored, cut, and pasted. In contrast, Aaron readily participated in quiet activities at the Center. Aaron's family did not participate in costume holidays, but Aaron did participate in costume play. He has used his raincoat and baby blanket as capes, in order to "fly" through the house and jump off furniture.

Bryan's favorite play activity was basketball (F. Pink, personal communication, March 23, 1998; child dialogue; parent interview, April 1, 1998). He was attracted to Michael Jordan, and since Jordan starred in the movie "Space Jam", that was Bryan's favorite movie. Bryan was also interested in sports that his father enjoyed, including bowling and football. Bryan played with a variety of toys but preferred monsters and superheroes, such as Power Rangers, Superman, Batman, and Spiderman. Other toys Bryan enjoyed were his baby doll, cars, dalmatian dogs from the movies, and McDonald's toys. Bryan's mother stated, "Bryan would try anything that looked like fun" (April 1, 1998). Bryan would sit down and draw at home but not for long lengths of time. His mother said he preferred to be active.

Bryan's family did participate in costume holidays, and Bryan enjoyed "dressing up." He would imitate his father by wearing his father's shoes, shirt, and cologne. Bryan also used his "blankie" as a cape to fly through the house as Superman. Bryan played well with his siblings and with children at his pre-school and at the Center. His mother said he was "very friendly" and approached children in an effort to make a new friend.

Clothing preferences and practices. Matthew said his favorite garment was a Washington Redskins pullover winter coat (personal communication, April 1, 1998). According to Matthew's mother, his favorite garment was a burgundy wind suit (personal communication, April 1, 1998). Matthew's favorite color was red. Storm (1987) stated that young children tended to prefer the red color class, as children are better able to perceive and distinguish color differences in the red class. Matthew had difficulty donning and doffing clothes, including proper use of buttons, zippers, and laces. Stress or wear was most evident on the knees of Matthew's clothes. Matthew's small waist had been a fitting problem when purchasing pants. (Parent interview, March 17, 1998).

Aaron preferred clothes that featured a movie theme, such as "Space Jam" or "Looney Tunes." However, he would wear whatever his mother selected. Aaron was not hard on his clothes, and most of the stress or wear on his clothes occurred in the chest area from food stains. Aaron dressed himself and liked to be complimented on his appearance. (Parent interview, April 1, 1998).

Bryan's favorite clothes included items that featured Michael Jordan, "Space Jam," or basketball. His favorite colors were red and black. Bryan preferred clothes that featured a character image, motif, or pattern instead of a solid color. He was able to button some of his clothes, had trouble with snaps, and did not tie his shoes. (Parent interview, April 1, 1998).

Summary. The wearer needs categories for product development are to provide opportunities to integrate the proprioceptive, vestibular, and tactile systems; provide opportunities to integrate the olfactory, gustatory, and auditory systems; provide opportunities to increase gross motor, fine motor and perceptual motor skills, and motor planning; provide opportunities to aid in the child's self organization and attention to task; promote play preferences; promote clothing preferences; and provide opportunities to improve the skills of donning, doffing, zipping, buttoning, and tying.

Activity

The primary activity of this research was the child's participation in sensory integrative methods of occupational therapy. Other activities observed were physical therapy, play in the Primary Care Room, and speech therapy if it was done as a co-treatment with occupational therapy.

Efforts to integrate the child's senses through occupational therapy involved active participation by the child in a playful environment. Direct occupational therapy services, using a sensory integrative approach, were being used to integrate sensory motor functioning and increase functional skills. Each occupational therapy session lasted 40 minutes.

Proprioceptive system and gross motor skills. A variety of activities were observed to provide active proprioceptive input, increase muscle tone and co-contraction, and improve gross motor skills. The activities involved the active participation of the child with the equipment and the therapist. The activities can be summarized by the categories of swinging, spinning, bouncing, pressure, vibration, rolling, jumping, and riding. Table 2 presents the goals for Matthew, Aaron, and Bryan for overall sensory integration and the activities that were observed to provide proprioceptive, vestibular, and tactile input. The proprioceptive input activities are indicated in Table 2 by the letter "P".

Passive proprioceptive input was provided through the wearing of wrist weights, ankle weights, and a weighted vest; vibration from vibrating toys; joint compression by the therapist compressing joints; and being bounced on a therapy ball while hips were being held by therapist. Deep pressure proprioceptive input was provided from pressure applied to child's body by the therapist with a therapy ball or large bean bag; pressure applied to the child's body while in the cheese bag (large fabric bag full of foam pieces); and by wearing a weighted vest.

Vestibular system and gross motor skills. A variety of activities were used to integrate the vestibular system and improve gross motor skills. The activities incorporated motion and balance and can be categorized as swinging, spinning, scooter use, balancing, and rolling. Body positions of sitting, prone, supine, and kneeling were incorporated with the vestibular integrating activities. Table 2 presents specific goals to integrate the vestibular systems of Matthew, Aaron, and Bryan, and the activities observed during data collection. The activities to integrate the vestibular system are indicated with the letter "V".

Table 2

Goals/Activities to Improve Overall Sensory Integration and Gross Motor Skills

Goal/Activity	System	Source/Subject
Straddle bolster swing with moderate varied motion and throw 10 bean bags into container without holding on	V, P, T, GM	Patient Plan of Care (B); observation (B, A)
Straddle bolster swing for 1 min. without holding on	V, P, T, GM	Patient Plan of Care (M); observation (M, A, B)
Straddle bolster swing while assembling puzzle	V, P, T, PM	observation (M, B)
Kneeling over bolster swing while working on an activity	V, P, GM	Patient Plan of Care (M); observation (M)
Initiate swinging motion while tall kneeling on platform swing for 1 min.	V, P, T, GM	Patient Plan of Care (M); observation (A)
Swinging and spinning while sitting on platform swing	V, P, T, GM	observation (A)
Swing prone in net swing while pulling hula-hoop for 30 sec.	V, P, T, GM	Patient Plan of Care (A)
Swing prone in net swing while pulling on thera-band for 30 sec. (M), 1 min. (A), 2 min. (B)	V, P, T, GM	Patient Plan of Care (M, A, B); observation (A, B)
Swing and spin sitting in net swing	V, P, T, GM	observation (A)
Swing supine in net swing	V, P, T, GM	observation (B)
Bouncing, swinging, and spinning on frog swing while seated	V, P, T, GM	observation (A, B)
Prone on frog swing	V, P, GM	observation (M, A)
Swinging into foam shapes while on frog swing	P, V, T, GM	observation (A)
Prone on scooter for 40'	V, GM	Patient Plan of Care (A); observation (M, B)
Propel self while supine on scooter using arms and legs along taught rope for 15'	V, P, GM	Patient Plan of Care (A)
Prone on scooter with arms extended holding onto hula-hoop	V, GM	Patient Plan of Care (B)

Goal/Activity	System	Source/Subject
Prone on scooter down ramp and crash into foam shapes	V, P, T, GM	observation (B)
Walk on balance beam	V, GM	observation (B)
Tolerate deep pressure for 1 min.	P, T	Patient Plan of Care (A); observation (M, A, B)
Tolerate 5 min. (A), 2 min. (B) of joint compression and brushing program	P, T	Patient Plan of Care (A, B); observation (M, A, B)
Tolerate 2 min. of self-vibration	P, T	Patient Plan of Care (A); observation (M, A)
Deep pressure applied with therapy ball, bean bag, and cheese bag	P, T	observation (A, B)
Wrist and ankle weights	P	observation (M, B)
Weighted vest	P	observation (M)
Rolling in therapy tube	P, V	observation (A)
Jumping on one and two feet	P, V, GM	observation (M, B)
Held prone by therapist like and airplane	P, V, GM	observation (M)
Lifting foam shapes	P, GM	observation (M, A)
Boxing at vertical bolster	P, GM	observation (M, A)
Bouncing on therapy ball seated and prone	P, V, GM	observation (M, B)
Ride 3 wheeler	P, GM	observation (M)
Ride stationary bike	P, GM	observation (A)
Walk on balance beam	V, GM	observation (B)
Find 5 objects hidden in various textures with eyes covered	T, FM	Patient Plan of Care (M)
Finding objects in rice, putty, playdough	T, FM	observation (M)

Note. V = vestibular system; P = proprioceptive system; T = tactile system; GM = gross motor; PM = perceptual motor; FM = fine motor; M = Matthew; A = Aaron; B = Bryan.

Tactile system. Tactile input included interaction of the child's body with equipment, input provided by the therapist and self, and interaction of the hands with various textures. The child received tactile input from the equipment by grasping with his hands and flexion of his legs around the swings and balls. Tactile input of vibration was provided by a toy vibrator (shaped like an octopus) and applied to the child's body by the child and by the therapist. Tactile input was also provided by the therapist by brushing the arms, legs, and back with a surgical brush, and compressing child's joints. Activities to expose the child to a variety of textures were finding objects in rice, thera-putty, and playdough and using fingers to draw in foam. Table 2 presents the goals and activities for tactile input for Matthew, Aaron, and Bryan as indicated by the letter "T".

Fine and perceptual motor skills, and hand strength. Activities to improve fine and perceptual motor skills and hand strength included categories of cutting, glueing, drawing, fitting, and manipulating small objects. The activities were done either while seated or laying prone on a wedge. Table 3 presents the therapy goals and observed fine and perceptual motor skills and hand strengthening activities of each child.

Motor planning, self organization, attention to task, and transition. To improve motor planning, self organization, attention to task, and resistance-free transitions the therapist and child planned either two step or three step directions or planned motor mazes with up to three stages (see Tables 4 and 5). Bryan and his therapist motor maze planned most of his therapy sessions with three stages and then repeated the three stages approximately three times. The stages typically included two sensorimotor/gross motor activities and one fine motor activity. An observed example was walking up padded steps and jumping down, walking on the balance beam, then scootering prone on the scooter board across the room to retrieve a few puzzle pieces, and scootering back across the room to put the pieces in the puzzle board (observation, March 4, 1998). This sequence was repeated until the puzzle was finished.

Matthew and his therapist co-planned his sessions to include Matthew's therapy goals and to provide the input he was craving (B. Blue, personal communication, March 18, 1998). "Matthew's behavior is better if he is able to help structure his therapy" (B. Blue, personal communication, March 18, 1998). On one occasion, Matthew requested and ran to the frog swing. Blue interpreted this to be a need for vestibular and proprioceptive input. Blue and Matthew then planned the session to include time on the frog swing, building a car with foam shapes, swinging on the bolster swing, and boxing at a vertical bolster (observation, March 13, 1998).

Aaron's therapist, Gray, had been letting Aaron take the initiative when planning therapy activities in an effort to keep him in the OT/PT Room. Aaron previously had difficulty transitioning to the OT/PT Room. Gray would ask Aaron what he would like to do first. Gray would then make a suggestion for the second activity, but would ultimately let Aaron guide the session.

Bryan and Matthew were prompted by their therapists to use their imaginations throughout the therapy session in an effort to organize the self and the motor planning. Bryan and his therapist picked a theme (usually a superhero) and then used that theme through the session's stages. For example, Bryan pretended he was the white Power Ranger when he completed the motor maze

Table 3

Goals/Activities to Improve Fine Motor Skills, Perceptual Motor Skills, and Hand Strength

Goal/Activity	System	Source/Subject
Cut across page	FM, HS	Patient Plan of Care (M)
Cut along 1/4" wavy lines	FM, HS	Patient Plan of Care (A)
Cut along curved 1/4" line that forms half circle	FM, HS	Patient Plan of Care (B); observation (B)
Cutting shapes	FM, HS	observation (B)
Glue objects to paper	FM	observation (B, A)
Imitate circle, vertical, horizontal, and cross on vertical plane	FM	Patient Plan of Care (M, A, B); observation (A, B)
Imitate line and circles in shaving cream on vertical plane	FM	Patient Plan of Care (A); observation (A)
Crayon rubbing	PM, HS	observation (M)
Complete an 8-10 piece non-interlocking puzzle	PM	Patient Plan of Care (M); observation (M)
Place 10 shapes into foam board puzzle	PM	Patient Plan of Care (A)
Complete 7-9 piece semi-interlocking puzzle	PM	Patient Plan of Care (A, B); observation (B)
Complete pre-school Mighty Mind cards (1-5)	PM	Patient Plan of Care (M, B)
Copy 10 cube tower and 4 cube train	PM	Patient Plan of Care (A)
Unbutton 3 3/4"buttons on dressing frame in 75 sec.	PM	Patient Plan of Care (M, A, B)
Button 3 3/4" buttons on dressing frame	PM	Patient Plan of Care (M)
Place zipper foot in catch on dressing frame and pull zipper up	PM	Patient Plan of Care (M)

Goal/Activity	System	Source/Subject
Criss-cross lace shoe or dressing board	PM	Patient Plan of Care (B); observation (B)
Copy a square with 4 rubber bands on a geoboard	PM	Patient Plan of Care (B)
Use pincer grasp to manipulate small objects	FM, HS	Patient Plan of Care (A, B); observation (B)
Pick up small objects (10-15) using tweezers	FM, HS	Patient Plan of Care (B); observation (B)
Two min. of hand strengthening	HS	Patient Plan of Care (M, A)
Squeeze water gun	HS	observation (B)
Remove 20 pegs from medium grade theraputty in 3 min.	FM, HS	Patient Plan of Care (A); observation (M)
Wind various toys a minimum of 180 degrees	HS	Patient Plan of Care (M)
Playing games on the computer such as dot-to-dot and mazes	PM	observation (A, B)

Note. FM = fine motor skills; HS = hand strengthening; PM = perceptual motor; M = Matthew; A = Aaron; B = Bryan.

Table 4

Goals/Activities to Improve Motor Planning and Reflex Integration

Goal/Activity	Source/Subject
Plan and complete 2 part (A), 3 part (M, B) motor maze	Patient Plan of Care (A, M, B); observation (A, B)
Tolerate kneeling over a bolster working on an activity for 5 min.	Patient Plan of Care (M); observation (M)
Wheel barrow walk 40' (M), 30' (A) with support at ankles	Patient Plan of Care (M, A); observation (M)
Hippity hop 3 times (M), 2 min. (B)	Patient Plan of Care (M, B)
Climb in and out of net swing with minimal assistance	Patient Plan of Care (M); observation (M, A, B)
Climb on/off medium height bolster swing	Patient Plan of Care (M); observation (M, A, B)
Two min. of rotation movement while straddling low hanging bolster	Patient Plan of Care (A); observation (M, A, B)
Two min. of reflex game on big therapy ball	Patient Plan of Care (A); observation (M, B)
Sit on scooter being pulled while holding onto hula- hoop	Patient Plan of Care (A)
Throw bean bags through hula-hoop while straddling bolster swing with moderate motion	Patient Plan of Care (A); observation (A)
Negotiate a hopscotch course	Patient Plan of Care (A)
Crab walk 15'	Patient Plan of Care (B)
Walk 6' using blue monster feet maintaining appropriate foot placement	Patient Plan of Care (B); observation (B)
Stand on one foot	observation (B)
Walk up steps and slide down incline	observation (A)

Note. A = Aaron; M = Matthew; B = Bryan.

Table 5

Goals to Improve Self Organization and Attention to Task

Goal	Source/Subject
Follow 2 step (M, A), 3 step (B) motor directions	Patient Plan of Care (M, A, B); observation (M, B)
Work on task for 5 min. with minimal verbal assistance for re-direction	Patient Plan of Care (M)
Work on task while seated at table for 7 min.	Patient Plan of Care (B); observation (B)
Not run away and jump on equipment	Patient Plan of Care (M); observation (B)
Complete activities without signs of frustration	Patient Plan of Care (M); observation (B)
Wait, look, and listen to therapist's instructions prior to initiating play on sensory-motor equipment	Patient Plan of Care (M); observation (B)
Transition to a fine motor task from sensorimotor area without refusal	Patient Plan of Care (M); observation (B)
Transition between activities without resistance	Patient Plan of Care (A); observation (B)
Demonstrate 1 min. (A), 5 min. (B) of organized fine or perceptual activities following 10 min. of sensory integration therapy	Patient Plan of Care (A, B); observation (B)
Work in tall kneeling position for 2 min.	Patient Plan of Care (A)
Engage in an activity for 5 min. while prone on wedge	Patient Plan of Care (A); observation (A)

Note. M = Matthew; A = Aaron; B = Bryan.

discussed above. Along the maze route the white Power Ranger had to loose the evil Puddy's (climbing steps and jumping), avoid the fish in the river (balance beam), and take the secret message to his leader (scooter with puzzle pieces). Bryan was always observed to be able to stay with the imaginative themes and maintain his self organization.

Matthew's imaginative themes usually changed throughout the session and did not keep his attention for more than a couple of minutes. The only exception was when Matthew insisted on having "Baby Matthew" (toy doll) with him during therapy. "Baby Matthew" was present during the therapy session discussed above. In an effort to get Matthew off the frog swing, Blue (Matthew's therapist) had Matthew build a car (foam shapes) to take "baby Matthew" for a ride; "baby Matthew" then "got sick" and had to be taken on an elevator to the hospital (bolster swing). (Observation, March 13, 1998).

Aaron was not observed verbally participating in imaginative themes to aid motor planning and self organization. However, Aaron did use a Superman action figure to help him lift foam shapes (observation, March 18, 1998)

Favored therapy activities. Pink (personal communication, March 23, 1998) stated Bryan's favorite therapy activities were using the scooter, bolster, trampoline, and hippity-hop. An additional favorite activity was working on the computer with dot-to-dot programs. Bryan did not enjoy the brushing program, joint compression, nor fine motor activities, such as cutting and puzzles (F. Pink, personal communication, March 23, 1998; observation; dialogue with Bryan). Bryan said his favorite things to do during therapy were basketball and boxing.

Matthew said his favorite therapy activity was boxing. Blue (personal communication, March 18, 1998) stated Matthew's favorite occupational therapy activities were running the room and jumping, swinging, and spinning on the frog swing. Matthew's favorite activity in the Primary Care Room was water play, where he washed plastic polar bears, penguins, and seals (instructor dialogue; observation; B. Blue, personal communication, March 18, 1998).

Aaron's favorite activities during occupational therapy were the suspended swings, especially spinning in the frog swing (R. Gray, personal communication, March 18, 1998) and being rolled while in a padded tube (observation). Aaron's therapist believed Aaron was craving vestibular input through the spinning. Aaron's mother supported this belief by saying she often holds him and swings him in a circle at home for 15-20 minutes.

Summary. The activity needs for product development are to provide or promote opportunities for sensory integration activities, gross motor activities, fine and perceptual motor activities, and motor planning activities, while improving self organization and attention to task.

Needs Assessment Summaries

1. Environment Needs. The environment needs for product development were to support the program's goals and therapy philosophy. The product should promote communication between the child and therapist, refine motor skills, encourage social interaction with other children, promote independence in the environment, and be a form of play.

2. Wearer Needs. The wearer needs for product development were to provide opportunities to

integrate the proprioceptive, vestibular, and tactile systems; provide opportunities to integrate the olfactory, gustatory, and auditory systems; provide opportunities to increase gross motor, fine motor and perceptual motor skills, and motor planning; provide opportunities to aid in the child's self organization and attention to task; promote play preferences; promote clothing preferences; and provide opportunities to improve the skills of donning, doffing, zipping, buttoning, and tying.

3. Activity Needs. The activity needs for product development were to provide or promote opportunities for sensory integration activities, gross motor activities, fine and perceptual motor activities, and motor planning activities, while improving self organization and attention to task.

<u>Garment Specifications</u>

The environment, wearer, and activity needs assessment were used to develop garment specifications. Four garment specification themes emerged from the needs assessment data, (a) movement, (b) sensory integration, (c) motor development, and (d) play. Each garment specification and criteria are presented below. Following each specification criteria, in parentheses, are the source(s) of data from which the criteria was assessed.

1. Movement specification.

The movement garment specification included the environment need of refining motor skills; the wearer needs of integrating the sensory systems and increasing motor skills; and the activity needs of providing or promoting opportunities through activity and equipment use for sensory integration and motor development. In order to meet these environment, wearer, and activity needs, the garment criteria for the movement specification were as follows:

a. The garment should allow for full body movement by the wearer. (Observation, Literature Review).
b. The garment should allow the wearer to participate in all occupational therapy activities and allow for the use of all equipment in the OT/PT Room. (Observation, Literature Review).
c. The garment should be safe for the wearer. (Observation, Literature Review).

2. Sensory integration specification.

The sensory integration specification included the environment need to refine motor skills; the wearer needs of integrating the proprioceptive, vestibular, and tactile systems; and activity needs of providing or promoting sensory integrative activities. The need to provide olfactory, gustatory, and auditory input was not addressed in this project. The sensory integration specification criteria were as follows:

a. The garment should provide opportunities for active proprioceptive input. (Observation, Interview, Document Review, Literature Review).
b. The garment should allow for passive and deep pressure proprioceptive input. (Observation, Interview, Document Review, Literature Review).
c. The garment should promote use of equipment to provide vestibular input. (Observation, Interview, Document Review, Literature Review).
d. The garment should provide opportunities for tactile input. (Observation, Interview,

Document Review, Literature Review).

3. Motor development specification.

The motor development specification included the environment needs to refine motor skills, promote communication, and encourage social interaction and independence; the wearer needs to increase skills in gross motor, fine motor, perceptual motor, motor planning, donning, doffing, zipping, buttoning, and tieing; and activity needs of providing or promoting gross motor, fine motor, perceptual motor, and motor planning activities, and improving self organization and attention to task. The motor development specification criteria were as follows:

a. The garment should provide and promote fine and perceptual motor activities. (Observation, Interview, Document Review).
b. The garment should allow for and promote gross motor activities. (Observation, Interview, Document Review).
c. The garment should promote motor planning up to three stages. (Observation, Interview, Document Review).
d. The garment should promote transitions without behavior resistance from the child between activities and, thus, aid in the wearer's self organization and attention to task. (Observation, Interview, Document Review).

4. Play specification.

The play specification included the environmental need that therapy work should be a form of play and the wearer needs to promote play preferences and clothing preferences. The play specification criteria were as follows:

a. The garment should follow the philosophy that occupational therapy work should be a form of play. (Observation, Interview, Literature Review).
b. The garment structures should revolve around a play theme favored by the wearers. Themes included action figures and superheroes (Batman, Robin, Superman, Spiderman, Beetle Borgs, Power Rangers), sports (basketball, football, bowling), other cartoon characters (Rugrats, Dalmatians). (Observation, Interview).
c. The surface treatment of the garment should include clothing preferences of surface patterns and motifs over solid colors, and the favored color was red. (Interview).

CHAPTER 4

Prototype Development

Prototype development is the third stage of the Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996), whereby ideas are generated to meet garment specifications in terms of structure, materials, and assembly. At this stage, the problem of creating garments that integrate the senses has been developed. The needs have been assessed for three preschool children with sensory integration dysfunction and impaired motor development who participated in occupational therapy that use sensory integrative methods; and garment specification criteria based on the assessed needs of the environment, wearers, and activities have been presented for prototype development. The four garment specification criteria areas were (a) movement, (b) sensory integration, (c) motor development, and (d) play.

The next step of the design process was to generate solutions for each garment specification as they related to structure, materials, and assembly. The process proceeded from written ideas, to coding and combining the ideas, to sketches, to samples, and through solutions. This chapter presents this process and is organized in two phases with sections of structure, materials, and assembly. The chapter concludes with a description of the prototype garment.

Phase One

Structure

The first step of the prototype development stage was to write out solution ideas for those garment specification criteria that would directly influence the garment structure of the upper body. Specifications addressed in the first phase of prototype development were movement, motor development, and the proprioceptive criteria of the sensory integration specification. The play specification and sensory integration criteria of vestibular and tactile input were not addressed in the initial structural ideas.

Written ideas. The movement specification criteria were that the garment allow for full body movement, allow for participation in all activities and equipment, and be safe for the wearer. One garment structure solution idea for movement was considered.

1. Garment Structure Solution Idea for Movement:

A. Large sleeveless armholes. A structure with large armholes would allow for full upper body movement and would be easy to don and doff over the children's clothing. This structure would not compromise the child's safety and would allow for participation in all therapy activities.

The sensory integration specification criteria addressed for initial written garment structure ideas were that the garment provide opportunities for active proprioceptive input and allow for passive and deep pressure proprioceptive input. The criterion to promote the use of the vestibular integrating equipment was not addressed in the initial written ideas. Promoting the use of equipment did not appear to have an immediate impact on the upper body garment structure. Three ideas were written for active proprioception and two ideas for passive and deep pressure proprioceptive input.

2.1 Garment Structure Solution Ideas for Active Proprioception:

The goal for active proprioceptive input was that the child provide input to his joints and muscles. The ideas presented below are on the creation of resistance at joint bearing areas on his body.

A. Thera-band loops attached to a garment structure. Thera-band loops attached to a sleeveless top at the shoulders and hemline would provide the opportunity for the child to interact with the thera-bands and thus provide active proprioceptive input, increased muscle resistance for increased muscle tone, and hand strengthening. The thera-bands at the shoulders could be pulled downward and outward for input at the shoulder, elbow, and wrist joints. The thera-bands attached at the hemline could be looped around the child's feet the create input at the shoulder, hip, knee, and ankle joints.

B. Pockets for thera-bands on a garment structure. Thera-bands could be placed or stored in pockets, whereby the thera-bands could be removed by the child and used to provide active proprioceptive input. The child would determine with or without direction the location and placement of the bands.

C. Cape of bands. Thera-bands interlaced to form a cape would allow the child opportunities for active proprioceptive input as he pulled on the thera-bands. The child would select from several bands along the cape to provide input at different joint bearing areas of the body.

2.2 Garment Structure Solution Ideas for Passive and Deep Pressure Proprioception:

A. Pocket weights. Pockets on the garment structure would hold weights to provide passive and deep pressure proprioceptive input.

B. Weights other places. Weights and weight holders in any form on any part of the garment structure and accessories would allow for weight and pressure to be applied to the child's body in a variety of places.

The criteria for motor development was that the garment provide and promote fine and perceptual motor activities and allow for and promote gross motor activities, motor planning up to three stages, positive behavior transitions, and aid in the wearer's self organization and attention to task. Two written ideas addressed the motor development criteria.

3. Garment Structure Solution Ideas for Motor Development:

A. Chamber. A chamber (e.g., egg, space capsule) would allow the child to physically enter and actively participate in gross motor, fine motor, and perceptual motor activities. The walls of the chamber would be flexible so the child could actively push against the walls for gross motor movement. The walls would hold and store fine motor activities for the child to use. Since the gross and fine motor activities would be housed on the same structure a smooth transition between gross and fine motor activity would be promoted.

B. Pockets on cape. The wearing of a cape would promote gross motor activity as the child pretended to "fly." The pockets on the cape would provide the opportunity for fine motor activity in two ways: (a) each pocket closure would have a different fastening system for the child to manipulate through fine motor skills, and (b) the pockets could hold a variety of fine motor activities (i.e., puzzles, paper shapes to cut or color, games). By placing the fine motor activities in the cape, a smooth transition is promoted. The child would discuss and select a fine motor activity, retrieve the activity, physically place it in the cape pockets, and carry it on his body through the cape.

Solution idea combinations. Each written structural solution idea was coded and combined with the other solutions in all possible combinations. The non-workable combinations were eliminated. The remaining combinations were:

1A,2.1A,2.2A,3B - large armholes, thera-band loops, pocket weights, pockets on cape.
1A,2.1A,2.2B,3B - large armholes, thera-band loops, other weights, pockets on cape.
1A,2.1B,2.2A,3B - large armholes, thera-band pockets, pocket weights, pockets on cape.
1A,2.1C,2.2A,3B - large armholes, cape of bands, pocket weights, pockets on cape.
1A,2.1C,2.2B,3B - large armholes, cape of bands, other weights, pockets on cape.

The five remaining combinations were further combined to reflect the three main structural ideas of (a) thera-band loops hanging from a structure, (b) pockets with thera-bands on a structure, and (c) a cape of bands. Each of these ideas included large armholes, pockets on a cape, and pockets or other places for weights.

Sketches. The three structural combinations were sketched (Figures 2, 3, and 4) and evaluated by Boles and myself. The sketch of the thera-band loops hanging from a top (Figure 2) was pleasing aesthetically but appeared as if it would cause excessive stress on the garment neckline and hemline from pulling, and therefore was rejected. The sketch to hold thera-bands in the garment pockets (Figure 3) was structurally and aesthetically acceptable; however, the vest looked like existing solutions. The sketch of the cape with interlaced bands forming the structure (Figure 4) was rejected because the construction of the cape did not appear to support the lacing of the bands. Even though these three sketches were not acceptable to Boles and myself, additional ideas and sketches were generated from the process.

Figure 2. Idea of thera-band loops hanging from a sleeveless top with large armholes.
(PDF, 55 KB, Fig2.pdf)

Figure 3. Idea to hold thera-bands in garment pockets.
(PDF, 45 KB, Fig3.pdf)

Figure 4. Idea of cape with interlaced bands to form the structure.
(PDF, 28 KB, Fig4.pdf)

The additional ideas and sketches included (a) the concept of interlaced bands, but these bands were interlaced as part of the bodice structure (Figure 5) instead of the cape structure; and (b) the use of the cape as a chamber (Figure 6). The child could physically enter the cape and interact against the cape to gain proprioceptive input.

Figure 5. Idea to interlace bands as part of a top structure.
(PDF, 46 KB, Fig5.pdf)

Figure 6. Idea to use a cape as a chamber.
(PDF, 29 KB, Fig6.pdf)

To further develop the idea of interlacing bands, an elastic circle was made to experience active proprioceptive input, joint compression, muscle co-contraction, and comfort. The experimentation with the elastic circle modified the structural idea from interlacing the bands to creating channels by stitching the lining and the exterior fabrics (Figure 7). Elastic bands could then be inserted through the channels. The channels would hold the elastic and provide access to the elastic at joint compression areas. The vertical elastic loops could be placed around the foot or extended upward from the shoulder by the hands to create downward pressure at the shoulder joint, compression at the hip joint and knee joints, and upward pressure at the ankle joint. The horizontal band when stretched by the hand would create inward pressure against the shoulder joint, elbow joint, and wrist joint.

Figure 7. Idea to create channels by stitching the lining and exterior fabrics.
(PDF, 35 KB, Fig7.pdf)

Samples. Two structural ideas, the cape chamber and the top with channels were made into samples to fit me. The reason the initial samples were made to fit me instead of child models was that I wanted to more fully understand the problem between body and garment by experiencing joint compression. The cape chamber idea (Figure 6) was eliminated after the first sample, due to structure (entering, closing, and exiting) and material (too heavy) problems.

The top with channels idea was made into a sample (Top 1, Figure 8) to fit me. The horizontal band at the waistline was not providing direct pressure to the shoulder joint. Another horizontal channel was stitched to provide access to an additional band as near the shoulder as possible. The addition of the channel (Top 1A, Figure 9) provided the inward input at the shoulder joint.

Figure 8. Sample Top 1 with two vertical channels and one horizontal channel stitched through the lining and exterior fabrics to hold elastic bands.
(PDF, 34 KB, Fig8.pdf)

Figure 9. Sample Top 1A with two vertical and two horizontal channels stitched through the lining and exterior fabrics to hold elastic bands.
(PDF, 36 KB, Fig9.pdf)

The placement of the upper horizontal band felt uncomfortable under the arm and over the arm. Figures 10 and 11 represent ideas to secure the elastic bands when not in use, ideas to access the elastic bands, and ideas to allow the band to be lowered when not in use. Figure 10 indicates loops at the shoulder, underarm, and hemline to secure the excess elastic strap in an effort to decrease discomfort when the horizontal band is not in use. Figure 10 also indicates ideas for the child to access the elastic through a variety of bound shapes on the top. Figure 11 (A and B) indicates ideas to lower the horizontal band when not in use, by creating slots down the length of the top.

Figure 11B was made into sample Top 2 to fit me. Sample Top 2 (Figure 11B) featured long openings for the elastic to be raised when in use and lowered when not in use. I rejected the slot openings on Top 2 (Figure 11B), because the openings gaped and were distracting.

Figure 10. A = Ideas to secure the elastic bands when not in use.
B = Ideas to access the elastic bands. (PDF, 34 KB, Fig10.pdf)

Figure 11. Ideas to lower elastic bands when not in use by
creating vertical slots. Idea 11B was made into sample Top 2.
(PDF, 50 KB, Fig11.pdf)

The next idea was to move the bound openings closer to the garment edge and have an upper and a lower slot to hold the horizontal elastic bands (Figure 12). Another idea was to lower the armhole, so the band formed the underarm (Figure 13).

Figure 12. Idea to have the horizontal band's
[upper (A) and lower (B)] slots closer to the top edges.
(PDF, 38 KB, Fig12.pdf)

Figure 13. Idea for elastic band to form underarm.
(PDF, 36 KB, Fig13.pdf)

Sample Top 3 (Figure 14) was constructed to explore slot opening ideas. The left upper slot openings on the front and back were bound with a fabric binding on one side of the opening. The lower curve caused the fabric binding to bunch. The left side seam opening and left hemline opening were bound in fabric in the shapes of a circle and triangle. This binding method caused the garment fabric to bunch around the bound opening. The third technique was to create a slot by stitching knit interfacing to the right side of the garment around the opening. The fabric was cut, turned, and top-stitched. The faced slot was a satisfactory solution for finishing the channel openings.

Figure 14. Sample Top 3 constructed to explore slot opening ideas.
A = fabric binding and top stitching on one side of slot opening.
B = fabric binding around entire slot opening.
C = facing and top stitching the slot opening.
(PDF, 26 KB, Fig14.pdf)

The cape idea for the motor development specification was sketched and featured pockets along the hem (Figure 15). Three samples were made before my son, age 7, approved the cape length and width. My son indicated that the front cape length needed to hang to the wrist, and the width allow for the cape to wrap around the body. In this way he could grasp the cape ends and have enough fabric flowing behind him to "fly".

Figure 15. Idea for cape with pockets along hemline and buttons
on upper cape surface. Sample Cape 4 was constructed from this idea.
(PDF, 44 KB, Fig15.pdf)

Materials

The process of selecting materials for the first phase of prototype development included writing solution ideas for each specification addressed in the structure section with the addition of the play criterion for color preference. Materials were experimented with during construction of sample Tops 1, 1A, 2, and 3, the cape chamber sample, and the cape samples.

Written ideas. The written solution ideas for movement, sensory integration, motor development, and play are presented below.

1. Materials Solution Idea for Movement Specifications:

The structure solution for movement was a pullover top with large armholes and straps to secure excess band lengths. One solution idea of materials for the movement specification was considered.

A. Fabrics with stretch capability (spandex). The fabric solution idea for movement was to use fabric that had stretch capability. Stretch fabrics would allow for wearer movement and participation in activities and equipment use. The stretch fabric would also aid in donning and doffing and accommodate a variety of sizes.

2.1 Materials Solution Ideas for Active Proprioceptive Input:

The structural idea for active proprioceptive input was the use of bands. The bands to be inserted in the top channels should have stretch capability and shape retention. Ideas for the bands were:

A. Elastic. Elastic bands inserted in the top channels would provide proprioceptive input when the child pushed the band outward with their arms. The elastic bands looped around the foot would provide proprioceptive input upward from the ankles and downward on the shoulder joint.

B. Thera-bands. Thera-bands are latex strips, tubing, or loops used in therapy for resistive activities. The thera-band idea was not pursued since the elastic was more readily available and less expensive than the thera-bands.

2..2 Materials Solution Idea for Passive and Deep Pressure Proprioceptive Input:

The structural solution idea for passive and deep pressure proprioceptive input was that weights be placed in garment pockets. One material solution idea was considered.

A. Weights consisting of steel shot in pouches. Materials of sand, rice, beans, and steel shot were experimented with as weight in pouches during the Haar and Giddings (1997) study. Steel shot was found to provide the most weight with the least amount of bulk.

3.1 Materials Solution Idea for Motor Development:

A cape was the structural solution for the motor development specification. Materials solution ideas of fastening systems on the cape are presented below.

A. Inclusion of manipulative materials on the cape. The pockets on the cape hemline will include a variety of closures (i.e., separating zipper, non-separating zipper, buckle, hook and loop tape, lacing eyelets, snaps, and button). Each time the child opens a pocket to place or retrieve a fine motor activity he will experience fine motor skills by manipulating the fastening system. Buttons on the upper cape surface provide the opportunity to button objects onto the cape. The child would cut shapes out of paper or nonwoven interfacing, the therapist would cut a buttonhole slit on the shape, and the child would button the shape or artwork to his cape. In this way, the child has the potential to create a new cape each session.

4. Material Solution Idea for Play Specifications:

A. Red fabric. The color red was favored by the wearers.

Samples. The materials used in Top 1 and 1A (Figures 8 and 9) were fabric, elastic, and thread. The fabric used for the top exterior and lining was black cotton spandex (exact content unknown). The fabric was available from the Clothing and Textiles Research and Development Laboratory at Virginia Tech, Blacksburg, Virginia. The elastic used in Top 1 (Figure 8) was 1" wide white non-roll elastic. The white elastic was from my personal supply. The additional elastic in Top 1A (Figure 9) was 1" wide black elastic (68% polyester, 32% rubber) by Stretch Rite®. The black 1" wide elastic was selected from the black elastic selections at JoAnn's Fabric. This particular elastic was selected due to its good shape recovery after stretching. Shape recovery was determined by measuring the stretch distance of a 12 inch length and observing the shape while stretched and relaxed. The thread was black mercerized cotton covered polyester by Coats and Clark®.

The cape chamber was constructed from black cotton spandex (exact content unknown) and stitched with black mercerized cotton covered polyester thread by Coats and Clark®. The fabric was obtained from the Clothing and Textiles Research and Development Laboratory.

The materials used in Top 2 (Figure 11B) were fabric, elastic, and thread. The fabric used for the top exterior and lining was red nylon spandex (85% Antron® nylon, 15% Lycra® spandex). The fabric was from Guilford Mills, Inc., Greensboro, N.C., and purchased at a local Walmart. The slot openings were bound with three different fabrics: (a) black nylon spandex (85% nylon, 15% Lycra® spandex), (b) white stretch vinyl, and (c) black power knit spandex. The black spandex was purchased at JoAnn's Fabric, and there was no company identification on the bolt end. The white stretch vinyl and black power knit spandex were obtained from the Clothing and Textiles Research and Development Laboratory at Virginia Tech. The fiber content and company information was not available for the white stretch vinyl and black power knit spandex.

The elastic used in Top 2 (Figure 11B) was 1" wide black elastic (68% polyester, 32% rubber) by Stretch Rite®. The thread used was mercerized cotton covered polyester in red and black by Coats and Clark®.

Sample Top 3 (Figure 14) materials consisted of fabric, interfacing, and thread. The top exterior was red nylon spandex (85% Antron® nylon, 15% Lycra® spandex). Four slot openings were bound with black spandex (85% nylon, 15% Lycra® spandex). Six slot openings were faced with knit interfacing (100% polyester) called So Sheer®. The thread used was red mercerized cotton covered polyester by Coats and Clark®.

Cape samples 1, 2, and 3 were cut from shirting fabric and sample Cape 4 (Figure 15) was cut from black stretch vinyl. Both fabrics were obtained from the Clothing and Textiles Research and Development Laboratory at Virginia Tech. The fiber content and company information was not available for the black stretch vinyl nor the shirting fabric.

Material solutions for the top included red nylon spandex (85% Antron® nylon, 15% Lycra® spandex), knit interfacing (100% polyester) by So Sheer® for the slot facing technique, black 1" wide elastic (68% polyester, 32% rubber) by Stretch Rite® for the proprioceptive input bands, black power knit spandex (exact content unknown) to secure the elastic loops, hook and loop tape to secure the elastic bands when not in use, and red and black mercerized cotton covered polyester thread by Coats and Clark® to seam and top stitch the top. Material solutions for the cape were black stretch knit vinyl (exact content unknown) for the cape base and pockets; a zipper, button, lacing eyelets, and hook and loop tape for the pocket fastening systems; and black mercerized cotton covered polyester thread by Coats and Clark®.

Assembly

Assembly techniques of stitch type, stitch placement, and stitch width were experimented with throughout the sample development phase. The seams, channels, and slots in Tops 1, 1A, 2, and 3 (Figures 8, 9, 11B, and 14) were stitched with a conventional home sewing machine using a 3 mm stitch length. To provide flexibility in the seam, the fabric was stretched during seam stitching. The method of joining the elastic lengths to form a circle was to butt the elastic ends together, place a 1.5" x 3" strip of power knit spandex under the butted elastic ends, and stitch down the 3" length and across the 1" elastic width using a zig zag stitch (3 mm length and 3 mm width). The excess power knit spandex was trimmed. This assembly technique allowed the elastic to retain its stretchability and secured it in a circle.

Two bound edge assembly techniques and two stitch types were experimented with in the construction of sample Top 2 (Figure 11B). One bound edge technique was to create a binding by folding a fabric strip wrong sides together, stitching the binding to the slot opening, and top stitching the binding flat. This technique used a straight stitch for top stitching three bindings and a zig zag stitch on one binding. The second method of binding the slot opening was to stitch the binding to the slot edge right sides together, fold the binding wrong sides together, and stitching in the ditch.

Sample Top 3 (Figure 14) experimented with both bound assembly techniques described above and, in addition, a facing technique. The facing technique involved placing the interfacing on the top exterior, stitching the slot opening, cutting the fabric and interfacing inside the stitching, turning the interfacing to the top interior, and top stitching. Top stitching widths ranged from 1/16" to 3/8".

Summary

The initial phase of prototype development yielded solutions for the structure, materials, and assembly of the movement, active proprioception, motor development, and color preference specifications. The initial solutions are presented below.

1. Movement. The garment solution for movement was a sleeveless pullover top with large armholes. The top was constructed from red nylon spandex (85% Antron® nylon, 15% Lycra® spandex) to allow for movement, ease of donning and doffing, and accommodation of a variety of sizes. To aid in safety, hook and loop tape were used to secure excess elastic vertical bands. Seam construction consisted of a 3 mm straight stitch which was stretched during assembly for a flexible seam. Thread used was mercerized cotton covered polyester.

2. Sensory Integration. The garment solution for active proprioceptive input was to provide elastic band loops at joint compression areas. The elastic band loops were held by stitched channels between the exterior and lining fabrics and accessed through slots near the front and back shoulder seams, armscyes, side seams and hemline. The slots were finished by facing the opening with knit interfacing (100% polyester) called So Sheer® and top stitching 1/4" from the opening. The elastic was 1" wide black elastic (68% polyester, 32% rubber) by Stretch Rite®. The elastic loops were created by butting the elastic ends together and zig zag stitching through the elastic and a piece of power knit spandex.

Passive and deep pressure ideas of weights and pockets to hold the weights were written but did not go through the sample stage. Tactile and vestibular integration were not addressed in the early prototype development process.

3. Motor Development. The garment solution for motor development was a cape with several pockets. The idea was for each pocket opening to have a different fastening system (zippers, button, snap, hook and loop tape, lacing, and buckle). The cape surface would feature buttons to hold the child's cut activities. The sample cape was structured out of black stretch vinyl (content unknown) obtained from the Clothing and Textiles Research and Development Laboratory.

4. Play. The only play specification specifically addressed was the color red. However, the cape idea did follow the superhero play theme identified by the wearers.

Phase Two

Structure

The prototype development procedures thus far had addressed the movement specification through large armholes, spandex fabric, and flexible seams; the active proprioception criterion through placing elastic loops in channels at joint compression areas; the wearer's color preference of red; and the motor development criteria through creating a cape with pockets which will be accessed through a variety of fastening systems. The next phase of the prototype development process was to address the play specification. After a play theme was decided, the garment specification criteria were re-addressed or addressed for the first time.

Written ideas. The play specification required that the garment follow the philosophy that occupational therapy work should be a form of play; the garment structures should represent a play theme of the wearers; and the surface treatment include clothing preferences of surface design and color.

1. Structure Solution Idea for Play:

The structure solution idea for play was a bug superhero. Even though the superhero idea had emerged with the cape structure, an overriding theme had not been applied to the surface structures of the samples. The theme for a bug superhero evolved from the data collection on the children's play interests, clothing preferences, and imaginative scenarios during therapy. Each child played frequently with superhero action figures, such as Power Rangers, Superman, Spiderman, Batman, and Beetle Borgs and preferred clothing that featured superheroes or other characters. During therapy the children often pretended they were superheroes and that the equipment (swings, scooters) used were superhero vehicles. The importance of superheroes was demonstrated during one of Aaron's therapy sessions. Aaron was having trouble lifting foam blocks to build a house. To assist him with this task he pulled a Superman action figure from his pocket. With the help of the Superman action figure he was able to lift the remaining foam blocks.

I did a library search for images of spiders, bats, and insects; cartoon/comic book images of superheroes; illustrations of Greek gods and Norse gods; and toy department searches for toys with the theme of spiders, bats, and insects; and a search for action figure superheroes. The bug theme emerged as the most exciting and inspiring to me, due to the colors, shapes, and textures of the insects. My sons also approved of the idea to create a bug superhero.

The sensory integration criterion for active proprioceptive input was thoroughly addressed in the first phase of prototype development. The solution was to provide elastic bands through the garment structure for the child to interact with and thus receive active proprioceptive input. The passive and deep pressure proprioceptive criterion ideas had not gone to samples, and the tactile and vestibular input criteria had not been addressed.

2.1 Structure Solution Idea for Passive and Deep Pressure Proprioceptive Input:

The sensory integration criteria for passive and deep pressure proprioceptive input was that the garment allow for passive and deep pressure input. The idea was to structure weights to represent baby bugs. The baby bug weights would be held in pockets on the garment top front and back. Pocket placement should be in line with the vertical channels and be above waist level. Being in line with the vertical channels allows for downward pressure on the shoulder joint. The pocket length would end at waist level, so as not to interfere with the child's bending mobility when the weights are in the pockets. The role of care provider was important to all three wearers. By structuring the weights as baby bugs to be placed close to the wearer's body in pockets, the role of care provider will be satisfied.

2.2 Structure Solution Idea for Vestibular Input:

The vestibular input criterion required that the garment promote use of equipment that provides vestibular input. During data collection it was observed that the children often pretended they were flying when using the suspended equipment for vestibular input. The cape should enhance this imaginative theme and thus promote the use of the suspended equipment to provide vestibular input. Applying the bug theme to the cape surface structure would further entice the children to wear the cape.

2.3 Structure Solution Idea for Tactile Input:

The tactile criterion was to provide the wearer a variety of tactile experiences. The structural solution idea for tactile input was to provide the wearer a variety of textures to experience through interaction with the structural bug designs on the top, cape, and bug weights. Images of bugs were studied to evaluate the placement of texture on bugs. Fabrics were sought that represented colors and textures of bugs.

The motor development criteria were addressed in the first phase of prototype development. The structural solutions were to use a cape to provide the opportunity for fine and perceptual motor activities through the interaction with a variety of fastening systems on the cape's pockets. The use of the pockets to hold the fine motor activities will aid in the transition from gross motor to fine motor activities. The bug superhero theme modified the structural layout ideas for the cape.

3.1 Structure Solution Idea for Motor Development:

The structure solution idea for motor development still included the use of a cape with pockets; however, the idea was updated to represent the bug theme. A large beetle would be featured, with the beetle shell containing large pockets. Large pockets would hold the 8.5" x 11" paper that is typically used for fine motor activities of drawing, cutting, and gluing.

The movement specification structure solution did not change from the first phase of prototype development. The structure remained as a sleeveless pullover top with large armholes and straps to hold the excess elastic.

Sketches. The surface design structure for the bug theme went through a series of sketches for the top, cape, and weights (field book sketches dated 5/3/98, 5/4/98, 5/5/98, 5/7/98). Figures 16 and 17 are examples of sketches for the bug surface design structures for the top, weights, and cape.

Figure 16. Idea for surface design structures for the top, weights, and cape.
(PDF, 23 KB, Fig16.pdf)

Figure 17. Idea for the surface design structures for the top, weights, and cape.
(PDF, 43 KB, Fig17.pdf)

Samples. A surface design sample (Figure 18) was made of a bug for placement on the top front and back. The sample featured a variety of fabrics and the inclusion of pockets as part of the beetle shell. The sample represented in Figure 18 was rejected as the angles of the bug structure were too harsh.

Figure 18. Surface design sample of bug.
(PDF, 32 KB, Fig18.pdf)

Even though the initial bug surface design sample was rejected, it did influence a structural change in the channels of the top. The channels were moved to the lining fabric where casings were constructed with knit interfacing. In this way the channel stitching did not interfere with the surface design.

Sample Top 4 (Figure 19) was constructed to experiment with the structural changes added to the lining. Sample Top 3 (Figure 14) and Top 4 (Figure 19) were fitted on child models. The child models were at a neighborhood daycare; therefore, several children tried on the samples. The child models ranged in size from three through eight. The range of sizes were used to check fit and ease of donning and doffing for a variety of sizes. While child models of several sizes tried on the sample, particular attention was paid to those who were size four through six, since the study participants wore size five. The size four through size six models, in addition to fit and donning and doffing, were fitted for elastic band lengths, and band placement. Results of the fitting session were that the torso circumference was appropriate; the shoulder angle needed to be decreased; the neckline opening needed to be decreased as the elastic vertical bands were pulling the sample off the shoulder; the waist channel needed to be raised one inch; the length was appropriate; and the armhole opening was appropriate.

Figure 19. Sample Top 4 of lining and channel casings for holding vertical elastic loops. (PDF, 43 KB, Fig19.pdf)

Sample Top 5 (Figure 20) was constructed with the changes noted above and tried on the child models. The vertical elastic bands were still pulling the garment off the shoulder. To solve this problem, raglan shoulder pads were added and the elastic band length was increased. Sample Top 6 (Figure 21) reflected those changes in the lining structure. Sample Top 6 (Figure 21) was tried on the child models and the fit was satisfactory.

Figure 20. Sample Top 5 of lining and channel casings for the vertical and horizontal elastic loops. (PDF, 38 KB, Fig20.pdf)

Figure 21. Sample Top 6 of lining, shoulder pads, and channel casings for the vertical and horizontal elastic loops. (PDF, 48 KB, Fig21.pdf)

The bug theme was addressed in Sample Cape 5 (Figure 22) and structural layout changes were made to accommodate the surface image. Two large pockets were created to represent a beetle shell, and wings were created as areas for lacing and zipping. The pocket size was 9" x 12" in order to accommodate the 8.5" x 11" paper typically used for fine motor activities. Sample Cape 5 (Figure 22) was fitted on the child models. The fit was satisfactory.

Figure 22. Sample Cape 5 featuring bug surface design.
(PDF, 46 KB, Fig22.pdf)

Materials

Written ideas. The material solution ideas for play, sensory integration, and motor development are discussed below.

1. Materials Solution Idea for Play:

The materials solution idea for play was to use fabrics and materials that best represented the bug superhero theme. Therefore, the color preference for red was overridden by fabrics that represented the colors and textures of beetle shells, wings, and body parts.

2.1 Materials Solution Idea for Passive and Deep Pressure Input:

The materials solution idea for passive and deep pressure input was to create four baby bug weights to be placed in the top front and back pockets. The baby bugs would be constructed from a variety of fabrics and the weight would be steel shot. Materials of sand, rice, beans, and steel shot were experimented with as weight in pouches during the Haar and Giddings (1997) study. Steel shot was found to provide the most weight with the least amount of bulk. Each bug weight would weigh one-half pound. Therefore, when all four weights are in use, a total of two pounds will provide passive and deep pressure proprioceptive input.

2.2 Materials Solution Idea for Vestibular Input:

The materials solution idea for vestibular input was to use fabrics on the cape that would follow the bug superhero theme. In this way, the children would want to wear the cape to "fly" and thus use the vestibular integrating equipment.

2.3 Material Solution Idea for Tactile Input:

The goal of the material solution idea for tactile input was to provide the wearer a variety of tactile experiences with materials that were appropriate for a bug superhero. A fabric buying trip was made to a fabric store where fabrics were purchased that represented the colors and textures of beetle shells and beetle wings. I added fabrics from my personal fabric collection that represented the colors and textures of beetles. In addition, contact was made with a swimsuit designer in an effort to source a variety of stretch fabrics that would resemble colors and textures of beetles and not interfere with the stretch quality of the basic structural surface already established in phase one.

3. Material Solution Idea for Motor Development:

The bug theme changed the surface layout of the cape. The previous idea was a row of pockets along the hemline with a different fastening system on each pocket. and buttons on the cape surface to hold cut-out artwork. The new idea was a large bug with wings on the cape surface. Fine motor skills would be experienced with separating and non-separating zippers, button and buttonhole closure, and lacing. Fine and perceptual motor activities would still be housed in the cape pockets, which was now part of the bug shell.

Samples. Materials used in the bug surface design sample (Figure 18) were fabrics with a variety of textures and Wonder-Under® transfer web. The fabrics used in Figure 18 are presented in Table 6 according to their fabric name, content, color and description, and location of fabric on the sample.

The fabrics were fused to a black double knit (100% polyester) fabric with Wonder-Under® transfer web. The bug design represented in Figure 18 was rejected as the angles of the bug were too harsh and the bug did not have a personality. I did not find the bug visually appealing and, therefore, believed the children would not find the bug appealing.

Materials used in Top 4 (Figure 19), Top 5 (Figure 20), and Top 6 (Figure 21) were woven fabric, nonwoven fabric, knitted fabrics, elastic, thread, and Top 6 also included shoulder pads. Tops 4, 5, and 6 were made to experiment with the channels on the lining and fit on the child models. Therefore, the samples did not include the exterior fabric nor the bug surface design. Black cotton and spandex knit were used as lining for Tops 4 and 6. The lining fabric used for Top 5 was black spandex knit. The channel facings for all three tops were So Sheer® knit interfacing (100% polyester), the knit elastic was Stretch Rite® 1" wide black, and the thread was Coats and Clark® black mercerized cotton covered polyester. The shoulder pads in Top 5 were 1/2" thick foam raglan ladies shoulder pads trimmed to fit the sample top. The neckline binding on Top 4 was constructed from black spandex knit.

Sample Cape 5 was made to represent ideas in Figure 22. The cape ground fabric was black stretch vinyl (content unknown), which was obtained from the Clothing and Textiles Research and Development Laboratory. The bug design was created by fabrics fused to the cape surface with Wonder-Under® transfer web. The fabrics are presented in Table 7.

A 9" black non-separating zipper was used as a closure for one cape pocket. A 11/16" button and button hole was the fastening system on the other pocket. Metal eyelets were attached to vinyl strips to experiment with attaching eyelets for lacing.

A sample top (Top 7) was made using festive foil liquid gold knit (100% polyester). This fabric was rejected for the top exterior because it was a two-way stretch knit and the gold threads lost shape recovery after stretching.

When the stretch fabrics arrived from the swimwear designer, fabric was selected for the top exterior and for the cape exterior. Matte gold spandex knit (82% polyester, 18% Lycra®) was selected for the top exterior. The matte gold spandex was a four way stretch knit and the matte gold was an appropriate color for the beetle superhero theme. Sincronia® (100% polyester), a silver and black speckled plastic adhered to a black knit ground was selected for the cape exterior. The Sincronia® was an appropriate light weight which would not be heavy for the children to wear and the colors were appropriate for the bug superhero theme.

Table 6

Fabrics Used for Bug Sample Surface Design (Figure 18)

Fabric Name	Fiber Content	Color/Description	Location
Velvet	100% rayon	Black woven	Eyes, neck, body center
Festive foil liquid gold	100% polyester	Gold knit adhered to black knit ground	Head
Flocked iridescent taffeta	100% acetate	Green/black woven taffeta with ½" black flocked circles	Beetle body, pockets
Festive foil liquid marble	100% polyester	Silver/pink/green knit adhered to black knit ground	Lower portion of beetle body

Table 7

Fabrics Used for Cape Sample 5 (Figure 22)

Fabric Name	Fiber Content	Color/Description	Location
Velvet	100% rayon	Black woven	Eyes, part of neck section
Confetti foil dot	72% nylon 23% metallic	Black dots adhered to black knit ground	Head
Chromspun iridescent taffeta	88% acetate 12% metallic	Teal/black woven	Neck section
Festive foil liquid marble	100% polyester	Silver/pink/green knit adhered to black knit ground	Part of mid-section, body bottom
Velvet	100% rayon	Deep red woven	Mid section, body center
Flocked iridescent taffeta	100% acetate	Green/black woven taffeta with ½" black flocked circles	Body, pockets

Assembly

Assembly procedures addressed in the second phase of prototype development were methods of attaching the surface design beetle fabrics to the ground fabrics. The process began by fusing Wonder-Under® transfer web to fabrics, cutting the desired shapes, and then fusing the shapes to the ground fabric samples. Machine embroidery variations of the satin stitch (a compacted zig zag stitch type) were experimented through varying the width, length, and shape of the satin stitch.

Prototype Garment Solutions

The second phase of prototype development addressed the play specification which influenced decisions for specifications that had been previously addressed and for specification criteria that had not been addressed. The results of phase one and phase two of prototype development was a prototype garment that is described below, and each specification solution is addressed in terms of structure, materials, and assembly.

Prototype Garment Description

The garment solution consisted of a sleeveless pullover top, removable cape, and weights (Figures 23 - 27.). The top front and back and cape exterior featured a beetle design, and the weights were structured as baby bugs. The hip length top had a fitted round neckline, padded raglan shoulders, and large armhole openings. The top was seamed at the shoulders and sides. The top held 1" wide elastic band loops that were assessable from slots near the hemline, side seam, armscye, and shoulder seam. The top was constructed from gold spandex, and the neckline, armholes, and hemline were bound with black spandex. The surface of the top front and back featured a beetle that was constructed from fabrics that were machine embroidered with black thread to the gold spandex. The beetle shell created two pockets each on the front and back. One-half pound weights (3 1/2" x 5") structured to represent baby bugs (Figure 28) fit in the top front and back pockets (Figure 29).

Figure 23. Front view of prototype garment of pullover top
and removable cape photographed on a child size 5 dress form.
(PDF, 63 KB, Fig23.pdf)

Figure 24. Front view of the prototype top and the four bug weights.
(PDF, 110 KB, Fig24.pdf)

Figure 25. Back view of the prototype top and the four bug weights.
(PDF, 94 KB, Fig25.pdf)

Figure 26. Back view of cape while supported on a hanger.
(PDF, 106 KB, Fig26.pdf)

Figure 27. Back view of cape while lying flat.
(PDF, 84 KB, Fig27.pdf)

Figure 28. Front and back view of four bug weights.
(PDF, 46 KB, Fig28.pdf)

Figure 29. Bug weight placed in a top pocket.
(PDF, 97 KB, Fig29.pdf)

The top was lined with cotton spandex knit. The lining organized the network of elastic band loops through channels. The channels were created by sewing polyester knit interfacing to the inner side of the lining fabric.

The top exterior had a total of sixteen slots, located on the front and back, from which the elastic band loops emerged from the lining. The shoulder slots (1 1/2" x 1/8") were located 1" below the shoulder seam, the armscye slots (6" x 1/8") were located 1/2" in from the armscye opening, the side slots (2" x 1/8") were located 1" in from the side seams at the natural waistline height, and the hemline slots (1 1/2" x 1/8") were 1" above the hemline and 2 1/2" from center front.

There were a total of six 1" wide elastic band loops, four vertical bands and two horizontal bands. The vertical band loops (20 1/2" and 27 1/2" hanging length when relaxed) were accessed from the shoulder and hemline slots. The long vertical band loops had an elastic strap so they could be secured around the foot. The shorter vertical band loop is for placement around the knee when in the tall kneeling position. The horizontal band loops (23" in length when relaxed) were accessed from the armscye and side slots. The horizontal band loops were designed for pulling with the hands and arms.

The cape was 54" wide by 30" long. It could be attached and detached from the top with hook and loop tape at the shoulders and at the cape centerfront neckline overlap. The cape exterior fabric was a silver/black adhesive on a polyester knit ground. A large beetle design was featured on the cape and was created by fabrics that were machine embroidered with black thread to the cape's surface. The beetle body had two 9" x 12" pockets, one with a non-separating zipper closure and the other with a 5/16" button and machine stitched buttonhole. The cape beetle had two wings; one opened with eyelet laced fabric strips (Figure 30), and the other a separating zipper (Figure 31). A black knit cord was used for lacing. The cape lining was liquid gold knit. The neckline of the cape lining was polyester broadcloth, and the neckline and shoulder curves were reinforced with 1/8" twill tape.

Figure 30. Prototype cape featuring lacing eyelets on left wing.
(PDF, 113 KB, Fig30.pdf)

Figure 31. Prototype cape featuring separating zipper on right wing.
(PDF, 117 KB, Fig31.pdf)

The prototype garment top fits children sizes four through six. The children in the study were size five.

Structural Solutions

Movement. The movement specification required that the garment allow for full range of body movement so the child could actively participate in therapy and use all equipment, as well as be safe for the wearer. The structure of the prototype garment top with large armholes, a wide trunk width, and hip length was designed to allow for full range of motion and participation in all therapy activities and therapy equipment. The cape could be detached for activities in which the cape would interfere with the child's safety, for example, riding supine on a scooter board. The shoulder pads aided in the wearer's safety as they supported the pressure point on the shoulders when the vertical elastic bands were being used or when the bug weights were in the top pockets.

Another safety feature was hook and loop tape straps (5/8" x 3") to secure the elastic bands when not in use, so they did not hinder the child's movement nor interfere with donning and doffing. The hook and loop straps are located at the lower side seams and the underarm side seams of the top. Figure 32 shows the elastic bands secured with the hook and loop tape.

Figure 32. Prototype top with the horizontal elastic band loops secured with hook and loop tape at the underarm, and the vertical elastic band loops secured at the side seam hemline. (PDF, 63 KB, Fig32.pdf)

Sensory integration: Proprioception. The sensory integration specification for proprioceptive integration required that the garment allow for active, passive, and deep pressure proprioceptive input. Elastic band loops was the solution for active and passive proprioceptive input. Active proprioceptive input can be gained from active movement of the muscles and joints against the elastic band loops. Passive proprioceptive input can be gained when the child is not actively moving and the bands are looped around the child's feet, knees, or hands. When the vertical loops are placed around the foot, the elastic bands create compression downward from the shoulder and upward from the foot. The child can provide active proprioceptive input through the activities of walking, running, or jumping or gain passive proprioceptive input by wearing the bands while doing seated or swinging activities.

The child may select bands from the garment top at the shoulder, armscye, side, and bottom. As the child pulls on the horizontal bands with his hands, he will actively engage or co-contract his arm and shoulder muscles and provide pressure on his joints at the wrist, elbow, and shoulder, as well as increase his hand strength. When the child places the long vertical elastic band around his foot, he will engage his leg muscles and provide joint compression at his shoulders, hips, knees, and ankles. The shorter vertical bands were designed to be looped around the knee, so the child can gain proprioceptive input while in the tall kneeling position. The vertical bands can also be pulled up from the shoulder slots with the hands.

Deep pressure and passive proprioceptive input can be gained from putting the bug weights in the top pockets (see Figure 29). There are four weights (Figure 28) and each weighs one-half pound. When all four bug weights are worn, there is two pounds of weight on the child. The weights will provide additional resistance when doing physical activities and will provide grounding when doing desk activities.

Sensory integration: Vestibular. The sensory integration specification for vestibular input required that the garment promote vestibular integrating activities and equipment in the therapy environment. During data collection it was observed that the children often pretended they were flying when using the suspended equipment for vestibular input. The cape of the prototype garment was designed to enhance this imaginative theme and thus promote the use of the suspended equipment to provide vestibular input.

Sensory integration: Tactile. The layout of fabrics of the prototype garment was designed for the wearer to gain a variety of tactile experiences each time he felt the prototype. The bug weights were structured with four different fabrics so the child could select the texture(s) and rub that part of the bug against his body. The antennas were constructed from Sincronia®, the heads from velvet, the bodies from chromspun taffeta, and the wings were one of four sheer fabrics, each with a different surface texture. In addition to the exterior fabrics of the bug weights, the batting and steel shot pellets provided opportunities for tactile experiences.

The tactile experiences from vibration and brushing with a surgical brush were noted during data collection. While these experiences are not possible from the sensory costume itself, the cape and top pockets can hold these items.

Motor development. The specification criteria for motor development required that the garment provide or promote fine motor, perceptual motor, gross motor, and motor planning activities; promote a smooth transition between activities; and aid in self organization and attention to task. The solution for the motor development criteria was a cape with manipulatives to enhance fine motor skill development in the form of zippers, button and button hole, and a lacing strip, as well as large pockets to hold fine motor items. (See Figures 27, 30, and 31). The beetle shell on the cape created two 9" x 12" pockets. One pocket was accessed with a 9" black plastic non-separating zipper and the other pocket was accessed with a 11/16" blue plastic button and machine stitched buttonhole. The pocket size was planned so that 8 1/2" x 11" paper could easily be placed in the pockets. The beetle wings on the cape also featured fine motor activities. For lacing practice, one wing had fabric strips with metal eyelets and a 46" black nylon lacing cord. To aid in the lacing sequence the eyelets alternated between gold and silver. The other wing had a separating zipper.

The cape was designed to promote gross motor activities and a smooth transition between gross motor and fine and perceptual motor activities, as well as aid in three step motor planning. At the beginning of each therapy session the child and therapist planned the gross motor and fine motor activities they would work on that session. The fine motor activity, or a reminder of the activity, could be placed in the cape pocket. In this way, the child's memory and upcoming transitions were aided by the child discussing the activities, collecting materials for the activities, and physically placing the materials in the cape pockets.

Motor planning and activity transition could also be enhanced by using the prototype garment in imaginative scenarios. The futuristic looking top and cape, and the beetle theme, should spark the child's and therapist's imaginations.

Play. Specification criteria for play required that the garment follow the philosophy that occupational therapy work should be a form of play; the garment structures represent a favored play theme; and the surface treatment include clothing preferences of surface patterns and motifs and the color red. The solution for the play criteria was to use the theme of a bug superhero. The bug superhero theme addressed the children's interest in superheroes. The use of beetle surface structures addressed the preference for motifs instead of garments without surface motifs or patterns. The color preference for red was not met in the prototype garment color selections. Colors that represent beetles took precedence over the preferred color of red. However, red velvet was included on the cape surface design and on one baby bug weight in an effort to include the color red.

Material Solutions

Movement. Fabrics used to construct the top have stretch capability, which aids in the goal of full range of motion. The top exterior was constructed from gold spandex knit fabric (82% polyester, 18% Lycra® spandex), the top bindings were black spandex knit (85% nylon, 15% Lycra® spandex), the top lining was black cotton spandex knit (exact content percentages unknown), and the lining channels were knit interfacing (100% polyester). The use of hook and loop tape promoted safety and full range of movement. Hook and loop tape straps were used to secure the elastic bands when the elastic bands were not being used. Hook and loop tape was used at the shoulder seams of the top and the shoulder of the cape to allow the cape to be detached for activities where the cape would interfere with the child's movement.

Sensory integration: Proprioception. The elastic loops provide the opportunity for proprioceptive input. The loops are 1" wide black elastic (68% polyester, 32% rubber) by Stretch Rite®. This elastic was selected due to its good shape recovery after stretching. The baby bug weights provided the opportunity for passive and deep pressure proprioceptive input. Steel shot pellets were used for weight in the bug weights. Polyester batting lined the bug structure to provide comfort for the wearer and durability to the bug structure.

Sensory integration: Tactile. To provide a variety of tactile experiences the prototype garment was created with a variety of fabrics that had textures ranging from cool and smooth to warm and soft. Table 8 presents the fabrics used in the prototype garment and are organized tactile description and include the fabric name, fiber content, color, and location on the prototype garment. Other materials that provided tactile opportunities were the steel shot pellets and batting in the bug weights, the plastic and the metal zipper, the plastic button, velcro closures, metal eyelets, and the lacing cord.

Motor development. The materials used on the cape for fine motor activities included a 9" black polyester non-separating zipper, 11/16" blue plastic button with two thread holes, 12" black metal separating zipper, 5/16" gold and silver colored metal eyelets, and a 46" black nylon lacing cord.

Play. Materials were selected to best represent the bug superhero play theme. Iridescent taffeta fabrics were selected for the beetle bodies because the colors and textures resembled the shine of beetle shells. If you look closely at insects they are hairy; therefore, velvet was used to represent the hairy aspect of insects. A variety of tulle or netting was used to represent the airiness of bug wings. Black mercerized cotton covered polyester thread by Coats and Clark® was used for the machine embroidery. The repeating triangle machine embroidery stitch was used to represent the jagged lines of insect antennas and legs. The favored color of the three children was red. There was only one fabric used that was red. The use of fabric colors that fulfilled the bug superhero theme took precedence over the favored color of red.

Table 8

Fabrics Used for Prototype Garment

Fabric Name	Fiber Content	Color/Description	Location
		Cool and smooth	
Sincronia®	100% polyester	Silver/black plastic adhered to black knit ground	Cape exterior
Festive foil liquid gold	100% polyester	Gold knit adhered to black knit ground	Cape lining
Festive foil liquid marble	100% polyester	Silver/pink/green knit adhered to black knit ground	Lower portion of beetle body on the top, eyes of beetle on the top and cape
Spandex	Exact content unknown	Gold rubber adhered to white knit ground	Eyes on bug weights
Spandex	85% Antron® nylon 15% Lycra® spandex	Black knit	Binding around the top's neckline, armholes, and hem
		Cool with slight scratch	
Spandex	82% polyester 18% Lycra® spandex	Matte gold knit	Top exterior
		Cool and bumpy	
Flocked iridescent taffeta	100% acetate	Green/black woven taffeta with ½" black flocked circles	Beetle body, pockets on top and cape
Chromspun iridescent taffeta	88% acetate 12% metallic	Teal/green/black woven	Beetle head on top, beetle neck on cape, beetle body of two bug weights
Chromspun iridescent taffeta	88% acetate 12% metallic	Pink/black woven	Beetle neck of top, bug body of one bug weight
Chromspun iridescent taffeta	88% acetate 12% metallic	Gold/black woven	Beetle head on cape, bug body of one bug weight

	<u>Somewhat scratchy</u>		
Metallic rainbow sheer	90% polyester 10% metallic	Black woven organdy with gold, bronze, and green metallic threads	Beetle wings on cape
Metallic rainbow sheer	90% polyester 10% metallic	White woven organdy with gold, pink, and green metallic threads	Wings on one bug weight
	<u>Scratchy</u>		
Glitter color tulle	100% polyester	Black tulle with 1/16" blue and green glitter	Layered over top beetle head, wings on one bug weight
Glitter tulle	100% polyester	Black tulle with 3/16" gold glitter circles	Wings on one bug weight
	<u>Scratchy and soft</u>		
Flocked tulle	100% polyester	Black tulle with 1/8" to ½" black flocked circles	Wings on one bug weight
	<u>Warm, soft, and scratchy</u>		
Speckled velvet	100% rayon	Black woven velvet with pink and green speckles	Part of beetle body on cape
	<u>Warm</u>		
Spandex	Exact percentages of cotton and spandex unknown	Black knit	Top lining
Broadcloth	100% polyester	Black knit	Facing on cape
	<u>Warm and soft</u>		
Velvet	100% rayon	Black woven	Beetle eyes on top and cape, part of beetle body on top, bug head on one bug weight
Velvet	100% rayon	Red woven	Part of beetle body on cape, bug head on one bug weight
Velvet	100% rayon	Green woven	Bug head on one bug weight

Velvet	100% rayon	Black woven	Beetle eyes on top and cape, part of beetle body on top, bug head on one bug weight
Velvet	100% rayon	Blue woven	Bug head on one bug weight

Assembly Solutions

Movement. All seams, topstitching, and understitching were stitched with a conventional home sewing machine using a 3 mm stitch length. To provide flexibility in the seam, the fabric was stretched during seam stitching.

Sensory integration. The elastic loops were constructed by forming a circle with the elastic. Prior to forming a circle, the elastic bands were inserted in the exterior slots and through the lining channels. The elastic ends were then connected in circle by butting the elastic ends together, placing three inches of black power knit spandex under the elastic, and zig zag stitching over the length for three inches. This technique allowed the elastic to retain its stretchability and secured it in a circle without a lumpy overlap. The horizontal elastic lengths were 46" long before loop assembly. The vertical elastic lengths were 41" and 55" long before loop assembly.

Assembly techniques that provided tactile experiences were three types of satin machine embroidery stitches. The straight satin stitch (.4 mm stitch length x 2 - 5 mm stitch width) was used to secure the fabric to the top and cape, a repeating triangle stitch was used for the bug antennas and legs on the top and cape, and a wave stitch was used to create the smile on the bug weights.

Motor development. Assembly techniques for motor development included machine stitching a button hole and attaching metal eyelets. The eyelets were hammered into strips of Sincronia® cape fabric. The strips were then straight stitched to the wing on the cape.

Play. The beetle on the top front, top back, and cape exterior were created by machine embroidering fabrics to the ground fabric. The process for the top began by fusing knit interfacing to the underside of the gold spandex fabric for stability. The beetle fabrics were fused to Wonder-Under® transfer web, cut out in the desired shapes, and then fused to the gold spandex. To support the stitching a layer of Stitch 'n Tear® was placed next to the underside of the gold spandex, and then the edges of the beetle fabrics were secured with a satin stitch (.4 mm stitch length and 2-6 mm stitch width) through the layers of beetle fabric, gold spandex, and Stitch 'n Tear®. The Stitch 'n Tear® was removed after stitching.

The prototype garment was designed to meet the garment specifications garnered from the needs assessment of the environment, the wearers, and the activity. The specifications for movement, sensory integration, motor development, and play were addressed in terms of the structure, materials, and assembly. The evaluation of the sensory costume is presented in Chapter five.

CHAPTER 5

Evaluation

The evaluation of the prototype is the final stage of the Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996). The purpose of this study was to design apparel products for children with sensory integrative dysfunction who participated in occupational therapy that used sensory integrative methods. The environment, wearer, and activity needs were assessed for three preschool aged children. The needs were translated into garment specifications. The specifications were developed into ideas, sketches, and samples. The resultant prototype was addressed in terms of the structure, materials, and assembly.

This chapter presents the evaluation of the prototype garment. The prototype was evaluated against garment specifications using methods of observation, interviews with family members of the children, natural dialogue with the children and significant others, and an evaluation form completed by the occupational therapists.

The Participants

Wearer Sample

The wearer evaluation participants were Aaron (4.5 years of age), Bryan (4.7 years of age), and Matthew (4.8 years of age), the three males for whom the wearer specifications were developed. After the first evaluation session, Aaron was withdrawn from the evaluation. Aaron eagerly anticipated his turn to wear the prototype garment and showed his enjoyment for the garment through smiles, hugging the cape to his body, and admiring himself in the mirror. However, at the end of the session he would not remove the prototype garment. He cried and physically lashed out at the therapist. After ten minutes of trying to calm Aaron and with a bribe of candy, he allowed the garment to be removed. After removal of the garment, Aaron cried for another ten minutes in the Primary Care Room. Aaron's therapist expressed that Aaron was not ready to manage the use of the garment and was consequently withdrawn from the evaluation.

Significant Other Respondents

Evaluation forms were completed by Pink and Blue, each certified occupational therapy assistants. Pink was Bryan's occupational therapist and Blue was Matthew's occupational therapist. Both Pink and Blue are females between the ages of twenty-four and forty. Pink has been Bryan's occupational therapist since the beginning of his program in October, 1995. Blue has been Matthew's occupational therapist since the beginning of his program in June, 1996.

Interviews were conducted with Bryan's mother and Matthew's mother, step-father, and brother. Additional significant others included physical therapists, Primary Care Room instructors, and speech therapists. The adult respondents were ten females and one male between the ages of 22 and 40 and one male sibling seven years of age.

Procedures

The prototype garment was evaluated against garment specifications, through observations, interviews, and an evaluation form. Eight weeks and five days had passed from the last day of the needs assessment data collection to the first day of the evaluation of the prototype.

The observations took place at a rehabilitation center in Virginia. I observed Bryan and Matthew, the two four-year-old males professionally diagnosed with sensory integrative dysfunction, during each child's 40 minute occupational therapy sessions, three times per week for two weeks. The prototype garment was available for use one additional week after the observations without my presence. The children were also observed in the Primary Care Room prior to and after each therapy session for approximately 10 minutes. I took notes or video recorded the observation sessions. After each observation session I wrote field notes and transcribed the video tapes. I discussed the field notes with the occupational therapists to provide validity for the observations.

Natural dialogue or informal interviews were ongoing throughout the evaluation phase with the wearers, each child's occupational therapist, the Primary Care Room instructors, and each child's speech and physical therapists. Interviews were conducted with Bryan's mother and Matthew's mother, stepfather, and brother. Interviews sought answers to whether the garment met the child's therapy, play, and clothing needs. The interviews were guided by the questions presented in the evaluation forms (see Appendix C). The interviews with family members took place at each child's home and lasted approximately 30 minutes. The interview with Bryan's mother was audio recorded using a Sony® microcassette-corder. The interview with Matthew's family was not audio recorded, but notes were audio recorded following the interview. The audio recordings were transcribed following each interview.

An evaluation form (see Appendix C) was completed by Blue and Pink, the two therapist informants. The evaluation form sought answers to whether the prototype garment met the therapy, play, and clothing needs of their client.

Analyses

The goal of the analyses was to evaluate if and how the prototype garment met the garment specifications. The observations and video tape recordings were coded and categorized according to the categories established in the needs assessment data analysis. The grounded theory coding procedures of Strauss and Corbin (1990) were followed. The observation categories were guided by the following questions: Where is the child? What is the child doing? What equipment (including the prototype garment) is being used? How is the equipment being used? Why was the activity/equipment selected? What types of sensory input are occurring? Who is interacting with the child? What is the behavior of the child and interacting individuals? What is going on in the environment?

Each category was dimensionalized for intensity, duration, and behavior reaction as documented in the needs assessment analysis section. Intensity was based on the child's concentration, attention, facial expressions, body language, and verbal comments. Duration was recorded in minutes of participation. Behavior of the child was based on the child's actions, facial expressions, and verbal comments.

The open-ended responses from the evaluation forms and interviews were coded and categorized according to each garment specification. The evaluation findings are presented under each garment specification.

Findings

Movement

The movement specification criteria required that the prototype allow for full body movement, allow the wearer to participate in all occupational therapy activities, allow for the use of all equipment in the Occupational/Physical Therapy Room, and be safe for the wearer. The movement specification, as well as the play specification support Scardina's (1981) statement that equipment design (including clothing) should allow for maximum play, while involving full body movement.

The wearers were able to participate in all occupational therapy activities observed (see Tables 2, 3, and 4) and had full range of motion while wearing the prototype garment (Blue, evaluation; Pink, evaluation; observation). The therapists commented that the cape would need to be removed (Pink, evaluation) or adjusted (Blue, evaluation) for activities involving the scooter board, crab walking, and wheelbarrow walking; however, Bryan was observed crab walking while wearing the cape.

Hook and loop straps at the top’s underarm sideseam and hemline were created to hold the excess elastic bands when the bands were not being used in an effort to prevent the bands from interfering with donning, doffing, equipment, and full participation in activities. The hook and loop straps did keep the horizontal elastic bands from interfering with donning and doffing (observation). When the elastic bands were hanging loose, the horizontal bands interfered with donning by looping over the shoulder (observation). However, once the prototype garment was on the child the loose horizontal and vertical bands did not interfere with the equipment nor activities during the therapy sessions (observation).

Even though the cape was detachable, the children usually kept it on, even when moving on all fours in an inflatable large barrel called a Tractor Treader. Hook and loop fasteners were added to the cape and top at the shoulder seam area after the first evaluation session to alleviate the cape pulling against the wearer's neckline. The addition of the hook and loop fasteners was a satisfactory solution and kept the cape securely in place. The cape length was satisfactory and allowed for participation in all activities observed. The shoulders pads on the top prevented the vertical bands from slipping off the shoulders and appeared to support the pressure points at the shoulders. The spandex knit fabric and large armhole structure of the top allowed the children full range of movement and ease of donning and doffing the garment (observation).

Sensory Integration: Proprioceptive Input

The sensory integration criteria for proprioceptive input required that the garment provide opportunities for active, passive, and deep pressure proprioceptive input. The wearers' gained active proprioceptive input by actively moving their muscles while wearing the long vertical bands around their feet and stretching the horizontal bands with their hands (Blue, evaluation; Pink, evaluation; observation). This active use of the body with the garment supports Fisher's (1991) statement that producing an adaptive behavior against resistance may be the most effective means available for generating proprioceptive feedback.

Bryan wore the vertical bands at each observation session. Bryan maintained his good attention to task during the evaluation observations; however, while wearing the vertical bands he appeared to work harder than when not wearing the bands and appeared to tire more readily. This was evident as he paused during activities and was visually tired at the end of the session. This could be because of the additional resistance on his body created by the vertical bands. Another indication that the bands made Bryan work harder was garnered from his request to stop wearing the garment. After two weeks he didn't want to use the garment and said it was "too hard". Bryan used the horizontal bands only two times to gain proprioceptive input and hand strengthening. The horizontal band length was appropriate for Bryan's muscle strength, as he was able to accomplish the stretch, but his strength was challenged.

During Matthew's first session he was observed wearing the vertical leg bands and Matthew made sure he had them on for all of his activities. During the first observation evaluation session, there were no straps on the vertical bands to secure them to the foot. While a need for foot loops was obvious to me, Matthew was also aware of this need and informed me, "You need some tape down here.” At the second session Matthew informed the therapist, "I don't need those today,” in reference to the vertical bands. Matthew remembered the input he received and did not need that type of input on that particular day. Matthew's hand strength was too weak to pull the horizontal bands. The band length was increased after the first session, and Matthew was able to pull on the new horizontal bands. The vertical bands were used by Matthew at eight of the nine sessions, and the horizontal bands were only used at one session (observation).

A noticeable benefit from wearing the vertical bands for Matthew was a decrease in toe walking (Blue, evaluation; Pink, evaluation; observation). Matthew's therapist said nothing had helped to decrease his toe walking previously (Blue, evaluation).

After the first session the therapists requested another set of vertical bands for placement around the knees, so proprioceptive input and posture maintenance could be received while doing tall kneeling activities. The knee bands were added by the second session. The knee bands were not voluntarily used during any observation sessions.

Prior to the use of the prototype garment, active proprioceptive input was received through the active use of the child's muscles from independent activities such as hopping and jumping, and from equipment activities such as bouncing in the frog swing, lifting foam shapes, swinging into foam blocks, riding a three-wheeler, and boxing at a vertical bolster. With the prototype garment the wearer was still able to participate in the independent activities and the equipment integrating proprioceptive activities listed above. In addition, proprioceptive input was provided by wearing the prototype garment's elastic bands around the limbs, as the elastic bands created resistance for the muscles to co-contract against (Blue, evaluation; Pink, evaluation; observation).

Passive and deep pressure proprioceptive input was received by wearing the bug weights in the top pockets and also through wearing the vertical elastic bands when the child was sitting on chairs or swings (Blue, evaluation; Pink, evaluation; observation). Matthew could not tolerate the simultaneous use of the vertical bands and the bug weights when actively moving, as his balance was impaired (observation). The bug weights were each one-half pound, totaling two pounds of weight on the body when all four bugs were worn. One-quarter pound weights should also be constructed. Bryan could tolerate both the leg bands and the weights for active activities but only for a few minutes. After a few minutes, his balance was noticeably impaired. Because of excessive overload, I recommended that two pounds of weight and the vertical bands not be used in combination for active activities. Liotta-Kleinfeld (Joe, 1998) in an article published after the construction of the prototype garment, recommended a total of 1 pound weight for preschool aged children when using a weighted vest. In the same article, Blanchard (Joe, 1998) stated the vests are initially calibrated to 5% of the child's body weight and may be gradually increased as the situation warrants. Matthew was able to tolerate both the vertical bands and weights for seated activities (observation).

Prior to the wearing of the prototype garment, passive and deep pressure proprioceptive input was applied to the child by the therapist, with the exception of wearing weighted products. The therapist compressed the child's joints and applied pressure with their hands, a therapy ball, a bean bag, or by pressing against the child while he was in the cheese bag (bag of foam pieces). With the prototype garment the wearer was able to provide proprioceptive input independently in addition to the therapist's input. The wearers were able to provide their own joint compression by using the arm and leg bands and receive deep pressure input by placing the bug weights in the top pockets. The need for the child to control the amount of input he or she receives is supported by Ayres (1979), Grandin (1992), and Koomar and Bundy (1991). The garment was not designed for the child to apply pressure to all body parts. The elastic bands, when stretched, apply pressure downward from the shoulder, upward from the ankles, and inward from the arms and shoulders. Pressure on the entire limbs, head, and body was not provided by the prototype garment.

Recommended changes on the prototype garment for the proprioceptive input solution were the construction of lighter weights (Blue, evaluation; observation) and more location pockets throughout the garment (Blue, evaluation). The lighter weights would lower the beginning stage of involvement, and along with the increased number of pocket locations, provide the child additional opportunity for proprioceptive input. In addition, both Blue and Pink requested a head covering constructed to stimulate proprioceptors on the head and face of the child. To accommodate the different hand strengths of the wearers, elastic horizontal bands of varying lengths could be added (observation).

Sensory Integration: Vestibular Input

The sensory integration criterion for vestibular input was to promote the use of the vestibular integrating equipment. The prototype garment with its futuristic top and cape, promoted use of the vestibular integrating suspended equipment. Matthew's therapist stated, "...the cape entices children to want to 'fly', so this could aid in more vestibular activities, such as prone in the frog swing" (Blue, evaluation). Each child wore the prototype garment with the cape and pretended to fly. At each session Bryan pretended he was Batman and used the net swing as his Batjet and the bolster swing as his Batcar; his therapist was Robin and they were running from Mr. Freeze. In each therapy session Bryan and Pink created a new scenario for Batman and Robin.

The vestibular integrating suspended equipment provided for the children a favorite therapy activity as indicated in the needs assessment data. The benefit of the prototype garment was to extend the amount of time the wearers spent on the equipment. Bryan was able to achieve the goal of laying prone in the net swing and pulling himself by grasping a thera-band with his hands for three minutes. While it is difficult to know how maturation and skill development helped to achieve this goal, the prototype garment could have also helped. The novelty of wearing the prototype garment and acting out a fantasy role (Batman on the Batjet) could have extended Bryan's length of time on the net swing and thus aided in achieving the three minute goal.

Sensory Integration: Tactile Input

The sensory integration criterion for tactile input was to provide opportunities for tactile input. The prototype garment provided opportunities for tactile input through the variety of materials used in the construction of the garment. As the child interacted with the garment (i.e., placing items in top and cape pockets, throwing bug weights) he received tactile input by manipulating the garment parts. The layout of the beetle designs were planned so the wearers could run their hands over the beetle surfaces and receive a variety of tactile inputs; however, the children were not observed doing this. Nor did they rub the baby bugs on their bodies. When I discussed this lack of obvious stroking of the garment with Blue, she stated that her client was receiving tactile input from the elastic bands and through interaction (placing items in pocket, donning, doffing, hugging cape to body) with the top and cape. Blue did think other children with greater tactile integration needs would stroke the garment for tactile input.

Blue stated that the garment did provide a variety of tactile experiences for the child's hands, face, and feet. Blue indicated the vibrator and brush could be put in the cape pockets for later use. A surgical brush was used for brushing the surface of the skin during two sessions with Bryan, and it was placed in either a cape pocket or a top pocket at the beginning of the sessions. Pink indicated her satisfaction with the sleeveless structure and removable cape, as access was allowed to Bryan's limbs and back for his brushing program. Bryan's mother and Matthew's parents were pleased with the variety of fabrics used for tactile input. The use of fabrics was a favored feature of the prototype garment for the parents of Bryan and Matthew.

Motor Development

The specification criteria for motor development required that the prototype should provide and promote fine and perceptual motor skills; should promote transitions between activities, especially between gross to fine motor, without behavior resistance from the child; should promote motor planning up to three stages; and should aid in the wearer's self organization and attention to task. There was an increase in the fine motor activities of buttoning, unbuttoning, and zipping a non-separating zipper while the prototype garment was being used. Prior to the prototype garment, buttoning, unbuttoning, and zipping a non-separating zipper were not observed. With the prototype the child placed activities in the cape pockets at the beginning of the session and then retrieved the activities later in the session. Each time the cape pockets were accessed the child experienced unbuttoning and buttoning, or unzipping and zipping.

The amount of time spent lacing remained the same between the needs assessment stage and the evaluation stage. Prior to the prototype a lacing board was used, and with the prototype the lacing was on the cape. A benefit of the lacing on the cape was the alternating gold and silver eyelets. Bryan's lacing skill improved by using the eyelet colors as a visual aid (observation).

The separating zipper on the cape was used once by each child. Prior to the prototype garment, separating zipper experiences were limited to the days when the weighted vest was worn. Therefore, during the needs assessment observations, Bryan did not experience a separating zipper, and Matthew experienced the separating zipper only once. The metal separating zipper on the prototype cape was difficult for the children and the therapists to zip. A plastic separating coat zipper should replace the metal separating zipper as the zipper teeth are larger and more similar to the zippers in children's coats.

There was an increase in the duration and intensity of fine motor activities performed by Matthew while using the prototype garment. Prior to the prototype, Matthew was unable to sit still and complete fine motor tasks. While wearing the prototype garment he was able to stay focused for an entire 40 minute session. On one occasion Matthew picked up jacks with pincers, drew letters and shapes in shaving foam, tried the separating zipper on the cape, and drew a snake with markers on paper and then used scissors to cut on the snake line. Matthew's therapist, Blue, had never seen him this focused. Matthew had on the vertical bands and all four bug weights while doing the seated activities. The increase in Matthew's attention span while wearing the bug weights and elastic vertical bands, support Liotta-Kleinfeld's (Joe, 1998) research that weighted vests help children improve their school performance by reducing their motor activity.

The prototype garment promoted a smooth transition between gross motor and fine motor activity. "Before the prototype, the client had difficulty with these transitions but never had difficulty while wearing the prototype and was able to maintain concentration in a noisy, overstimulating environment; where normally we would have had to move to a quieter environment" (Blue, evaluation). Transitions were aided with "activities hidden in the cape, as this encouraged the move from sensorimotor to fine/perceptual" (Blue, evaluation). Immediate proprioceptive input through use of the elastic bands or use of the weights were also identified as factors that aided in transitions (Blue, evaluation; Pink, evaluation).

Motor planning was promoted by use of the prototype garment. The therapist and child discussed which motor activities they were going to do during the session and also created an imaginative theme to take them through the motor sequence. Koomar and Bundy (1991) found verbalizing motor plans can help the child organize and understand their actions. Bryan had been doing well with this type of motor planning prior to the prototype garment, and the prototype garment maintained his ability. Pink commented on how Bryan and she incorporated the prototype garment into their sessions, "This therapist would use her imagination to give Bryan character choices for him to use while wearing the costume. With the character chosen this therapist would set up a motor maze, incorporating Bryan's goals: 'Batman' driving the 'Batmobile' (pulling thera-bands while prone in cargo net swing); 'Batman' would then leap tall buildings (frog jumping to puzzle stations); and staying low away from villains (crab walking to puzzle stations)" (Pink, evaluation).

In addition to completing three step directions during imaginative motor mazes, Pink stated the donning of the prototype provided four step directions: (a) top on, (b) cape on, (c) weights in pockets, and (d) feet in straps. Pink also commented on the benefit of proprioceptive input from the elastic straps on motor planning, "Providing proprioceptive input to large motor joints (arms and legs), increased body awareness and where Bryan's body is in space. In turn, this assisted the brain in organizing movement (various kinds - crab walking, frog jumping) and assisted the brain in refining awkward and uncoordinated movement" (Pink, evaluation). Pink's comments support Koomar and Bundy's (1991) intervention emphasis that the "client perform active movements against resistance to assist them in developing improved body schemes as a foundation for improving the planning of their movements" (p. 305).

The prototype garment improved Matthew's ability to stay on task with motor planning. Prior to the prototype, Matthew's concentration was low and he often ran about the room. With the prototype he was able to remember and stay on task with the planned motor activities. Blue (evaluation) believed the immediate proprioceptive input received through the vertical bands helped Matthew to organize and follow through with the motor planning. The use of the prototype garment also appealed to Matthew's high imaginative abilities and thus helped him to focus on motor planning.

Blue (evaluation) found the prototype garment provided a limited opportunity for direct fine motor (button, zippers, lacing) and hand strengthening experiences, however, many opportunities to indirectly enhance fine motor activities were provided. Objects for fine motor training were placed in the prototype's pockets. The cape pockets were used to carry paper, markers, Perfection game, puzzle pieces, and Geoboard. The top pockets were used to carry tweezers, Micro Machine figures and plastic worms to be picked up with tweezers, rubber bands for the Geoboard, and puzzle pieces. The therapists and children used the pockets to hold objects for fine motor activities, thus aiding in the planning and transition of the session and the memory and organization of the child. The use of a garment with pockets to aid in the planning and transition to fine motor activities was not documented in the literature.

Additional benefits of the prototype garment's fine motor features was the promotion of independent self care and daily life skills. "The use of buttons, zippers, lacing, hook and loop tape, and donning and doffing of the prototype during therapy, can be translated into everyday clothing and grooming skills required to be independent in other environments" (Blue, evaluation). The transition from therapy activities to daily life skills is a goal of intervention (Koomar and Bundy, 1991).

<u>Play</u>

Play specification criteria required the prototype garment support the philosophy that occupational therapy work should be a form of play, the garment structures should revolve around a play theme favored by the wearers, and the surface treatment should include preferences of the child. Matthew's therapist stated, "The prototype facilitates the child's desire to engage in imaginative play, while allowing the therapist to elicit 'work' toward goal progress through use of sensory input and the cape's ability to structure tasks" (Blue, evaluation). Similarly, Pink commented, "In order to do treatment, the therapist needs to get on the child's level. The garment enables the therapist to use his/her imagination in order to encourage the child to perform tasks that will work towards improving deficit areas" (Pink, evaluation). The prototype garment fulfilled Michelman's (1974) request that play in a child's treatment influence behavior, thinking, performance, and provide the child a sense of control. The child's positive reaction to the prototype followed Bundy's (1991) recommendation that play during therapy be intrinsically motivated, internally controlled, and free of objective reality. Similarly, the use of a costume-like garment supports Stone's (1965) hypothesis on the importance of costume during imaginative play.

Matthew's imagination while wearing the prototype garment revolved around the bug theme. Immediately after donning the garment, Matthew would raise his arms and declare, "I am Bugman!" The fine motor activity objects which he placed in his cape also revolved around the bug theme. The game Perfection became an oven where he cooked bug food (Perfection game pieces). The bug theme inspired Matthew to independently draw a bug, which fulfilled a fine motor goal to draw circles and vertical strokes. He then continued to draw other insects and animals for the therapist. Previously, Matthew had not been able to remain seated for more than a few minutes at one sitting.

The prototype garment eliminated Matthew's need for a security toy during therapy. "My client always brought a security toy (baby doll) with him to therapy, but with the prototype available to him he never requested the doll" (Blue, evaluation).

During the needs assessment observations both Matthew and Bryan were noted as having good imaginations. Bryan had used imaginative scenarios prior to the prototype garment and continued using imaginative scenarios when using the prototype. Bryan pretended he was Batman when wearing the prototype garment. His entire sessions were planned around Batman scenarios; his therapist was Robin and the suspended equipment became Batmobiles. At the close of each session, Bryan removed the prototype and became Bruce Wayne. Bryan was proud to wear the prototype garment and regularly asked if he could show "Batman" to the children in the Primary Care Room. Showing the prototype to his friends provided Bryan an opportunity to practice social skills and communicate with the children in the program.

While Matthew used his imagination during the needs assessment observations, his imaginative ideas were constantly changing and had no focus. This lack of focus was also present in his self organization during therapy. He had difficulty completing activities and would often run from one activity to the next. If he didn't like an activity he would cry and throw a tantrum. When Matthew used the prototype garment he was focused, remained on task, had an increased skill level with fine motor activities, and did not tantrum. When Matthew stopped using the prototype garment after three weeks, his therapist reported that his concentration, self organization, and behavior management was lower than when he wore the prototype garment (Blue, evaluation). It appeared that the prototype garment allowed Matthew to function at the "just right challenge" level recommended by Ayres (1979) and Koomar and Bundy (1991), whereby the client is motivated to engage in therapy and demonstrates noticeable improvements in adaptive behavior.

The prototype garment was fun for the wearers and liked by the wearers. Blue stated, "Matthew liked the costume, otherwise he would not have engaged in any activity related to the costume" (evaluation). Matthew's parents said the garment looked like something Matthew would enjoy and even thought the beetles resembled Matthew. Bryan's mother said she could imagine Bryan wearing the garment. Matthew and Bryan liked the prototype and requested to wear it during therapy (Blue, evaluation; Pink, evaluation; observation), supporting Koomar and Bundy's (1991) recommendation that therapy activities motivate the client.

The prototype garment promoted the wearing of other apparel items (observation). Bryan indicated the need for a helmet and put on a padded helmet on one occasion. Matthew also indicated the need for a head covering and wore a fire helmet on one occasion and a padded helmet on another occasion.

The prototype's surface treatment and garment structures revolved around a play theme favored by the wearers. The theme of a bug superhero was accepted by the children in the study. Other children at the center also wanted to try the prototype. One four-year-old boy declared, "I need to be Batman!"

Matthew's therapist thought the dark colors of the fabrics presented an appropriate level of stimulation; whereas, bright colors could have been overstimulating (Blue, evaluation). The parent's of Matthew and Bryan were satisfied with the colors, textures, and beetle theme of the prototype. While the beetle theme was liked by Matthew, Matthew's therapist thought the beetle theme could be scary to some children (Blue, evaluation).

The fabrics selected for the beetle designs were appropriate in color and texture (Blue, evaluation; Pink, evaluation; parent interviews); however, the fabric (iridescent flocked taffeta) and/or the assembly techniques (machine embroidery) used to secure the top's beetle body was not durable (observation). The edges of the taffeta pulled away from the machine embroidery.

A final question asked of the therapists and the parents was: Would you purchase such a product? If so, how much would you be willing to spend? All respondents said they would be willing to purchase the prototype garment. The parent's of the children would be willing to pay $40-$50. The therapists would be willing to pay $100 for the prototype garment.

<u>Recommendations for Garment Improvements</u>

1. The assembly technique of machine embroidery used to secure the beetle body on the prototype top be changed to a more durable technique, such as a turn and stitch (observation).

2. A female theme be developed (Blue, evaluation), perhaps a ladybug design (observation).

3. Head coverings be constructed (Blue, evaluation; Pink, evaluation; dialogue with occupational therapist; observation). A head covering would provide another outlet for imagination, protect the head, and provide sensory input to the head.

4. Materials sourced and assembly developed to keep the garment in the $100 retail price range.

5. Lighter weights (maximum 1/4 pound) be constructed and more pocket locations throughout garment (Blue, evaluation; observation).

6. Differing lengths of horizontal bands be added to accommodate different muscle strengths (observation).

CHAPTER 6

Conclusions and Implications

The purpose of the study was to use the Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996) to develop apparel products for children with sensory integrative dysfunction for use with sensory integrative methods in the occupational therapy environment. The stages of the process were problem development, needs assessment, prototype development, and prototype evaluation.

Problem Development

The aim of problem development was to explore the problem through observations, interviews, and experiences. The initial interest for the study developed from an association with a girl with autism, who demonstrated sensory impairments. The problem was developed by observing children with sensory impairments; interviewing a parent, teachers, and therapists; experiencing sensory integrative methods; and reviewing the literature. The problem development stage set the parameters for the study to include three pre-school aged children with sensory integration dysfunction who participated in occupational therapy using sensory integration methods at a rehabilitation center in Virginia.

Needs Assessment

During the needs assessment stage, needs were identified from the perspective of the wearer, the activity, and the environment. The wearers were three four-year-old boys with sensory integrative dysfunction and impaired motor development, the activity was occupational therapy using sensory integrative methods, and the environment was a rehabilitation center in Virginia. Needs assessment data was collected from observations, interviews, and document reviews and followed the grounded theory data collection methods and analysis procedures outlined by Strauss and Corbin (1990).

The wearers were observed for four weeks during their occupational therapy sessions and in the Primary Care Room prior to and after their therapy session. Coding categories were established by the questions: Where is the child? What is the child doing? What and how is equipment being used? Why was the activity/equipment selected? What types of sensory input are occurring? Who is interacting with the child? What is the behavior of the child and interacting individuals? What is going on in the environment? The categories where dimensionalized according to duration, intensity, and behavior.

Structured interviews were conducted with each child's occupational therapist and family members. Natural dialogue or informal interviews were ongoing throughout data collection and included the wearers, occupational, physical, and speech therapists, and Primary Care Room instructors. The interviews sought insight to the child's sensory needs and practices, therapy goals, clothing practices, preferences, and behaviors, and play practices and preferences. Document review included obtaining information about each child's diagnosis, therapy history and therapy goals from the Patient Plan of Care: Occupational Therapy and Occupational Therapy Re-evaluation documents.

The needs assessment stage data were organized by environment, wearer, and activity needs for product development. The environmental needs for product development were for the product to promote communication between the child and therapist, refine motor skills, encourage social interaction between the child and other children in the program, promote independence, and be a form of play. The wearer needs for product development were to provide opportunities to integrate the proprioceptive, vestibular, tactile, olfactory, gustatory, and auditory systems; provide opportunities to increase gross motor, fine motor and perceptual motor skills, and motor planning; provide opportunities to aid in the child's self organization and attentions to task; promote play preferences; promote clothing preferences; and provide opportunities to improve skills of donning, doffing, zipping, buttoning, and tying. The activity needs for product development were to provide or promote opportunities for sensory integration activities, gross motor activities, fine and perceptual motor activities, and motor planning activities, while improving self organization and attention to task.

The environment, wearer, and activity needs were translated into garment specifications and product development criteria. The garment specifications and criteria included:

1. Movement specification.
a. The garment should allow for full body movement by the wearer.
b. The garment should allow the wearer to participate in all occupational therapy activities and allow for the use of all equipment in the Occupational/Physical Therapy Room.
c. The garment should be safe for the wearer.

2. Sensory integration specification.
a. The garment should provide opportunities for active proprioceptive input.
b. The garment should allow for passive and deep pressure proprioceptive input.
c. The garment should promote use of equipment to provide vestibular input.
d. The garment should provide opportunities for tactile input.

3. Motor development specification.
a. The garment should provide and promote fine and perceptual motor activities.
b. The garment should allow for and promote gross motor activities.
c. The garment should promote motor planning up to three stages.
d. The garment should promote transitions without behavior resistance from the child between activities and thus aid in the wearer's self organization and attention to task.

4. Play specification.
a. The garment should follow the philosophy that occupational therapy work should be a form of play.
b. The garment structures and forms should revolve around a play theme favored by the wearers. Themes included action figures, superheroes, sports, and cartoon characters.
c. The surface treatment and surface designs of the garment should include clothing preferences for the color red and surface patterns and motifs over solid colors.

The Boles design process framework guided the needs assessment stage from the perspective of the wearer, activity, and environment. The collection of data from all three perspectives was simultaneous as suggested by Boles, however this study presented the needs assessment in the order of environment, wearer, and activity, instead of wearer, activity, and environment. The reason for the order of presentation in this study was that I believed the new order better organized the presentation of needs. The environment section set the scene, the wearer section provided information about the wearer subjects, and the activity section placed the wearers in specific contexts.

Prototype Development

During the prototype development stage, ideas were generated to meet garment specifications in terms of structure, materials, and assembly. The process included writing ideas, coding and combining ideas, sketching ideas, constructing samples, and constructing a prototype garment solution. This study presented the prototype development process in two phases. The first phase addressed structure, materials, and assembly for the garment specifications of movement, motor development, and the sensory integration criterion for proprioceptive input. Inclusion in the first phase was determined by the specifications and criteria that directly influenced the garment structure of the upper body. The second phase addressed the structure, materials, and assembly for the play specification and remaining sensory integration criteria for vestibular and tactile input, as well as readdressing the movement and motor development specifications and proprioceptive criterion.

Phase One Solutions

Phase one solution for the movement specification was a sleeveless pullover top with large armholes constructed from red spandex in order to allow for movement and ease of donning and doffing. Safety features included hook and loop tape to secure elastic vertical bands. Seam construction consisted of a 3 mm straight stitch which was stretched during assembly. Thread used was mercerized cotton covered polyester.

Phase one solution for active proprioceptive input was to provide 1" wide elastic band loops at joint compression areas. As the child pushes against the resistance of the elastic band he will gain proprioceptive input to his joints and muscles. The elastic band loops were held by stitched channels between the exterior and lining fabrics and accessed through slots near the front and back shoulder seams, armscyes, side seams and hemline. The slots were finished by facing the opening with knit interfacing and top stitching 1/4" from the opening.

Phase one solution for motor development was a black stretch vinyl cape with several pockets accessed by a variety of fastening systems (zippers, button, hook and loop tape, lacing, and a buckle). The manipulatives on the cape would provide the opportunity for fine and perceptual motor activities. The pockets on the cape would aid the transition between activities by providing a place to store activities and a means to discuss upcoming activities.

Phase Two Solutions

Phase two addressed the play specification, which influenced the acceptance of or modification of solutions from phase one. Phase two also addressed the criteria for vestibular and tactile input. The phase two garment will be referred to as the prototype garment.

The solution for the play specification was a bug superhero theme. The bug superhero theme addressed the play interests of the children in the study. The bug superhero theme inspired bug surface designs on the sleeveless pullover top, cape, and weights. The color selection was also inspired by the bug motif to include colors that represented beetles.

Phase two solution for movement retained the sleeveless pullover top from phase one, however the prototype garment was constructed from gold spandex instead of red spandex. Safety features included hook and loop tape on the top and cape shoulder area for removing the cape during activities that would interfere with the child's safety, shoulder pads to support the shoulder pressure points, and hook and loop tape at the underarm and hemline to hold the elastic bands when not in use. All seams and topstitching were stitched with a conventional home sewing machine using a 3 mm stitch length and stretched during seam construction to provide flexibility.

The prototype garment retained the phase one use of two vertical and two horizontal elastic bands to provide proprioceptive input. An additional vertical band was added for tall kneeling activities and foot loops were added to secure the elastic around the foot. The opportunity for passive and deep pressure proprioceptive input was provided by baby bug weights stored on the beetle wing design of the pullover top. Each bug weighed ½ pound. The weight used was steel shot pellets.

The solution to promote vestibular integrating activities was the cape featuring a large beetle. The cape promoted the theme of "flying" used during therapy and play, and thus promoted the use of the suspended equipment to provide vestibular input.

The tactile criterion solution was to provide a variety of tactile experiences by constructing the prototype from fifteen types of fabric ranging from cool and smooth to warm and soft. Other materials that provided tactile opportunities were the steel shot pellets and batting of the bug weights, the plastic and metal zipper, the plastic button, velcro closures, metal eyelets, and the lacing cord.

The phase one cape solution with manipulatives for motor development was refined with the prototype garment. A beetle body surface design on the cape created two pockets accessed by a non-separating zipper and a button and buttonhole. The beetle wings surface design created areas for lacing metal eyelets and a separating zipper.

This study organized prototype development through two phases of structure, material, and assembly, simply as a means to guide the reader through the process. The Boles model does not indicate multiple phases, however Boles (personal communication, 1996) recognizes revisiting structure, materials, and assembly during the prototype development stage.

Evaluation

The prototype garment was evaluated against garment specifications through observations, interviews, and an evaluation form. Two of the three wearers (four-year-old males with sensory integration dysfunction and impaired motor developed) were observed for two weeks with the prototype garment available for use. Structured interviews were conducted with family members of the two wearers. Natural dialogue of informal interviews were ongoing with the wearers, the occupational, physical, and speech therapists, and the Primary Care Room instructors. An evaluation form was completed by each wearer's occupational therapist.

The movement specification criteria were fulfilled as the prototype garment allowed the wearer full body movement, participation in occupational therapy activities and equipment use, and was safe for the wearer. Equipment design (including clothing) that allows for full body movement and maximum play is supported by Scardina (1981). Creating a safe therapy environment is supported by Fisher and Bundy (1991).

The wearer interacting with the vertical and horizontal elastic band loops was the solution for gaining active proprioceptive input. The active use of the body against the elastic bands supports Fisher's (1991) statement that producing an adaptive behavior against resistance may be the most effective means available for generating proprioceptive feedback. Passive proprioceptive input was gained when the child was wearing the vertical elastic band loops during seated activities. The pressure applied passively from the vertical elastic bands downward from the shoulders and upward from the feet provided proprioceptive input and increased attention span. Deep pressure and passive proprioceptive input was provided by wearing the bug weights in the pockets of the top. The use of weight to provide proprioceptive input and improved behavior is supported by Liotta-Kleinfeld and Blanchard (as cited in Joe, 1998). The amount of weight used with the prototype garment, two pounds, should be lowered to a beginning maximum weight of one pound. The wearers in this study demonstrated impaired balance while wearing two pounds of weight and the elastic bands.

The prototype garment cape promoted the use of the vestibular integrating suspended equipment. Each child pretended they were "flying" and used the suspended swings as flying vehicles.

A variety of tactile opportunities were provided by the fifteen different fabric types and other materials (i.e., elastic, button, zippers, hook and loop tape, thread, steel shot, and lacing cord) used to construct the prototype garment. The use of multiple textures in the therapy environment is supported by Ayres (1979), Linkous and Stutts (1990), and Royeen and Lane (1991). As the child interacted with the garment he received tactile input. Interactions included wearing the elastic bands, hugging the cape to the body, throwing the bug weights, placing items in the top and cape pockets, and manipulating the cape’s zippers, button, and lacing strip. Fabric layout on the top was planned so the wearer would receive tactile input as he stroked the top. However, the wearers were not observed stroking the top. Nor did the wearers brush their bodies with the bug weights as intended.

Fine and perceptual motor skill activity increased by interacting with the cape's fastening systems of separating and non-separating zippers, button and buttonhole, hook and loop tape, and lacing. Resistance free transitions between gross motor and fine motor activities and motor planning were promoted by using the cape to store fine motor activities. The child planned the activity, retrieved objects for the activity, stored objects in the cape pockets, and then removed objects from the cape pockets. The use of garments with pockets promoted smooth transitions and organization of the wearer and increased the opportunity for fine and perceptual motor activities.

The play needs of the wearers were satisfied with the bug superhero theme. The prototype garment facilitated the wearers' desire to engage in imaginative play, while allowing the therapist to incorporate therapy goal activities. The importance of play in the therapy environment is supported by Bundy (1991) and Michelman (1974). The use of a fantasy garment supports Stone's (1965) premise on the necessity of costume during imaginative play.

The evaluation stage of this study included evaluating the prototype garment in the field through observation, interview, and an evaluation form. The Boles framework evaluates the garment through lab simulation, field testing, and resulting product choices. The lab simulation of this study was the use of child models during prototype development. For this study there was only one prototype choice to be evaluated, as other ideas were eliminated during the prototype development stage.

Summary of the Boles Design Process Framework

The Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996) was an appropriate framework for product development and analyses. The framework included four stages: a) problem development, b) needs assessment, c) prototype development, and d) evaluation.

The Boles framework guided me through problem development using methods of observation, interview, and experience. In addition to these methods, reviewing the literature also aided in problem development. Observation included spending time with individuals with sensory problems in a variety of settings. Interview included talking with parents, professionals, and children involved with sensory issues. Experience involved my physical participation with weighted products, therapy equipment, and therapy activities. The methods of observation, interview, and experience helped me to better understand and bring reality to what I was reading in the literature. The problem development process led to the development of sample criteria and established connections in the field for data collection.

The needs assessment stage documented and analyzed the needs of the wearer, the activity, and the environment. The three perspectives were an appropriate way to assess needs from different yet related perspectives. The wearer, activity, and environment needs were identified through methods of observation, interview, and document review. The needs were analyzed through qualitative procedures outlined by Strauss and Corbin (1990). The analyses resulted in garment specifications and criteria that were used to develop and evaluate the prototype garment. Since these specifications and criteria were addressed in both the prototype development and evaluation stages, I recommend that garment specifications be included in the model of the Boles design process framework. Currently, the garment specifications are represented as The Assessed Needs.

The prototype development stage addressed the garment specifications through experimentation with structure, materials, and assembly. Initial ideas were generated in writing by addressing specifications that could influence the structure on the upper body. While it may not be appropriate to address the upper body in all studies (i.e., a footwear study), it did guide and direct my ideas. The structure ideas for each specification were coded and combined in all possible combinations. The combinations that didn’t make sense were eliminated. The remaining combinations were sketched and modified until accepted by Boles and myself. Samples of the sketches were then constructed. The process was repeated until the structure solution ideas were satisfactory.

Materials ideas and solutions were generated for each specification and for compatibility with the structure solution ideas. Assembly ideas and solutions were generated for each specification and for compatibility with structure and materials. The idea generating process for materials and assembly followed the process described above for structure.

The process of generating ideas from written form, to combinations, to sketches, and through samples guided me through the development and selection of structure, materials, and assembly techniques. I recommend that this sequence be included in the model of the Boles framework.

I organized the writing of prototype development through two phases of structure, materials, and assembly. The reason for two phases was that one specification and criteria from another specification did not influence the upper body structure and was therefore not included in the generation of initial ideas. The second phase of prototype development addressed the remaining specification and criteria while also addressing the solutions established. The Boles model does not indicate multiple phases, however Boles (personal communication, 1996) recognizes revisiting structure, materials, and assembly during the prototype development stage.

The evaluation stage of this study included evaluating the prototype garment against garment specifications in the field through observation, interview, and an evaluation form. The Boles framework guides evaluation of the garment through lab simulation, field testing, and resulting product choices. The lab simulation of this study was the use of child models during prototype development. For this study there was only one prototype choice to be evaluated, as other ideas were eliminated during the prototype development stage.

The Boles design process framework (Alexander, 1998; J. F. Boles, personal communication, 1996) was an appropriate process to develop therapeutic apparel products for preschool children with sensory integration dysfunction. I recommend two additions to the Boles model: a) garment specifications be listed as the result of the needs assessment stage and b) the idea generating process of writing ideas, to coding and combing ideas, to sketching, and through samples be included in the prototype development stage of the model.

Value of Research to Subjects

The prototype garment addressed the needs of two male children with sensory integration dysfunction and impaired motor development, that participated in occupational therapy using sensory integrative methods. The prototype garment benefitted Matthew in several ways. The garment, structured as a bug superhero, connected with Matthew and enabled him to function at a higher attention level and skill level then when not wearing the prototype garment. Without the garment, Matthew had difficulty managing his behavior, organizing himself, and staying on task.

One reason for the noticeable improvement in Matthew while wearing the prototype garment could be that the elastic bands and/or the weights provided the correct amount of arousal, modulation, and discrimination, which lead to skill output. Proprioceptive input affects many skill output areas and could have influenced the increased skill level demonstrated by Matthew.

Another reason for Matthew's improved behavior could be that the bug superhero theme helped to organize Matthew by focusing his session around his role as "Bug Man." One needs to consider how the child's maturation and past two years of therapy could have aided the improvements. While these factors could influence the positive changes in Matthew, the improvements were only evident when Matthew was wearing the prototype garment or for the remaining 20 minutes of a therapy session after removing the garment. The improved attention and self-organization did not even carry over to the Primary Care Room. It appeared that the combination of the imaginative theme and the immediate proprioceptive input that was gained by wearing the garment aided Matthew to function at a higher level of organization than when not wearing the prototype garment. Another major benefit of wearing the vertical bands was that Matthew's toe walking decreased.

The prototype garment enabled Bryan to increase the amounts of muscle resistance and joint compression gained by challenging him in a play situation. The Batman theme created by Bryan kept him wanting to wear the garment even though he had to work harder when he was wearing the garment. The duration of swinging prone while pulling a thera-band increased while Bryan was wearing the prototype garment. Bryan's enjoyment of wearing the prototype garment and participation in the Batman scenario could have helped to achieve his therapy goal in the swing.

Questions to Inspire the Next Generation of Garments

1. How can the benefits of wearing the prototype garment in the therapy environment be carried to other environments?

2. Would the child have received the same benefits if the prototype did not include a play theme? What was the role of fantasy dress?

3. Would other populations benefit from the organizational pocket idea? How attached are we becoming to carrying everything with us in our portable environments?

4. What other populations would benefit from the built in muscle resistance of the elastic band loops?

REFERENCES

Alexander, L. (1998). Design criteria for female flight attendant uniforms: Wearer preference needs assessment. Unpublished master's thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Ayres, A. J. (1965). Patterns of perceptual-motor dysfunction in children: A factor analytic study. Perceptual Motor Skills, 20, 335-368.

Ayres, A. J. (1966). Interrelations among perceptual-motor abilities in a group of normal children. American Journal of Occupational Therapy, 20, 288-292.

Ayres, A. J. (1972a). Improving academic scores through sensory integration. Journal of Learning Disabilities, 5(6), 338-343.

Ayres, A. J. (1972b). Sensory integration and learning disorders. Los Angeles: Western Psychological Services.

Ayres, A. J. (1972c). Southern California sensory integration tests: Manual. Los Angeles: Western Psychological Services.

Ayres, A. J. (1972d). Types of sensory integrative dysfunction among disabled learners. The American Journal of Occupational Therapy, 26(1), 13-18.

Ayres, A. J. (1975). The Southern California Postrotary Nystagmus Test. Los Angeles, CA: Western Psychological Services.

Ayres, A. J. (1977a). Cluster analyses of measures of sensory integration. The American Journal of Occupational Therapy, 31(6), 362-366.

Ayres, A. J. (1977b). Effect of sensory integrative therapy on the coordination of children with choreoathetoid movements. The American Journal of Occupational Therapy, 31(5), 291-293.

Ayres, A. J. (1978). Learning disabilities and the vestibular system. Journal of Learning Disabilities, 11, 30-41.

Ayres, A. J. (1979). Sensory integration and the child. Los Angeles: Western Psychological Services.

Ayres, A. J. (1989). Sensory integration and praxis tests. Los Angeles: Western Psychological Services.

Ayres, A. J., & Mailloux, Z. (1981). Influence of sensory integration procedures on language development. The American Journal of Occupational Therapy, 35(6), 383-390.

Bauman, M., & Kemper, T. L. (1985). Histoanatomic observations of the brain in early infantile autism. Neurology, 35, 866-874.

Berk, R. A., & DeGangi, G. A. (1983). DeGangi-Berk test of sensory integration. Los Angeles, CA: Western Psychological Services.

Boles, J. F. (1982). Final report: Men's indoor exercisewear, L. L. Bean. Unpublished manuscript, Virginia Polytechnic Institute and State University at Blacksburg.

Bundy, A. C. (1989). A comparison of the play skills of normal boys and boys with sensory integrative dysfunction. The Occupational Therapy Journal of Research, 9(2), 84-100.

Bundy, A. C. (1991). Play theory and sensory integration. In A. G. Fisher, E. A. Murray, & A. Bundy (Eds.), Sensory integration: Theory and practice (pp. 46-70). Philadelphia: F.A. Davis Company.

Case-Smith, J. (1997). Variables related to successful school-based practice. The Occupational Therapy Journal of Research, 17(2), 133-153.

Center for Rehabilitation & Developement, Inc., n.d. [Brochure]. Roanoke, VA: Center for Rehabilitation & Development, Inc.

Clifford, J. M., & Bundy, A. C. (1989). Play preference and play performance in normal boys and boys with sensory integrative dysfunction. The Occupational Therapy Journal of Research, 9(4), 202-217.

Cook, D. G. (1990). A sensory approach to the treatment and management of children with autism. Focus on Autistic Behavior, 5(6), 1-19.

Courchesne, E., Yeung-Courchesne, R., Press, G. A., Hesselink, J. R., & Jemigan, T. L. (1988). Hypoplasia of cerebellar vernal lobules VI and VII in autism. New England Journal of Medicine, 318, 1349-1354.

Cummins, R. A. (1991). Sensory integration and learning disabilities: Ayres' factor analyses reappraised. Journal of Learning Disabilities, 24(3), 160-168.

Davis, S. L. (1983). The effect of specially designed garments on the observable make-believe play behavior of four- to six-year-old females. Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Dejonge, J. O. (1984). The design process. In S. M. Watkins, Clothing: The portable environment (pp. vii-xi). Ames: Iowa State University Press.

Densem, J. F., Nuthall, G. A., Bushnell, J., & Horn, J. (1989). Effectiveness of a sensory integrative therapy program for children with perceptual-motor deficits. Journal of Learning Disabilities, 22(4), 221-229.

Denzin, N. (1984). The research act. Englewood Cliffs, NJ: Prentice Hall.

Fetterman, D. (1989). Ethnography: Step by step. Newbury Park, CA: Sage.

Fisher, A. G. (1991). Vestibular-proprioceptive processing and bilateral integration and sequencing deficits. In A. G. Fisher, E. A. Murray, & A. Bundy (Eds.), Sensory integration: Theory and practice (pp. 71-107). Philadelphia: F.A. Davis Company.

Fisher, A. G., & Murray, E. A. (1991). Introduction to sensory integration theory. In A. G. Fisher, E. A. Murray, & A. Bundy (Eds.), Sensory integration: Theory and practice (pp. 3-25). Philadelphia: F.A. Davis Company.

Folio, M. R., & Fewell, R. R. (1983). Peabody developmental motor scales and activity cards. Austin, TX: Pro-ed, Inc.

Grandin, T. (1988). Teaching tips from a recovered autisitc. Focus on Autistic Behavior, 3(1), 1-8.

Grandin, T. (1992). Calming effects of deep touch pressure in patients with autistic disorder, college students, and animals. Journal of Child and Adolescent Psychopharmacology, 2(1), 63-72.

Grandin, T. (1994). Video of presentation at Virginia Foundation for the Exceptional Child and Adolescent.

Haar, S. J., & Gidding, V. L. (1997). Assessment of weighted vests. Unpublished manuscript, Virginia Polytechnic Institute and State University at Blacksburg.

Hatch-Rasmussen, C. (1996). Sensory integration. Available: http://www.autism.org/si/html

Humphries, T. W., Snider, L., & McDougall, B. (1993). Clinical evaluation of the effectiveness of sensory integrative and perceptual motor therapy in improving sensory integrative function in children with learning disabilities. The Occupational Therapy Journal of Research, 13(3), 168-182.

Humphries, T. W., Wright, M., McDougall, B., & Vertes, J. (1990). The efficacy of sensory integration therapy for children with learning disability. Physical and Occupational Therapy in Pediatrics, 10(3), 1-17.

Humphries, T. W., Wright, M., Snider, L., & McDougall, B. (1992). A comparison of the effectiveness of sensory integrative therapy and perceptual-motor training in treating children with learning disabilities. Journal of Developmental and Behavioral Pediatrics, 13(1), 31-40.

Imamura, K. N., Wiess, T., & Parham, D. (1990). The effects of hug machine usage on behavioral organization of children with autism and autistic-like characteristics. Sensory Integration Quarterly, 27, 1-5.

Joe, B. E. (1998). Are weighted vests worth their weight? OT Week, 12(21), 12-13.

Jones, J. V. (1988). Engineering design: Reliability, maintainability and testability. Blue Ridge Summit, PA: TAB Books, Inc.

Kaplan, B. J., Polatajko, H. J., Wilson, B. N., & Faris, P. D. (1993). Reexamination of sensory integration treatment: A combination of two efficacy studies. Journal of Learning Disabilities, 26(5), 342-347.

Kaufman, R. A., & English, F. W. (1979). Needs assessment: Concept and application. Englewood Cliffs, NJ: Educational Technology Publication.

Koomar, J. A., & Bundy, A. C. (1991). The art and science of creating direct intervention from theory. In A. G. Fisher, E. A. Murray, & A. Bundy (Eds.), Sensory integration: Theory and practice (pp. 251-314). Philadelphia: F.A. Davis Company.

Krauss, K. E. (1987). The effects of deep pressure touch on anxiety. The American Journal of Occupational Therapy, 41, 366-373.

Lamb, J. M., & Kallal, M. J. (1992). Conceptual framework for apparel design. Clothing and Textiles Research Journal, 10(2), 42-47.

Larson, K. A. (1982). The sensory history of developmentally delayed children with and without tactile defensiveness. The American Journal of Occupational Therapy, 36(9), 590-596.

Linkous, L. W., & Stutts, R. M. (1990). Passive tactile stimulation effects on the muscle tone of hypotonic, developmentally delayed young children. Perceptual and Motor Skills, 71, 951-954.

Matlin, M. W., & Foley, H. J. (1997). Sensation and perception (4th ed.). Boston, MS: Allyn and Bacon.

McClure, M. K., & Holtz-Yotz, M. (1991). The effects of sensory stimulatory treatment on an autistic child. American Journal of Occupational Therapy, 45, 1138-1142.

Michelman, S. S. (1974). Play and the deficit child. In M. Reilly (Ed.), Play as exploratory learning (pp. 157-207). Beverly Hills, CA: Sage Publications.

Mullet, K. K. (1984). Kayaker's paddling jacket: A needs assessment. Unpublished master's thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Murray, E. A., & Anzalone, M. E. (1991). Integrating sensory integration theory and practice with other intervention approaches. In A. G. Fisher, E. A. Murray, & A. Bundy (Eds.), Sensory integration: Theory and practice (pp. 354-386). Philadelphia: F. A. Davis Company.

Occupational therapy: Talk back. (1996). Available: http.well.com/user/jwhitson/ot/twelve.html

A parent's guide to understanding sensory integration. (1991). Torrance, CA: Sensory

Integration International, Inc.

Piaget, J. (1962). Play, dreams and imagination in childhood. New York: W. W. Norton & Co., Inc.

Polatajko, H. J., Kaplan, B. J., & Wilson, B. N. (1992). Sensory integration treatment for children with learning disabilities: Its status 20 years later. The Occupational Therapy Journal of Research, 12(6), 323-341.

Polatajko, H. J., Law, M., Miller, J., Schaffer, R., & Macnab, J. (1991). The effect of a sensory integration program on academic achievement, motor performance, and self-esteem in children identified as learning disabled: Results of a clinical trial. The Occupational Therapy Journal of Research, 11(3), 155-176.

Royeen, C. B., & Lane, S. J. (1991). Tactile processing and sensory defensiveness. In A. G. Fisher, E. A. Murray, & A. Bundy (Eds.), Sensory integration: Theory and practice (pp. 108-133). Philadelphia: F.A. Davis Company.

Scardina, V. (1981). From pegboards to integration. The American Journal of Occupational Therapy, 35(9), 581-588.

Schaffer, R. (1984). Sensory integration therapy with learning disabled children: A critical review. Canadian Journal of Occupational Therapy, 51(2), 73-77.

Schaffer, R., Law, M., Polatajko, H., & Miller, J. (1989). A study of children with learning disabilities and sensorimotor problems or let's not throw the baby out with the bathwater. Physical and Occupational Therapy in Pediatrics, 9(3), 101-117.

Schopler, E. (1995). Parent survival manual: A guide to crisis resolution in autism and related developmental disorders. New York: Plenum Press.

Stake, R. E. (1995). The art of case study research. Thousand Oaks, CA: Sage Publications, Inc.

Stepp-Gilbert, E. (1988). Sensory integration dysfunction. Issues in Comprehensive Pediatric Nursing, 11, 313-318.

Stone, G. P. (1965). Appearance and the self. In M. E. Roach & J. B. Eicher (Eds.), Dress, adornment, and the social order (pp. 216-245). New York: John Wiley & Sons.

Storm, P. (1987). Functions of dress: Tool of culture and the individual. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Strauss, A., & Corbin, J. (1990). Basics of qualitative research: Grounded theory procedures and techniques. Newbury Park, CA: Sage Publications, Inc.

Tesch, R. (1990). Qualitative research: Analysis types and software tools. New York: The

Falmer Press.

Tustin, F. (1992). Autistic states in children. New York: Tavistock/Routledge.

Watkins, S. M. (1984). Clothing: The portable environment. Ames: Iowa State University Press.

Watkins, S. M. (1995). Clothing: The portable environment (2nd ed.). Ames: Iowa State University Press.

Wilson, B. N., Kaplan, B. J., Fellowes, S., Gruchy, C., & Faris, P. (1992). The efficacy of sensory integration treatment compared to tutoring. Physical and Occupational Therapy in Pediatrics, 12(1), 1-36.

Yack, E. (1989). Sensory integration: A survey of its use in the clinical setting. Canadian Journal of Occupational Therapy, 56(5), 220-235.

Yin, R. K. (1989). Case study research, design and methods. Beverly Hills: Sage Publications.

Zissermann, L. (1992). The effects of deep pressure on self-stimulatory behaviors in a child with autism and other disabilities. American Journal of Occupational Therapy,46(6), 547-551.

Appendix A

Outline of Needs Assessment Adult Interview Questions

Outline of Needs Assessment Interview Questions to be Asked to Adult Respondents.

What are the clothing practices and related behaviors of children with sensory integrative dysfunction?

What are the child's clothing preferences and clothing dislikes?

What types of fabrics, fibers, textures, colors are preferred and disliked?

What clothing provides the most comfort?

What clothing provides the best fit?

What detergents, fabric softeners, starch, and water type (hard or soft) are used in the cleaning and care of the child's clothing?

Where does wear or stress occur on the child's garment?

What are the child's dressing routines and consequent behaviors?

Does the child over or under dress?

What types of clothes does the child wear for "dress-up"?

How does the child use clothing during play?

What behaviors (e.g., tantrum, chewing, sucking, tearing, scratching) are related to clothing use?

What types of clothing have been used as part of sensory integration therapy and what was the behavioral response to such therapeutic clothing?

Has a weighted vest, collar, or quilt been used as part of therapy? If so, how was the clothing or quilt accepted and what was the resulting behavior?

Describe the treatment procedures for wearing such a garment.

What is the child's sensory dysfunction history and therapy goals? (The goal of the following questions is not to re-diagnose the individual, but to provide a profile for each child's case study).
What is the professional diagnosis?

How long has the child shown evidence of the dysfunction?

What aspects of sensory integration dysfunction does the child show evidence (e.g., proprioceptive dysfunction, vestibular dysfunction, tactile dysfunctions)?

What behaviors are related to each aspect of the sensory integration dysfunction?

What are the therapy goals for the child?

How long has the child participated in therapy?

What is the anticipated duration of therapy for the child?

What types of therapy (e.g., occupational, sensory integration, physical, stimulation) and therapy activities has and is the child being treated with?

What therapy and therapy activities has shown positive results?

What therapy and therapy activities has shown negative or no results?

What are favorite therapy activities of the child?

What are least favorite therapy activities of the child?

What is the social relationship of the child with other children? with adults?

What are the play practices and preferences of the child with sensory integration dysfunction? The following questions are adapted from Takata's (1974) play history evaluation.

With *what* does the child play? (toys, materials, pets, etc.)

What is the child's *favorite* play item or activity?

How does the child play with toys and other materials?

What type of play is *avoided* or liked least?

With whom does the child play?

How does the child play with others?

What body postures does the child use during play?

How long does the child play with objects? with people?

Where does the child play?
Home: (indoors, outdoors)
Community: (park, school, church, other)

When does the child play? (daily schedule for weekday and weekend)

What gross physical play does the child participate in?

What pretend and make-believe play does the child participate in?

What sports and games does the child participate in?

What are the creative interests, hobbies, collections, or other leisure activities of the child?

What are the recreation and social activities of the child?

Appendix B

Outline of Questions to Ask Child Participants

Outline of questions to ask child participants.

What are your favorite clothes? Why?

What are your least favorite clothes? Why?

When you pretend, who or what do you pretend to be?

What do you wear when you play "dress-up"?

What would you like to wear for a Halloween costume?

What do you like to do during therapy? Why?

What don't you like to do during therapy? Why?

What do you like to play (with) when you are outside at home? at daycare? at therapy?

What do you like to play (with) when you are inside at home? at daycare? at therapy?

Appendix C

Evaluation Form

EVALUATION OF SENSORY COSTUME

I. Please answer each question. If you need additional space to respond, use the back side of the paper.

Does the costume help to improve overall sensory integration?
How do you know? and what do you think?

Does the costume help to improve motor planning?
How do you know? and what do you think?

Does the costume help to improve reflex integration?
How do you know? and what do you think?

Does the costume help to improve self organization and attention to task?
How do you know? and what do you think?

Does the costume help to improve hand strength?
How do you know? and what do you think?

Does the costume help to improve fine motor skills?
How do you know? and what do you think?

Does the costume help to improve perceptual motor skills?
How do you know? and what do you think?

Does the costume promote a smooth transition from gross motor activity to fine motor activity?
How do you know? and what do you think?

Does the costume promote self care and daily life skills by the wearer?
How do you know? and what do you think?

Does the wearer like the costume?
How do you know? and what do you think?

Does the costume stimulate the imagination of the wearer?
How do you know? and what do you think?
Is the costume representative of the wearer's play interests?
How do you know? and what do you think?

Does the sensory costume follow the philosophy that occupational therapy "work" or activities should be a form of play? How do you know? and what do you think?

Does the costume integrate and promote activities to help achieve the wearer's therapy goals?
How do you know? and what do you think?

How would you incorporate the costume during therapy?

What do you like best about the costume?

What concerns, changes or additions do you think should be addressed?

Would you or your center purchase such a costume?

How much would you or your center be willing to pay for such a costume?

II. Please answer the following questions. There is space provided for comments provided on the right side and below each section. If you need additional space for comments, please use the back side of the paper.

Does the costume allow for full range of motion?
Does the costume allow the wearer to participate in occupational therapy?
Does the costume allow the wearer to use all of the equipment?
Is the costume safe for the wearer?

Does the costume allow for active proprioceptive input?
Does the costume allow for passive proprioceptive input?
Does the costume allow for deep pressure proprioceptive input?
Does the costume allow for an increase in muscle tone and co-contraction?

Does the costume promote active movement?
Does the costume allow for jumping?
Does the costume allow for crab walking?
Does the costume allow for hopscotch?

Does the costume allow for joint compression?
Does the costume promote good posture?
Does the costume create body awareness?
Does the costume decrease tip toe walking?

Does the costume provide a variety of tactile experiences?
If so, where on the body do the tactile experiences occur?
Does the costume allow for the use of vibration?
Does the costume allow for a brushing program?

Does the costume provide a variety of olfactory (smell) experiences?
Does the costume provide for a variety of auditory experiences?

Is the visual design (colors, motif, style) of the costume stimulating to the wearer?
Does the visual design of the costume aid in motor planning?
Does the visual design of the costume aid in perceptual activities?

Does the costume allow for motor maze planning and completion up to three stages?
Does the costume promote motor planning?
Does the costume allow for kneeling over bolster?
Does the costume allow for wheel barrow?
Does the costume allow for the hippity hop?
Does the costume allow for the monster feet?

Does the costume allow for use of the cargo net while in the prone position?
Does the costume allow for use of the scooter board while in the prone position?
Does the costume allow for use of the scooter board while in the supine position?
Does the costume allow for straddling the bolster swing?
Does the costume allow for throwing bean bags through or in a target?
Does the costume allow for initiation of swinging motion while tall kneeling on platform swing?
Does the costume promote the use of the suspended equipment?

Does the costume help to improve self organization?
Does the costume help to keep the wearer's interest and attention to task?
Does the costume allow for following up to three step directions?

Does the costume allow for transition from sensorimotor to fine motor activities?
Does the costume allow for transition between activities without resistance?
Does the costume allow for tall kneeling work?
Does the costume allow for activities while prone on wedge?
Does the costume allow for activities while seated?

Does the costume allow for hand strengthening?
Does the costume promote opportunities to imitate and cut circle, vertical, and horizontal strokes?
Does the costume allow for winding motion?
Does the costume allow for removing pegs from puddy?

Does the costume allow for the pincer grasp to manipulate small objects?
Does the costume allow for use of tweezers to pick up small objects?
Does the costume allow for completing a non-interlocking and/or semi-interlocking puzzle?
Does the costume allow for cube copying?
Does the costume allow for rubber band square completion on the Geoboard?

Does the costume provide opportunity to unbutton and button 3/4" button?
Does the costume provide opportunity to use separating zipper?
Does the costume provide opportunity for criss-cross lacing?

What would you call or name the costume?

Do you have any other thoughts, comments, or suggestions?

Appendix D (PDF, 42 KB, Appendd.pdf)

Institutional Review Board Approval Letter

Appendix E

Informed Consent

Part One: Parent/Guardian Consent Form for Observation and Interview of Child

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants
of Investigative Projects

Title of Project: The Design of a Therapy Garment for Young Children with Sensory Integrative Dysfunction
Part One: Parent/Guardian Consent Form for Observation and Interview of Child
Principal Investigator: Sherry J. Haar
Advisor: Dr. Joann F. Boles

VI. The Purpose of this Research/Project

The purpose of the study is to design a therapy garment that provides sensory input for young children with sensory integrative dysfunction. The therapy garment will be designed for use during occupational therapy. If your child is diagnosed with sensory integrative dysfunction and is participating in occupational therapy at the identified rehabilitation center he/she is invited to participate in the study. This portion of the study involves your child being observed during occupational therapy sessions and 15-30 minutes before and after each therapy session. In addition, your child will be informally interviewed about his/her clothing and therapy preferences and dislikes.

II Procedures

The observation procedure involves the principal investigator observing your child during his/her regular occupational therapy session and 15-30 minutes prior to and after therapy. No changes will be made in the therapy session. The principal investigator will sit in the room, but not interact nor interfere with the session. The therapy sessions last approximately 40 to 60 minutes. The observations will take place two days per week for four weeks at the rehabilitation center. The principal investigator will record observations by written notes and audio notes. The researcher will compare her notes with the reports of the therapist for observation validity. The principal investigator will transcribe any audio recordings.

During the four weeks of observation your child will be interviewed by the principal investigator to seek insights to his/her most and least preferred clothing, therapy activities, and play activities. The interview process will last approximately 15 minutes. You as a parent/guardian may be present during the interview as long as you do not interfere with the interview. The interview will be conducted at a time and location of your preference. The interview will be audio recorded using a cassette recorder. The principal investigator will transcribe the interview. The expectations of your child are to answer the interview questions to the best of his/her ability.

After these four weeks of observation the principal investigator will develop a prototype garment that is compatible with your child's therapy program. Your child may be asked to comment on the design ideas for the garment.

Upon completion of the garment, your child will be observed again during his/her therapy session. Your child will have the opportunity to interact with the prototype garment during therapy as directed by the therapist. The observations will take place at your child's 40-60 minute occupational therapy session, two days per week for two through four weeks, at the rehabilitation center. The researcher will sit in the therapy room but not interact with the session. Your child will also be observed prior to and after therapy session for 15-30 minutes. The researcher will record the observations by written and audio notes. The researcher will compare her notes with the reports of the therapist for observation validity. The researcher will transcribe the audio recordings. The expectations of your child are to participate in the therapy session and use the prototype garment as directed by the therapist.

After the child has participated in therapy with the prototype garment your child will be interviewed. The interview will be conducted by the principal investigator and will seek insight to your child's opinion about the prototype garment. The interview process will last approximately 10 minutes and will take place at the center following a therapy session where the prototype garment was used. The interview will be audio recorded and transcribed by the researcher. The expectations of your child are to answer the questions to the best of his/her ability.

II Risks

There are no additional risks or discomforts to your child as a participant beyond the normal risks associated with occupational therapy. The risk of occupational therapy is sensory overload. Signs of sensory overload are pupil dilation, sweating, changes in the rate of respiration, flushing or pallor. If signs of sensory overload are observed the amount and type of sensory therapy is altered.

IV Benefits of this Project

Your child's participation in this study will aid in the design of therapy garments and expand the information available on sensory integration.

No promise or guarantee of benefits have been made to encourage your child to participate.

X. Extent of Anonymity and Confidentiality

The data of this study will be kept strictly confidential. At no time will the researchers release the data of the study to anyone other than individuals working on the project without your written consent. Your child's name will be not be used in any written research.

The observations and interviews with your child will be audio recorded using a cassette recorder. The audio tapes will be stored at the home office of the principal investigator. The tapes will be transcribed by the principal investigator. The principal investigator and the advisor will have access to the audio tapes and transcribed information. The tapes will be destroyed after completion of the dissertation.

II Compensation

Your child will receive no compensation for his/her participation.

II Freedom to Withdraw

Your child is free to withdraw from this study at any time without penalty. Your child is free not to answer any questions without penalty. Your child is free not to interact with the prototype garment without penalty.

II Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic and State University, by the Department of Housing, Interior Design, and Research Management/Clothing and Textiles, and by the rehabilitation center that your child attends.

IX Subject's Responsibilities

I voluntarily agree to have my child participate in this study. My child has the following responsibilities: To attend occupational therapy as scheduled with the center and interact with the prototype garment during therapy after is has been developed. To answer any interview questions to the best of his/her ability.

XV. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for my child's participation in this project.

If my child participates, he/she may withdraw at any time without penalty. I agree to abide by the rules of this project.

____

Signature

____

Date

Appendix F

Informed Consent

Part Two: Child Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants
of Investigative Projects

Title of Project: The Design of a Therapy Garment for Young Children with Sensory Integrative Dysfunction
Part Two: Child Consent

Principal Investigator: Sherry J. Haar
Advisor: Dr. Joann F. Boles

I agree to let Sherry watch me before, during, and after therapy at the rehabilitation center. When asked, I will wear the prototype garment. I may choose not to wear the garment at any time. I understand that Sherry will ask questions of me. I understand that I am not required to answer the questions if I choose not to.

Child participant's verbal or written consent

____

Witness ____

Date ________________________________

Appendix G

Informed Consent

Part Three: Adult Interview Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

Title of Project: The Design of a Therapy Garment for Young Children with Sensory Integrative Dysfunction
Part Three: Adult Interview Consent
Principal Investigator: Sherry J. Haar
Advisor: Dr. Joann F. Boles

I. The Purpose of this Research/Project

The purpose of the study is design a therapy garment to provide sensory input for young children with sensory integrative dysfunction. If you interact with a child that is diagnosed with sensory processing dysfunction then you are invited to participate in the study. This portion of the study involves your responses to interview questions at three different times during the next few months. Approximately 20 subjects will be interviewed.

II Procedures

The procedure for this part of the study is an interview. The first interview will last approximately 45 minutes. The interview will take place at your convenience, at a location of your designation. Interview questions will seek insight to the child's sensory needs and practices and clothing practices, preferences, and behaviors. You will be expected to answer the interview questions to the best of your knowledge. The interview will be audio recorded using a cassette recorder and transcribed by the principal investigator.

During the development of the prototype therapy garment, your opinions and suggestions will be sought about design ideas for the prototype garment. Your comments about the design ideas will be recorded using a cassette recorder and transcribed by the principal investigator. Your time involvement for your comments on the design ideas will be approximately 15 minutes.

After the prototype therapy garment has been developed you will again be interviewed. Interviews will seek opinions about the prototype garment and any observable changes in the child while wearing or after wearing the prototype garment. You will be expected to answer the interview questions to the best of your knowledge. This last interview will last approximately fifteen minutes. Interviews will be audio recorded using a cassette recorder and transcribed by the principal investigator. Interviews will take place at your convenience, at a location of your designation.

II Risks

There are no risks or discomforts to you as a participant.

IV Benefits of this Project

Your participation in this study will aid in the design of therapy garments and expand the information available about sensory integration dysfunction.

No promise or guarantee of benefits have been made to encourage you to participate.

V. Extent of Anonymity and Confidentiality

The data obtained from this study will be kept strictly confidential. At no time will the researchers release the data of the study to anyone other than individuals working on the project without your written consent. Your name will not be used in any written reports of research without your permission.

Your interview responses will be audio recorded using a cassette recorder. The audio tapes will be stored at the home office of the principal investigator. The tapes will be transcribed by the primary investigator. The primary investigator and the advisor will have access to the audio tapes and transcribed information. The tapes will be destroyed after the completion of the dissertation.

II Compensation

You will receive no compensation for your participation.

II Freedom to Withdraw

You are free to withdraw from this study at any time without penalty. You are free not to answer any questions you choose without penalty.

II Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic and State University, by the Department of Housing, Interior Design, and Resource Management/Clothing and Textiles, and by the rehabilitation center that you are employed.

IX Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities: 1) to answer the interview questions to the best of my knowledge concerning the child's sensory needs and practices and clothing preferences, practices, and behaviors; 2) to comment on the design ideas for the prototype garment; and 3) to answer questions regarding the final product.

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

____
Signature

____
Date

Should I have any questions about this research or its conduct, I may contact:

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VITA

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PROFESSIONAL EXPERIENCE

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Virginia Tech, Dept. of Clothing and Textiles, Graduate Teaching Assistant. (1995-97)

University of Nebraska, Research Associate. (1995)

University of Nebraska, Dept. of Textiles, Clothing & Design, Instructor. (1994-95)

University of Nebraska, Dept. of Textiles, Clothing & Design, Graduate Research Assistant and Graduate Teaching Assistant. (1992-94)

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