

# Tactile Toys

## The Design and Development of Three-Dimensional Textiles into Tactile Toys to be used as Tactile Therapy for Children with Tactile Dysfunctions

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# **Abstract**

Touch is a very important sense. Through our skin, we receive information regarding touch, pressure, texture, temperature and pain. Being able to react positively to touch sensations enables us to feel comfortable and emotionally secure. However, there are certain groups of children who are diagnosed with Sensory Processing Disorder who experience Tactile Dysfunction and have difficulty accepting touch; or are unaware of the sense of touch or even constantly seeking touch. To help this group of children, a series of tactile products known as Tactile Toys are designed specifically for their use during therapy to enhance, improve and encourage their sense of touch.

Tactile Toys are developed from three-dimensional textiles known as Tactile Textiles, which are constructed into three-dimensional forms by utilizing the thermoplastic qualities of synthetic fabrics. The design of the three-dimensional forms will attract children to feel and touch the textiles, and also encourages them to play with the toys. Tactile Toys are used in occupational therapy sessions, and the usage of specific Tactile Toys for each individual child with tactile dysfunction as tactile therapy will also be monitored by the occupational therapist.

Tactile therapy through the use of three-dimensional structural textiles will provide a variety of tactile sensations and explorations involving touch. The implementation of Tactile Toys as tactile therapy will better equip children with appropriate therapeutic tactile sensory benefits, with a focus in helping children with different tactile sensory needs to improve their ability to regulate, interpret and execute appropriate behavioral responses to touch sensations. The goal of tactile therapy for children is to help them develop appropriate responses to touch sensation so that daily tasks can be competently performed. As these competencies will increase with effective tactile therapy, the child's self-esteem and self-regulation will also improve, allowing them to live their lives in a functional manner.

Tactile Toys will be beneficial and a valuable contribution to the special needs community specially targeted at children with tactile dysfunction. Current textiles based toys utilized in the therapy sessions are mainly normal two-dimensional textured fabrics with no special textile treatments or manipulations. The creation of the three-dimensional textiles by heat setting has not been applied as a therapy method within the needs for the child with tactile dysfunction. Different versions of Tactile Toys targeting respective tactile needs will be included into the sensory treatment sessions of the occupational therapy, allowing the child to learn and become accustomed through exposure of these toys and materials. Hence, Tactile Toys will be able to fill up the gaps of the existing tactile therapeutic toys, materials and equipments used in occupational therapy for children with sensory processing disorder.

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# **Chapter 1**

## **Introduction**

Victoria is a five-year-old girl who is extremely sensitive to the types of clothes she wears and textures that she comes into contact with. The bedding, towels, upholstery and even the carpet must be of a certain level of comfort to her. If she cannot find her comfortable socks and if she walks on the carpet with her bare foot, it will trigger her frustrations and lead to a meltdown. In contrast, seven-year-old Jason generally seems unaware and unbothered by textures of any surfaces, unlike Victoria who is extremely sensitive. On the other hand, Aaron loves to touch and feel everything! He craves for certain textures and will touch, feel, stroke, poke or pull anything that comes into his sight. These three children do not react to the sense of touch as normally as compared to other children.

The above-mentioned three children are diagnosed with Sensory Processing Disorder. They are known to have tactile sensory dysfunction. To help them cope with this dysfunction, a series of tactile toys and tactile materials collectively known as Tactile

Toys are designed and prototyped for these children. This thesis focuses on the conception of Tactile Toys and the use of Tactile Toys as tactile therapy to help children with tactile sensory dysfunction to overcome their dysfunction. Tactile Toys are developed from Tactile Textiles, textiles being constructed and manipulated into three-dimensional forms by utilizing the thermoplastic qualities of polyester, a synthetic fabric. The technique of heat setting is applied on polyester fabric, which will transform the plain, flat fabric into three-dimensional structural and sculptural forms.

Tactile Textiles are then being evolved into a range of toys and materials as part of occupational therapy sessions that target children with tactile sensory dysfunction. Collectively known as Tactile Toys, they will help expose the children to different types of touch sensations within textiles that they will come into contact with, such as their play objects or daily necessities that they use regularly. Children who are oversensitive or under-responsive to the sense of touch as well as tactile-seeking will benefit from this range of play objects and materials. Tactile Toys will further attract children to explore and enjoy tactile experiences. The three-dimensional structural surfaces can respond to the child's sense of touch and sight. They are incorporated as sensory diets during the occupational therapy sessions facilitated by an occupational therapist that will be monitoring the appropriate use of tactile toys and tactile materials for the child with specific tactile sensory dysfunction.

Through tactile therapy, their tactile defensiveness can be improved, their low level of sensitivity to textures can be enhanced and their tactile seeking behaviours can be soothed. Tactile therapy will allow them to develop appropriate responses to touch sensations in their daily lives.



## **1.1. Tactile Toys as Tactile Therapy for Children with Tactile Sensory Dysfunction**

Touch is the most basic of human senses. The tactile sense provides information through the surface of our skin and allows us to receive information regarding the texture, shape and size of objects in our environment<sup>1</sup>. This is known as the discriminative factor of the tactile system. With a functioning sense of touch, we can feel pressure, temperature and pain, which is the protective factor of the tactile system. Protective factors alert us to potential dangers<sup>2</sup>. Being able to react positively to touch sensations enables us to feel comfortable and emotionally secure.

Tactile Toys are a series of play objects and materials designed for children with Tactile Sensory Dysfunction. They are made from specially designed three-dimensional fabrics known as Tactile Textiles, which are constructed by utilizing the thermoplastic qualities of synthetic fabrics. These three-dimension structural textiles are formed by using heat setting techniques, which is a technical approach of fabric manipulation that provides a platform into some of the most creative and innovative approaches in surface and textile design. This technique enables a flat fabric to be transformed into structural and sculptural forms. The creative process of pleating, crushing as well as moulding continues to evolve into different possibilities and hence creating a range of interesting surface designs that is fundamental to the design process of this project.

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<sup>1</sup>Carol Kranowitz, *The Out-of-Sync Child Has Fun, Revised Edition: Activities for Kids with Sensory Processing Disorder* (Perigee Trade, 2006), ISBN: 9780399532719.

<sup>2</sup>Christopher R Auer and Susan L Blumberg, *Parenting a child with sensory processing disorder: A family guide to understanding and supporting your sensory-sensitive child* (New Harbinger Publications, 2006).

The main choice of fabric material is polyester, chosen because the three-dimensional structures should be able to retain their shapes permanently. Polyester, with thermoplastic qualities in the form of fabrics and fibers can be given a three-dimensional form regardless of construction methods and amalgamation with different surface design techniques. By definition, thermoplastic refers to the quality of a fiber whose molecular structure breaks down and becomes fluid at a certain temperature<sup>3</sup>, making it possible to reshape the fabric by pleating, moulding or crushing. The fabric is ‘fixed’ on cooling and cannot be altered unless heated to a temperature greater than the one at which it was reshaped.

Polyester belongs to the fabric group called Synthetic Fibers. Some other examples in the synthetic fiber group include Polyamide, Acetate, Acrylic, Viscose and Elastane. Polyester is thermoplastic, that is, it can be transformed by heat into new configurations, which on cooling are completely stable<sup>4</sup>. Polyester fibers and fabrics, being thermoplastics can be given a new form by heat setting. In this project, different techniques of heat setting will be explored to show the flexibilities of Polyester being given a three-dimensional structure and form.

Moulding of the fabric creates structural surfaces on the fabric. Moulds of different shapes and sizes can be used to provide the three-dimensional effect of the fabric. One easy approach is to apply simple ‘shibori’ techniques, by using a binding technique; glass marbles can be tied to the polyester organza. Then fabric can be placed into a microwave or oven during the heating process. Once heated, the fabric will adhere to the form of the marble mould, which is below the melting point of the fabric. Once the fabric has been heat set, the marbles are removed. This creates an amazing textural, rounded and three-

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<sup>3</sup>Sarah E. Braddock and Marie O’Mahony, *Techno Textiles* (London: Thames & Hudson, Limited, 1998).

<sup>4</sup>Ibid.

dimensional effect to the fabric. This structural design can be customized to one's liking, whether the moulds are close together or further apart, each individual fabric can be created with a different form.

Shibori is a centuries old traditional Japanese textile finishing technique. It involves tying and folding a piece of fabric before the dyeing process. This technique is originally used on silks and plant fibers, which leads to unique patterns, textures, structural forms and colours after the dyeing process. On natural fibers, the three-dimensional effect will not be permanent. However, on synthetic fibers such as polyesters, when treated with the shibori technique and heat, the fabrics will have a permanent three-dimensional surface as a result. These three-dimensional textiles that have been created are collectively known as Tactile Textiles.

Tactile Textiles are three-dimensional fabrics created by using the heat-setting technique. Tactile Textiles are now being developed into a range of tactile sensory products that target children who suffer from tactile sensory dysfunction, specifically those that lack tactile sense; for example children who are oversensitive or under-responsive to the sense of touch.

For this research, the aim is to target children with tactile sensory dysfunction that involve the tactile sense – who may be suffering from either over-responsiveness, under-responsiveness or sensory-seeking disorders. A child who is sensory over-responsive overreacts to their sensory messages. Examples of symptoms include being highly irritable to fabric textures particularly those that are rougher such as denim or wool. If left untreated, the child may grow up to face problems in grooming, as

combing of hair, nail cutting, hair cutting will become highly irritable. Their senses are too sensitive to withstand such activities, which to them has become undesirable.

A sensory under-responsive child displays slowed response towards a sensory message. Some symptoms include not crying when hurt, not noticing when someone touches him, not reacting to different body sensations such as heat, cold, and hunger. Some children may also be socially withdrawn.

Lastly, a sensory-seeking child is fidgety and will be constantly touching or pulling something because he has a large sensory appetite. Constantly touching something or being fidgety is an attempt for him to satisfy his sensory cravings. Sensory seeking disorder (SSD) shares similar traits to attention deficit hyperactive disorder (ADHD). In SSD, after the child gets the amount of sensory stimulation he needs, he will stop. As for ADHD, the actions will not stop unless the child is tired. SSD is the inability to correctly process sensory messages between the different senses.

The treatment for tactile sensory dysfunction is through an occupational therapist. A sensory integration approach will be adopted. According to the child's symptoms, a customized sensory diet will be planned to treat the child. Some examples of existing treatments<sup>5</sup> include squeezing soft tactile balls, use of Willbarger's brush to apply pressure and proprioception and, doing art and craft that involves different textures such as clay and paint.

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<sup>5</sup>L.J. Miller, D.A. Fuller, and J. Roetenberg, *Sensational Kids Revised Edition: Hope and Help for Children with Sensory Processing Disorder (SPD)* (Penguin Publishing Group, 2014), ISBN: 9780698149052.

Tactile therapy through the use of three-dimensional structural textiles will provide a variety of tactile sensations and explorations using touch. The implementation of tactile sensory products into the sensory diets of the children will better equip them with the appropriate therapeutic tactile sensory benefits, and hence is able to focus on helping children with different tactile sensory needs to improve their ability to regulate, interpret and execute appropriate behavioral responses to touch sensations so that they are able to live their lives in a functional manner. The goal of tactile therapy for children is to help them develop appropriate responses to touch sensation so that daily tasks can be competently performed. As these competencies will increase with effective tactile therapy, the child's self-esteem and self-regulation will also improve.

## **1.2. Tactile Sensory Dysfunction as part of Sensory Processing Disorder**

Children with tactile dysfunctions in general either over respond to tactile senses or under respond to the sense of touch, or constantly seeking the sense of touch. Children who have difficulty accepting touch may be easily distracted and unsettled. They may be very selective in terms of their clothing and the materials they are in contact with. Very often, they tend to over-react when they are in contact with fabrics that they do not feel comfortable with. These children with tactile sensory issues may have difficulty tolerating the sensations generated from coming into contact with the different types of textures on fabrics.

Certain fabric textures may cause the child to feel unpleasant. Terri Mauro<sup>6</sup> explains that sensory integration disorder is characterized by the inability to accurately process information coming to the brain from the senses, which results in inaccurate judgment of sensory information such as touch, sight, movement, taste and sound. Specific to tactile sense, our sense of touch conveys message to our brains about temperature, texture, shape, size and much more. A normal sense of touch will allow a child to do everything from buttoning a shirt to enjoying a hug. As for a child whose tactile sense is not as well integrated with other sensory information, he or she will feel discomfort in many situations. For instance, the child will most probably not enjoy finger painting and he or she may get upset after touching sticky glue or paint. A child who is tactile defensive will also dislike walking barefoot on textured surfaces such as grass, sand or rough carpet. Dressing and grooming can be especially difficult for the tactile defensive child because he or she may complain about how certain clothes feel. Normal daily routines such as hair brushing, teeth brushing or fingernail clipping can also become intolerable. A child will be diagnosed with tactile defensiveness when he or she displays some of the above symptoms of tactile sensitivity, and when these symptoms are amplified more dramatically or more often than other children do.

Tactile dysfunctions in children normally indicates that they are either over responsive to tactile senses, under responsive to the sense of touch, or sensory seeking. It is important to note that children who have sensory processing disorder may have one or more sensory issues. These sensory systems include sound (auditory), touch (tactile), sight (visual), taste (gustatory) and smell (olfactory). Sensory processing disorder (SPD)

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<sup>6</sup>T. Mauro and J.L. Clark, *The Everything Parent's Guide to Sensory Processing Disorder: The Information and Treatment Options You Need to Help Your Child with SPD*, Everything® Parents Guide (F+W Media, 2014), ISBN: 9781440574573.

is made up of three main categories: sensory modulation disorders (SMD), sensory-based motor disorder (SBMD) and sensory discrimination disorder (SDD). The two main sensory processing disorders (SPDs) that involve tactile sense are sensory modulation disorders (SMD) and sensory discrimination disorder (SDD). For children suffering from sensory processing disorders (SPDs), they often have symptoms that overlap with other types of sensory processing disorders (SPD). Sensory modulation disorders (SMD) basically means that the child's sensory perceptions are disordered. This can be further split into three sub-categories: sensory over-responsivity (SOR), sensory under-responsivity (SUR) and sensory seeking disorder (SSD).

For sensory over-responsivity, ordinary sights, sounds, scents, tastes and touches in everyday lives can bother or sometimes even become painful to the affected child. The child may appear belligerent when he encounters overwhelming sensations. His hearing may become hyper-acute, his sense of smell highly sensitive, he is distressed by certain tastes and textures of food, and has difficulties tolerating lights or things that he see, and may feel uncomfortable when being touched. Children who are sensory under-responsive tend to be hyposensitive to sensory input. They often have low levels of alertness and their nervous systems are difficult to arouse. They could be very intolerant to loud noises, may not respond to offensive smells, unable to notice tastes and textures of food, have difficulty recognizing familiar sights and having difficulty noticing touch. For sensory seekers, they are constantly seeking ways to arouse their starved nervous systems. They will only be able to calm down and focus when they get enough of their sensory cravings. They tend to love loud noises, crave certain smells, certain types of food textures and flavours excessively; they may love to look at bright or spinning lights and love to touch certain textures or constantly touching everything around them.

This research will focus on the touch (tactile) part of the sensory system. In a normal tactile system, the tactile sensations are well paced, allowing a normal child to be aware, but not over responding or fussing over minute changes in wind speed, temperature, or very light touch. However, for a tactile dysfunction child, once the brain receives such tactile sensations, they will be perceived as dangerous or threatening. Most clothing tags, different types of fabric, or waistbands will easily aggravate the tactile dysfunction child. Being lightly touched may be a problem for them. They will appear to withdraw or strike out when being unexpectedly touched. They normally have preferences in clothing textures and may even excessively seek out certain types of textures in their clothing.

A child who is tactile over-responsive will have his tactile sense received through millions of nerve ending on the skin, detecting even the slightest touch sensations and sending it to the brain. Once the brain receives this information, it may not respond accurately, hence creating a defense mechanism. The child's brain will also have a hard time accepting certain touch sensations. The child may show uncontrollable and inappropriate responses, such as getting overly agitated, distressed, reacting violently or even refusing to perform normal daily tasks. For example, a clothing tag can be a constant agitation. Stitching on the clothing seams may feel like thousands of needles poking into the skin and perceived as painful by the child. Most clothes will feel too tight and cause a sensation of being overheated, causing the child to fidget and adjust his clothing constantly, making it almost impossible for them to focus on any work they do.

For a child who is tactile under-responsive, he does not seem to feel or respond to anything. If someone touches him, he may not even notice. Under-responsive is also known as hyposensitive. Children who are hyposensitive to tactile input are often unable



to feel light touches or even pain and temperature extremes. This will pose a danger to their health and well being, as they may not be aware that they could have hurt themselves – even when they break a bone, they will not be able to feel it.

As for children who are tactile sensory seeking, they will constantly touch any objects of their interest and seemingly cannot get enough of such stimulation. Tactile sensory seekers often seek out tactile sensations, like playing with sand and mud. They may lather certain things on their body to achieve the stimulation they are craving on their skin. They may run their hands or fingers across walls, railings, or other objects in their environment. It is also common for them to constantly touch other people. Tactile seekers may have a hard time refraining from grabbing and handling everything, which is often viewed as bad behaviour or a character flaw.

These are the general symptoms that occur in the three categories of tactile sensory dysfunction. A child can be taught to cope with the dysfunction with the help of an occupational therapist. The design of tactile toys and tactile materials being further developed from Tactile Textiles will be used as sensory tools that are integrated into a child's sensory diet. The occupational therapist will allocate the right type of tactile toys or tactile material for the specific child, taking into consideration their tactile sensory acceptability. Through a prescribed sensory diet for each specific child, the child can improve on his tactile sensory processing capabilities.

### **1.3. Therapy Approaches for Tactile Sensory Dysfunction**

According to Dr Lucy Jane Miller, founder of Sensory Processing Disorder research programme in the US and author of book ‘Sensational Kids’, children with sensory processing disorder who have gone through occupational therapy with a sensory integration approach has helped them to improve their ability to learn, explore, play and socialize. For more than forty years this approach has produced countless success stories in which children with sensory processing disorder and their families have emerged with a higher quality of life<sup>7</sup>. There are specific therapy approaches catered to deal with issues faced by the different senses. Specifically for tactile sensory dysfunction, existing tactile therapy techniques are utilized by occupational therapists to help children.

An example of an existing therapy method is known as Wilbarger Protocol. This is a therapy program developed by Patricia Wilbarger, an occupational therapist who is a leading expert in the area of sensory processing disorders. The first step of the protocol consists of firmly and slowly brushing the skin of the child with a specific sensory brush. Brushing starts from the hands and down to the feet as well as the back of the child’s body. After brushing, the next step of the protocol is a series of gentle joint compressions to the shoulders, elbows, wrists, fingers, hips, knees and ankles. If the protocol is being administered over a period of time, it will help by shutting down inappropriate responses from the child and regulating the child’s sensory processing abilities.

To soothe children who are over responsive, therapists and parents will apply Wilbarger Protocol, providing deep pressure and proprioceptive stimulation. Another alternative will

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<sup>7</sup>Miller, Fuller, and Roetenberg, *Sensational Kids Revised Edition: Hope and Help for Children with Sensory Processing Disorder (SPD)*.

be for an adult to give the child a firm hug and then instructing the child to press hard against an adult's hands. Proprioceptive information (from the joints and muscles) and deep pressure (from the skin) can calm the child down as these tools utilize mechanical forces to quiet the alarms tripped by over-responsivity. This is how it works - when there is perceived discomfort or danger, the part of the brain responsible for arousal and emotions gets activated where it is eventually diminished by the proprioceptive and deep pressure, and the danger signals are then overridden.

For the under-responsive child, therapists will usually provide frequent, varied and extended opportunities for tactile stimulation. At home, parents should integrate the use of direct tactile stimulation into daily routines, e.g. drying the child vigorously after bath with towels of different textures, providing a variety in seating textures, choosing clothing with noticeable textures. Under-responsive children have to receive more sensory messages in order to wake up their under-responsive systems. They need bright lights and vivid colours to stimulate their visual sense, louder sounds to arouse their auditory sense and zesty foods to rouse their gustatory and olfactory senses. They need novel sensations and lots of movement and tactile stimulation to enable them to increase their alertness in their daily lives.

To calm an over-aroused sensory-seeking child, therapists often apply deep pressure on the child. In terms of tactile sensation, it will be good to provide the child with textures that provide tactile stimulations in daily use items. For example, textured bath mats, seating pads, stuffed toys, shoes and socks. The child should have access to fidget toys and a variety of tactile materials and play objects to satisfy his or her sense of touch.

There are intervention methods that are incorporated within occupational therapy for this disorder. Occupational therapy with a sensory integration approach has been in use for more than forty years and has produced countless success stories in which children with sensory processing disorder and their families emerged with a higher quality of life<sup>8</sup>. There are wide ranges of therapy activities that target the tactile sense<sup>9</sup>. Some of the activities include: popping bubble wraps which gives the child good tactile input; putting hands and feet into sand or rice can be a comforting and rich tactile sensory experience. Another effective activity is to let the child step or jump on textured stones or special pathway that offers a variety of sensory experiences such as bumpy, rough, prickly and smooth. These activities, generally termed as tactile sensory play, stimulate the child's sense of touch. Occupational therapists will also use tactile toys to help children explore their sense of touch<sup>10</sup>. Tactile toys as well as other fun sensory activities can help children to make discoveries and experiment with their environment. Tactile toys include items that specifically encourage the child to use his sense of touch in an exploratory way. These may include ridged or softly spiked rubber balls, touch and feel books or any other items that possess a specific feel.

One of the effective approaches to increasing comfort levels with touch is desensitization<sup>11</sup>. Desensitization is a gradual process whereby the child is introduced to a variety of textures and materials where he or she will become more comfortable in

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<sup>8</sup>Miller, Fuller, and Roetenberg, *Sensational Kids Revised Edition: Hope and Help for Children with Sensory Processing Disorder (SPD)*.

<sup>9</sup>Mauro and Clark, *The Everything Parent's Guide to Sensory Processing Disorder: The Information and Treatment Options You Need to Help Your Child with SPD*.

<sup>10</sup>Erica Loop, "Tactile Toys and Fun Sensory Ideas for Children," accessed November 2, 2013, <http://everydaylife.globalpost.com/tactile-toys-fun-sensory-ideas-children-12024.html>.

<sup>11</sup>Jill H. Mays, "Your Child's Motor Development Story," accessed November 2, 2013, [http://www.TheMotorStory.com/The\\_Motor\\_Story/Tolerating\\_Touch.html](http://www.TheMotorStory.com/The_Motor_Story/Tolerating_Touch.html).

feeling the different textures over time. As long as the child has been exposed to a variety of touch sensations, the uncomfortable sensation that he or she has felt initially will gradually diminish as the intensity of touch sensation increases. Therefore, the design of Tactile Textiles will be aimed at assisting children overcome their fear of tactile sensations through incorporating these toys into the sensory diets of their occupational therapy programme. This will help to boost the sensory processing system, allowing the brain to become more receptive to touch in general and learning to manage tactile information better.

## **1.4. Creating Tactile Toys and Tactile Sensory Materials from Tactile Textiles**

Tactile Textiles will be developed into Tactile Toys and Tactile Materials. Collectively known as Tactile Toys, these products will be woven into the sensory diets of children who are sensory over-responsive, sensory under-responsive and sensory-seeking. The treatment for specific tactile defensiveness is through an occupational therapist. According to the child's symptoms, a customized tactile sensory diet will be planned as treatment for the child. Tactile Toys will be tested out on the children. For children who are sensory-seeking, tactile toys will provide them with sufficient sensory cravings and the cause-and-effect play would capture their attention so that they can sit still long enough to go through the sensory therapy. For sensory over-responsive children, Tactile Toys will allow them to practice the feel and touch of different types of fabrics so that they will become more comfortable in feeling the different textures over time. As long as the child has been exposed to a variety

of touch sensations, the uncomfortable feel that she has initially will gradually diminish. This will be the strategy of desensitization, which is a gradual process whereby the child is introduced to a variety of textures and materials and over time, they will learn to accept the tactile sensation. As for sensory under-responsiveness children, they will be able to benefit from the tactile and visual stimulation provided by the tactile toys and materials. The invigorating three-dimensional structures and the bright vivid colours together with the cause-and-effect play catches the children's attention and interest, while allowing them to maintain sufficient focus on the toys.

Currently, there are specific tactile materials and toys available in the market. They are mainly fidget toys made from plastics or PVC. Tactile toys made from fabrics with three-dimensional forms have not been developed so far. With the creation of three-dimensional fabrics, unique features such as the structural surface and vivid colours will intrigue the children to touch the fabric. Over a period of time, tactile toys will be able to provide specific sensory inputs for the children in each of these categories through therapy and allow them to overcome their tactile dysfunctions.

At present, there are already several effective solutions created, which will help children with sensory over-responsiveness, under-responsiveness and sensory seeking, which work into the sensory diets of their occupational therapy programme. The four Tactile Toys being prototyped are Tactile Touchables, Tactile Balls, Tactile Runway and Tactile Wrap. The purpose of designing these series of Tactile Toys is to help the child identify different textures and to appreciate them, developing an awareness that it may lead to a joyful experience. These sensory touch toys can also double as sensory teaching supplies and can provide a variety of tactile sensations and opportunities for fun learning

and exploration using touch. Tactile Toys can also be used in the desensitization of tactile defensiveness in a child when used in their daily lives.

In order to prove the concept of Tactile Toys, it will be necessary to work with an occupational therapist to incorporate the toys into a child's sensory diet. The occupational therapist will provide feedback on the effectiveness of the toys based on her experience over a sample of children. Based on the feedback, the success of the textiles will be determined.

It is important to introduce tactile experiences slowly and gradually and only when the child is ready to experience them, so that any defensive reaction can be avoided. A child with tactile defensiveness should never be forced to touch anything they do not want to, as this will cause further apprehension and avoidance. The therapist will need to encourage, explain, understand and communicate with the child as they attempt to introduce touch sensations to them in a safe and non-threatening way. If the child with tactile defensiveness is fearful of any materials, the therapist will let the child play with it in a less threatening way. For example, the child can hold the therapist's hand to start touching the tactile toys. The child can put objects or toys inside or outside the three-dimensional tactile textiles, or push his or her toy cars or plastic animals through it. After a child begins to feel safe, he or she will be slowly encouraged to try other fun ways in which the therapist can demonstrate, such as splatting it, poking, pulling, rolling etc. Eventually, the child will be encouraged to use their whole hand, including their palm to touch the tactile textures, or even roll their body over it.

Textiles now have a new potential beyond fashion and aesthetics. For this research, it is found that textiles can be used as a source of new textures, which could then be added to the current range of sensory toys and products targeted at helping children suffering from

tactile sensory dysfunction. The flexibility of textiles allows new frontiers in textile toys and products. The advantages that fabrics have over plastics makes it more attractive to have products made from fabric instead of plastics, which pose unnecessary risks to a child already suffering from Sensory Processing Disorder.

Further tests will be carried out based on the current products to assess how successful the textiles and products are. Different ranges of textiles and products will also be made in future to aid these children suffering from tactile sensory dysfunctions. These developments will be based on field tests conducted with the aid of an occupational therapist experienced in prescribing sensory diets and dealing with tactile sensory dysfunctions.



## **Chapter 2**

### **Literature Review**

Tactile Textiles are fabrics that possess three-dimensional surface textures created by using the heat setting techniques. The contribution of this research is to create original Tactile Textiles that has three-dimensional surface structures, which will be further designed into Tactile Toy. This will be integrated as sensory diets within a child's tactile therapy session, coordinated by an occupational therapist. The design of Tactile Toys with three-dimensional surface textures can assist children to overcome specific reactions to tactile sensations through incorporating these toys into the sensory diets of their occupational therapy. It is through tactile therapy that a child can improve his ability to regulate, interpret and execute appropriate behavioral responses to touch sensations so that they are able to live their lives in a functional manner.

In this review, the effectiveness of occupational therapy on children with sensory processing disorder will be discussed. Occupational therapist practices the Sensory

Integration Approach on children and it is important to review how therapy is being administered for children and specific therapy methods used for these children. Next, the usage of generic textiles as therapy and the current textile-based materials used for tactile therapy for children with tactile dysfunction will be reviewed. Subsequently, the fundamentals of using the heat setting technique to achieve three-dimensional structural qualities on fabrics, which is a vital feature in this design of Tactile Textiles, will also be reviewed. Finally, the conception of tactile-toys and tactile sensory materials for tactile therapy along with how these are distinctive to the existing generic textiles. Tactile Textiles will contribute to the existing tactile therapy and eventually allow the children to overcome the dysfunction and respond appropriately to tactile senses in their daily lives.

## **2.1. Occupational Therapy for Children with Sensory Processing Disorder**

In the 3rd European Congress of Sensory Integration 2014<sup>1</sup>, researchers share their research results and knowledge of sensory integration and sensory processing disorder. Current research and knowledge got its start from research by the late Dr Jean Ayres. Ayres was both an occupational therapist and an educational psychologist who developed sensory integration therapy for children with Sensory Processing Disorder. Till today, there are still on-going research to look into the effectiveness of the sensory integration approach and how this approach has helped children to overcome the disorder.

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<sup>1</sup>“3rd European Congress of Sensory Integration, ESIC2014” (2014), <http://www.congress.utu.fi/esic2014/index.php>.

Founder of Sensory Processing Disorder Foundation, Dr Lucy Jane Miller, one of the key presenters at this congress has published numerous evidence-based researches on the effectiveness of occupational therapy using the sensory integrated approach for children. Miller et al<sup>2</sup>, conducted a controlled trial on three groups of children with sensory processing disorder. First group of children received the occupational therapy-sensory integration approach, second group received activity protocol and the third group no treatment at all. The children's behaviour, sensory and adaptive functions were closely administered. The findings showed that the group who received the occupational therapy-sensory integration approach has improved tremendously in terms of the child's sensory responsivity, social behavior, motor competence, and participation in meaningful daily activities. Sensory integration approach do ameliorate difficulties of children with sensory processing disorder, which supports the claim of this research whereby the design of appropriate tactile sensory materials with three-dimensional surface textures can assist children to overcome specific reactions to tactile sensations through incorporating these toys into the sensory diets of their occupational therapy.

Teresa A. May-Benson, Executive Director at the Spiral Research Center and Laboratory is a well-known expert in sensory integration in occupational therapy and known clinically for her work with children and adults with sensory processing problems. This center is dedicated to expanding the body of research on sensory processing.

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<sup>2</sup>Lucy Jane Miller, Joseph R. Coll, and Sarah A. Schoen, "A Randomized Controlled Pilot Study of the Effectiveness of Occupational Therapy for Children With Sensory Modulation Disorder," *American Journal of Occupational Therapy* 61, no. 2 (2007): 228–238, doi:10.5014/ajot.61.2.228, +%20http://dx.doi.org/10.5014/ajot.61.2.228.

May-Benson together with Koomar<sup>3</sup> reviewed the effectiveness of sensory integration approach on the ability of children with sensory processing disorder to engage in desired daily activities. Results suggest the sensory integration approach may result in positive outcomes in sensorimotor skills and motor planning, socialization, attention and behavioral regulation, reading-related skills, participation in active play and finally achievement of individualized goals. The findings have shown positive trends supporting the effectiveness of the sensory integration approach, especially when measuring goals customized for the child. This review suggests that there is a trend towards positive evidence to support the sensory integration approach.

Associate Professor, Beth Pfeiffer from the Department of Rehabilitation Sciences at Temple University, Philadelphia, United States did a more focused study on children with Autism Spectrum Disorder who has sensory processing difficulty. Pfeiffer et al<sup>4</sup> test out the effectiveness of sensory integration approach on a group of children between ages six to twelve. These children were randomly put into two groups; the first group received fine motor skills therapy and the second group sensory integration therapy. The children's social responsiveness, sensory processing, functional motor skills and social-emotional reactions were closely tracked before, during and after the therapy. The findings showed significant positive changes for both groups; but even more significant changes occurred in the group who received sensory integration therapy with significant decrease in their autistic mannerisms.

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<sup>3</sup>Teresa A. May-Benson and Jane A. Koomar, "Systematic Review of the Research Evidence Examining the Effectiveness of Interventions Using a Sensory Integrative Approach for Children," *American Journal of Occupational Therapy* 64, no. 3 (2010): 403–414, doi:10.5014/ajot.2010.09071, +%20http://dx.doi.org/10.5014/ajot.2010.09071.

<sup>4</sup>Beth A Pfeiffer et al., "Effectiveness of sensory integration interventions in children with autism spectrum disorders: A pilot study," *The American journal of occupational therapy: official publication of the American Occupational Therapy Association* 65, no. 1 (2011): 76.

In a more specific case study led by Schaaf et al<sup>5</sup>, from Department of Occupational Therapy, Thomas Jefferson University, Philadelphia; the occupational therapists worked with a child with autism for a 10 weeks intensive occupational therapy using a sensory integrative approach. This case study examines the effectiveness of using this approach and has found that the child has improved in his sensory processing abilities, allowing him to have an enhanced participation at home, school and family activities. The results of this case allow the therapists to provide a treatment model for children with autism having sensory processing difficulties. An intensive occupational therapy programme consisting of thirty sessions of therapy over a period of ten weeks using the sensory integration approach will be useful for children with autism whose participation challenges are related to difficulty in processing and integrating sensory information.

At the 3rd European Congress of Sensory Integration 2014, Beaudry et al<sup>6</sup> presented and published the very first study of using sensory integration approach to treat a three years old boy with retentive fecal incontinence. The boy is diagnosed by occupational therapists as tactile over-responsive and he is not unable to tolerate the tactile sensation of sitting on the toilet or potty. This has lead to constipation problems as the boy is not relaxed enough and hence could not defecate. This happened when the boy started potty training and he has refused to sit on the potty at home or at school despite different types of potties and toilet seat reducers were used. Due to his over-responsiveness to tactile sensations, the

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<sup>5</sup>Roseann C. Schaaf, Joanne Hunt, and Teal Benevides, "Occupational Therapy Using Sensory Integration to Improve Participation of a Child With Autism: A Case Report," *American Journal of Occupational Therapy* 66, no. 5 (2012): 547–555, doi:10.5014/ajot.2012.004473, +%20http://dx.doi.org/10.5014/ajot.2012.004473.

<sup>6</sup>Isabelle Beaudry Bellefeuille, Roseann C Schaaf, and Eduardo Ramos Polo, "Occupational therapy based on Ayres Sensory Integration in the treatment of retentive fecal incontinence in a 3-year-old boy," *American Journal of Occupational Therapy* 67, no. 5 (2013): 601–606.

boy has difficulty tolerating the contact of the potty and this has led to him to withhold his stools or defecate in his pants.

To address the boy's tactile over-responsivity, sensory integration intervention is designed to tailor to his needs specifically to reduce his tactile over-responsivity. Therapy sessions are mainly sensory-motor activities that target the total body tactile and proprioceptive inputs. Together with the gastroenterologist's recommendations, occupational therapy using the sensory integration approach and collaboration with school personnel and parents, the underlying issues affecting this child's ability to acquire age-appropriate toileting habits has significant improvements. More importantly, occupational therapy using sensory integration is unique in that it identifies and addresses underlying sensory issues in any child with sensory processing difficulties.

Professor Ellen S. Cohn from the Department of Occupational Therapy from Boston University has recently published an article to describe parents' concerns and hopes for their children who would be receiving occupational therapy using a sensory integration approach. Parents are hopeful that early intervention will help their child improve in their self-regulation, interaction with peers, participation in skilled motor activities and self-confidence; hence sending their child for occupational therapy sessions that will address these concerns. Cohn et al<sup>7</sup> analyzed 275 parental responses to three open-ended questions on developmental sensory history of their child. In their responses, parents often linked these concerns together, citing examples of their children's challenges and how these challenges affect occupational performance. Parents hoped occupational

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<sup>7</sup>Ellen S Cohn et al., "Parents' explanatory models and hopes for outcomes of occupational therapy using a sensory integration approach," *American Journal of Occupational Therapy* 68, no. 4 (2014): 454-462.

therapy would help their children develop self-understanding and frustration tolerance to self-regulate their behavior in socially acceptable ways.

The reviews of sensory integration approach of occupational therapy do support the claim of this research, which is to design appropriate tactile sensory materials with three-dimensional surface textures that can assist children to overcome specific reactions to tactile sensations through incorporating these toys into the sensory diets of their occupational therapy. Sensory-based strategies using the right products in an occupational therapy session can help in the improvement of a child's ability to tolerate or make sense of sensory input. The review concludes that sensory integration approach indeed shows evidence that children do respond to sensory integration positively by reducing the child's behavioural responses to environmental stimuli, modulating of child's cortisol levels as well as allowing better school and social participation. The focus is to provide the child with opportunities to experience sensory inputs at just the right level that he can tolerate, along with engaging him in sensory activities that will help calm or alert him. By using this approach, the child begins to accept and respond more appropriately to play and daily activities and hence allowing him to live his life in a functional manner.

## 2.2. Using Textiles as Therapy - Current Textile-based Therapeutic Products

In the occupational therapy practice guidelines published by Renee Watling et al, sensory-based therapy will provide a child with vestibular, proprioceptive, auditory and tactile inputs in the form of different activities<sup>8</sup>. These activities can help the child to organize their sensory system and improve their sensory processing skills. Specially designed equipments and materials can provide the right sensory input for the child. A typical occupational therapy treatment room looks like a play gym. There are suspended swings, therapy balls, mats, tactile materials, and developmentally appropriate toys. The child will be lead by the occupational therapist to work on different types of equipment during the session and activities are adapted depending on the child's acceptance and behaviour.



Figure 2.1: A typical occupational therapy treatment room looks like a play gym  
Image from : <http://www.funfactoriesensorygym.com/testimonials/>

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<sup>8</sup>Renee Watling et al., "Occupational therapy practice guidelines for children and adolescents with challenges in sensory processing and sensory integration," *Dysphagia* 1005 (2011): 5.



Specifically for children with tactile dysfunction, there are textile-based toys, materials and equipments that are utilized in the therapy sessions. In another pilot study conducted by Professor Sandra Dunbar et al<sup>9</sup>, tactile experiences are also embedded around classrooms and playgrounds. These materials often incorporate a variety of textures made from different types of fabrics, plastics, papers, feathers and other textured materials. Different tactile sensations are also being explored by asking the child to find ‘treasures’, which are very often small toys hidden in a tank of sand, pasta, rice, shaving cream or Play-Doh. Occupational therapists are aware of the individual child’s tactile dysfunction, from tactile over-responsive to under-responsive to sensory seeking and will plan which activities to work with the child accordingly.



Figure 2.2: Tactile sensory play bins with assorted textures

Images from :

<http://www.schooltimesnippets.com/2014/06/mini-sensory-bin-free-play-tactile.html>

There are specific textiles based therapeutic products available commercially. One good example is the ‘weighted vest’. Associate Professors Jennifer Stephenson and Mark

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<sup>9</sup>S Dunbar et al., “A pilot study comparison of sensory integration treatment and integrated preschool activities for children with autism,” *The Internet Journal of Allied Health Sciences and Practice* 10, no. 3 (2012): 1–8.

Carter from Macquarie University, Australia; reviewed the use of weighted vests on children with autism spectrum disorders and other disabilities. Weighted vests are being used during sensory integration therapy as an intervention strategy and may assist in remediating problems such as inattentiveness, hyperactivity, stereotypic behaviors and clumsiness<sup>10</sup>. In another pilot study of the effectiveness of weighted vests, Collins and Dworkin focused on the use of weighted vest on attention to task for children with attention difficulties. Weighted vests are widely considered to be a sensory-based approach because they are intended to provide specific sensory input to improve performance and function. The weight of the vest provides proprioceptive input, which is defined as deep pressure and promotes production of neurotransmitters such as serotonin and dopamine, which modulate the activity of the central nervous system<sup>11</sup>.



Figure 2.3: Weighted compression vest from fun and function  
Image from : <https://funandfunction.com/weighted-compression-vest.html>

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<sup>10</sup>Jennifer Stephenson and Mark Carter, “The use of weighted vests with children with autism spectrum disorders and other disabilities,” *Journal of autism and developmental disorders* 39, no. 1 (2009): 105–114.

<sup>11</sup>Amy Collins and Rosalind J Dworkin, “Pilot study of the effectiveness of weighted vests,” *American Journal of Occupational Therapy* 65, no. 6 (2011): 688–694.

In Kansas State University, apparel design students had a special project to design and produce special vests for children with autism or sensory integration disorders. The small weights on the vests are strategically placed so they can be felt on different points of the body; provide a calming effect to children so they can focus on a particular task. There are several pockets for weights and the vests provide a tight fit to help the child to be calm and focus. Recycled or donated fabrics are used to make the vests, and the students ensure that they select materials that would be comfortable for the children and also easy to maintain. Extra design elements, such as buttons are added for the child to practice fine motor skills<sup>12</sup>.



Figure 2.4: Students in Apparel Production II designed and made vests that help calm children with autism. Vests were distributed locally and internationally  
Image from : <http://www.he.k-state.edu/news/2011/07/13/apparel-design-students-produce-vests-for-children-with-autism/>

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<sup>12</sup>“A Comforting Design: K-State Students Design, Produce Vests for Children with Autism,” *Targeted News Service*, June 27, 2011,

Closer to home, T.Ware is a new start-up company who has created a jacket that could ‘hug’ its wearer. The research and technology behind the T.jacket started at the research lab of the Keio-National University of Singapore Connective Ubiquitous Technology for Embodiments Centre. The T.jacket looks like an ordinary jacket, but it has three pairs of inflatable air bags placed at the shoulders, abdomen and lumbar regions of the jacket. All are connected to a tiny motor box at the back. Users can download an app into their smartphones and use it to control the pressure levels of the individual airbags. The smartphone remote controller allows a single caregiver or therapist to control multiple jackets with different pressure levels. The T.jacket mimics deep-pressure stimulation, such as hugs, used by therapists to calm children when they get overexcited. As explained by Mr James Teh, the chief executive of the company, the unique feature of the jacket is the ability to alter the pressure levels and it is the key to the effectiveness of the jacket because different children respond better to different levels of ‘hugs’<sup>13</sup>.



Figure 2.5: T.Jacket by T.Ware  
Images from :<http://www.mytjacket.com>

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<sup>13</sup>“Cashing in on the Calming Power of Hug Therapy,” *The Straits Times*, April 11, 2012,



Another popular item used by the occupational therapists is a weighted blanket. Similar to the weighted vest and the compression jacket, the weighted blanket provides proprioceptive input for the child to help enhance sleep and calm anxiety and stress. Other similar commercially available products include weighted wraps and weighted lap pads. These can be wrapped around the shoulders or whole body, or place them on the laps when the children are doing homework and reading times for the extra calming deep pressure input their bodies crave. The use of these weighted textile products not only provide proprioceptive input and deep pressure to the muscles, joints, tendons and ligaments, it also allows the central nervous system to better interpret and integrate both tactile and proprioceptive input<sup>14</sup>.



Figure 2.6: Weighted Blanket from Fun and Function

Images from : <https://funandfunction.com/calming-comforter-weighted-blanket.html>

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<sup>14</sup>“Sensory Processing Disorder,” <http://www.sensory-processing-disorder.com/weighted-blankets.html>.

A simpler version of an outfit that can provide deep pressure input is the “Compression Shirts”<sup>15</sup>. These shirts are commercially available and they look like ordinary T-shirts, made of stretch fabrics such as spandex or Lycra. These shirts are designed to be tight, snug fitting and hug the shoulders, body pressure calming effects, which provides comfort to the child as evidence suggests that weight and pressure inputs provide both tactile and proprioceptive input to the body, calming the central nervous system.



Figure 2.7: Compression Shirt from Fun and Function

Images from : <https://funandfunction.com/sens-ational-hug-tee-long-sleeves-navy.html>

US Company, Knit-Rite Incorporated<sup>16</sup> has invented a new range of seamless compression shirts under their SmartKnitKIDS Seamless Sensitivity Products<sup>17</sup>. In their patent application publication<sup>18</sup>, it is stated that the compression shirt is a knitted tubular fabric receptacle made of core-spun yarn. All the sections are being seamlessly joined along the receptacle side margins. This is different from other compression shirts that have side seams or at least a seam connecting at the top of the shoulder sections. For

<sup>15</sup>Debra S Jacobs and Dion E Betts, *Everyday Activities to Help Your Young Child with Autism Live Life to the Full: Simple Exercises to Boost Functional Skills, Sensory Processing, Coordination, and Self-care* (Jessica Kingsley Publishers, 2012).

<sup>16</sup>“KNIT-RITE Incorporated,” KNIT - RITE % 20Incorporated . %20http : / / knitrite . com / orthotics/seamlessensitivitysocks/kidscompressot.html.

<sup>17</sup>“SmartKnitKIDS,” [http://smartknitkids.com/seamless\\_technology.html](http://smartknitkids.com/seamless_technology.html).

<sup>18</sup>Mark W.L Smith, Compression shirt (Patent US 14/193765 [US], filed February 28, 2014).

children with tactile sensory issues, normal shirts and garments with seams are already causing irritation for them. For compression shirts, which are supposed to provide steady hug-like feeling, the SmartKnitKIDS seamless Compresso-T provides optimal comfort in a seamless compression shirt for children.



Figure 2.8: Seamless products from SmartKnitKIDS  
Images from :<http://www.smartknitkids.com>

There are sensory activities that are textile-based, able to provide both proprioceptive and tactile input like the weighted blankets and wraps. Commonly known as “Burrito time”<sup>19</sup>, this activity involves the use of an ordinary blanket, which is laid flat on the floor. The child will have to lay on top of the blanket, with his head above the blanket and being rolled up by layers of the material, pretending to be a burrito. Once rolled up, he will need

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<sup>19</sup>Jacobs and Betts, *Everyday Activities to Help Your Young Child with Autism Live Life to the Full: Simple Exercises to Boost Functional Skills, Sensory Processing, Coordination, and Self-care*.

to be unrolled in the opposite direction. By repeating this motion, the deep pressure from the floor and the compression from the blanket will give the child the needed proprioceptive and tactile input.



Figure 2.9: Child wrapped up as “Burrito”

Image from :

<http://www.doyouyoga.com/10-fun-and-proven-ways-to-help-kids-enjoy-relaxation/>

In a study done by McGinnis et al<sup>20</sup>, they investigated the effects of using deep pressure touch as a therapy method when occupational therapists are utilizing the sensory integration approach. When an individual is hugged, squeezed, stroked, or held, a sense of deep pressure touch is produced. In occupational therapy interventions, activities associated with deep pressure are frequently used. For example, occupational therapists often use equipment such as mats, pillows, beanbag chairs, mattresses, trampolines, trapeze bars, chin-up bars, and climbing structures that are thought to provide deep

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<sup>20</sup>Amy A McGinnis et al., “The behavioral effects of a procedure used by pediatric occupational therapists,” *Behavioral Interventions* 28, no. 1 (2013): 48–57.



pressure stimulation. The results of this study suggest that the activities occupational therapists use to administer deep pressure can improve the proprioceptive sense for children with autism and related spectrum disorders. These deep pressure activities are advantageous for several reasons. The materials involved, such as blankets, therapy mats, or cushions, are typically a one-time, low-cost investment. These materials are easily accessible in many home and community settings and are a healthy alternative to oral medications given to the children.

Other textile-based tactile activities that can alert or calm a child's sense of touch are commonly used in a therapy session. Occupational therapist, Mary Lashno; author of book *Mixed Signals*<sup>21</sup> has put together a list of alerting tactile activities for a child who is under-responsive, and a list of calming tactile activities for the over-responsive child. Textile-based alerting tactile activities for the under-responsive child are known to “wake up” the hands include brushing the child's hands with fabrics of different textures, vigorous rubbing with towel to body and hair after a bath; squeezing or pulling odd textures such as Koosh™ balls, stretchy toys, loofas and Velcro. Calming textile-based tactile activities for the over-responsive includes reducing his anxiousness by wrapping him up snugly in a warm blanket, “sandwich” activities such as “burrito time”, lying under weighted items like heavy quilt or pillow filled with beans or rice. For a child who will avoid using his hands to play or manipulate objects, the therapist will also brush his hands with different fabric textures, but this will have to be carefully administered depending on the child's willingness and tolerance level. Only when his tolerance increases, then the therapist can introduce more varied fabric textures for the child to handle.

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<sup>21</sup>Mary Lashno, *Mixed Signals: Understanding and Treating Your Child's Sensory Processing Issues* (Bethesda, MD : Woodbine House, 2010).



Figure 2.10: Koosh™Balls

Image from : [http://www.newitts.com/product/PE-18/Original\\_Koosh\\_Ball\\_8cm.htm](http://www.newitts.com/product/PE-18/Original_Koosh_Ball_8cm.htm)

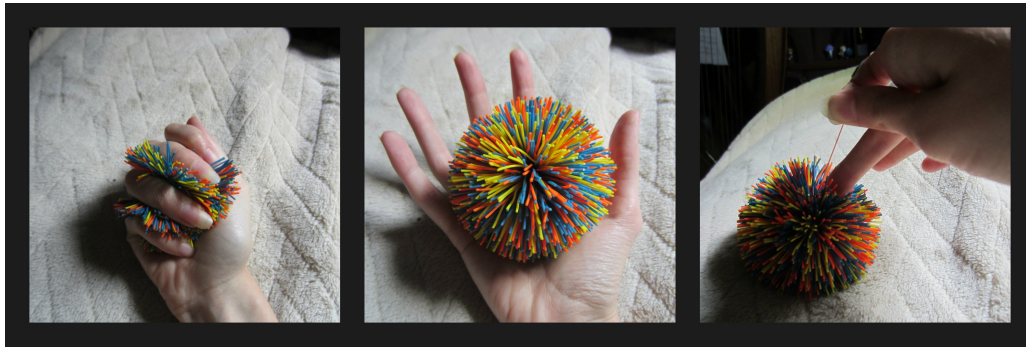


Figure 2.11: Playing with Koosh™Balls

Images from : <http://www.annettanesler.com/?p=238>

The reviews of current textile-based sensory products do support the claim of this research, which ascertains the design of textile-based sensory toys and materials. Tactile Textiles are fabrics that possess three-dimensional surface textures created by using the heat setting techniques and are designed into tactile-toys and tactile sensory materials. These newly created sensory toys and materials will be integrated as sensory diets within a child's tactile therapy session. This review reinforces that sensory integration approach is successful with the incorporation of specific equipments, toys and materials, all rightfully prescribed into sensory activities that can assist children to overcome specific

reactions to tactile sensations. By using this approach, the child will be provided with the sensory experiences he needs to feel more balanced and comfortable in his life.

### **2.3. Developing Tactile Textiles – Using Heat Setting to Create Three-dimensional Textiles**

The integral part of Tactile Textiles is the design and creation of the three- dimensional structural forms of textiles. These three- dimensional structural textiles are formed by using the heat setting techniques which is a technical approach of fabric manipulation that provides a platform into some of the most creative and innovative approaches to surface and textile design. The design of tactile-toys and tactile sensory materials from Tactile Textiles with three-dimensional surface textures can assist children to overcome specific reactions to tactile sensations through incorporating these toys into the sensory diets of their occupational therapy.

In order to achieve three-dimensional textures on a fabric, the technique of heat setting is applied. Professor Sara Kadolph from Iowa State University, College of Human Sciences; also author of 'Textiles'<sup>22</sup> has defined that heat setting is a process that uses heat to stabilize the shape and dimensions of fabrics. The fabric is heated to bring it to a temperature specific for the fiber being heat set. At this temperature, the fiber molecules move freely to relieve stress within the fiber. Tension remains until the fiber has cooled,

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<sup>22</sup>Sara J Kadolph, *Textiles* (Prentice Hall, 2007).

locking this shape into its molecular structure. After cooling, the fabric will be stable to any heat lower than that at which it was set.

An active researcher in the field of Textile Design and specialist in resist patterning for contemporary fabrics, Dr Kate Wells author of 'Fabric Dyeing and Printing'<sup>23</sup> explains that heat setting of all synthetic fibres will melt at a certain temperature, but below this point they will often heat set into a different form. Tying, stitching or clamping fabrics into folds before heating can create various features. One hundred percent polyester fabric works best with heat setting. Polyester belongs to the group of synthetic fibres. Polyester is thermoplastic, that is, it can be transformed through heat into new configurations, which on cooling is completely stable. The definition of thermoplastic by Braddock and O'Mahony<sup>24</sup> states that the molecular structure of the fiber breaks down and becomes fluid at a certain temperature, making it possible to reshape the fabric by pleating, moulding, vacuum-forming or crushing. The fabric is 'fixed' on cooling and cannot be altered unless heated to a temperature greater than the one at which it was reshaped. This three-dimensional surface structure is hence permanent and it can be maintained even with washing in cold water.

Professor Sherry Haar from the Department of Apparel, Textiles and Interior Design of Kansas State University<sup>25</sup> defines heat setting as the creation of three-dimensional textures on fabrics through shaped-resists. During this process, heat has been applied to stabilize the shape of the fabric. This technique is achieved by mass production in an industry and designers have also adapted it by using non-industrial heat setting methods.

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<sup>23</sup>Kate Wells, *Fabric dyeing and printing* (Conran Octopus Limited, 1997).

<sup>24</sup>Braddock and O'Mahony, *Techno Textiles*.

<sup>25</sup>Sherry J Haar, "Studio practices for shaping and heat-setting synthetic fabrics," *International Journal of Fashion Design, Technology and Education* 4, no. 1 (2011): 31–41.

Haar has further researched into the other possibilities of shape and resist techniques and categorized the methods of resist as binding, stitching, clamping and pole wrapping. There are endless possibilities of shaping fabric to create three-dimensional structures. Methods can be combined and adapted, unique heat setting forms can also be developed through utilizing interesting shapes as moulds.

The three-dimensional structures on the textiles can be attained by applying ‘shibori’ techniques. President of World Shibori Network, Yoshiko Iwamoto Wada author of ‘Memory on Cloth: Shibori Now’ defines shibori as a variety of ways of embellishing textiles by shaping cloth and securing it before dyeing. The areas that are secured will resist the dye and when released, beautiful dyed patterns are formed on the cloth. However, in the heat setting of three-dimensional structures, fabrics are securely tied to moulds or manipulated before putting into the steamer or boiler. The resulting three-dimensional effects will be very effective and the shape will be permanent. The heat set fabrics can be hand wash in cold water and the shapes will still be stable.



Figure 2.12: Shibori techniques - Tying, binding, clamping and pole wrapping of fabrics before dyeing

Images from :<http://honestlywtf.com/diy/shibori-diy/>



Figure 2.13: Shibori techniques – Dyeing the fabrics and the outcomes  
 Images from :<http://honestlywtf.com/diy/shibori-diy/>

Wada<sup>26</sup> further elaborates the technical production of polyester and how polyester fabric reacts to heat setting. Invented in 1940s, polyester is made up of chemical composition of oil, ethylene glycol and terephthalic acid. It comprises of linear molecules of carbon, hydrogen and oxygen bonded together. This bond can be broken by heat and hence be shaped in response to heat. Heat is crucial in the production of polyester filament. During the extrusion process, melted polyester is extruded through tiny holes and stretched to many times its original length that changes the inner structure of the material to provide strength and stability. The stretched filament is then heat set at a temperature below its melting point. When this degree of heat is applied to polyester fabric, it reverts to its un-stretched state, shrinking drastically. Polyester's softening point is about 240°C and its melting point is 260°C. The ideal temperature for polyester fabric

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<sup>26</sup>Yoshiko Iwamoto Wada, *Memory on cloth: Shibori now* (Kodansha International, 2002).

to be heat set to achieve a three-dimensional structure is around 200°C to 220°C. The time taken for heat setting should be between 20 to 30 minutes for ideal results.

Dr Rachel Philpott<sup>27</sup>, a British textiles designer and researcher explains that contemporary pleating and shibori practices have been transformed by the advent of thermoplastic materials like polyester, which have shape memory capabilities allowing permanent folds to be created. Her area of research concentrates on the development of high performance textiles and she creates adaptable, self-supporting three-dimensional textile structures with shape memory materials applicable in sportswear, medicine, architecture, interior and product design.

Another well-known textiles educator, design innovator and researcher, Dr Sharon Baurley who is currently the head of design products at Royal College of Arts, started her research on three-dimensional textiles back in 1995 where she spent a year in Tokyo, studying the latest development in textile technology<sup>28</sup>. She created three-dimensional fabrics by the technique of moulding, sandwiching of the hundred percent polyester fabrics between positive and negative metal moulds and heat setting the fabric to create permanent new form. As explained by Dr Janette Matthews, a designer working in the area of laser cutting technology to create textiles with three-dimensional surfaces from Loughborough University; the other techniques of moulding includes vacuum moulding and chemical treatments<sup>29</sup>. For vacuum moulding, fabrics are coated in liquid resins and laid in moulds and heat set under pressure. One example of the application is the

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<sup>27</sup>Rachel Philpott, "Crafting innovation: The intersection of craft and technology in the production of contemporary textiles," *Craft Research* 3, no. 1 (2012): 53–74.

<sup>28</sup>Braddock and O'Mahony, *Techno Textiles*.

<sup>29</sup>Janette Matthews, "Textiles in three dimensions: an investigation into processes employing laser technology to from-led three-dimensional textiles," 2013,



manufacture of body parts for the automotive industry using textile carbon fibre composites. As for chemical treatments, fabrics are soaked in various liquids before heat setting or drying naturally. This will allow the fabric to retain the shape of the mould to achieve the three-dimensional structure.

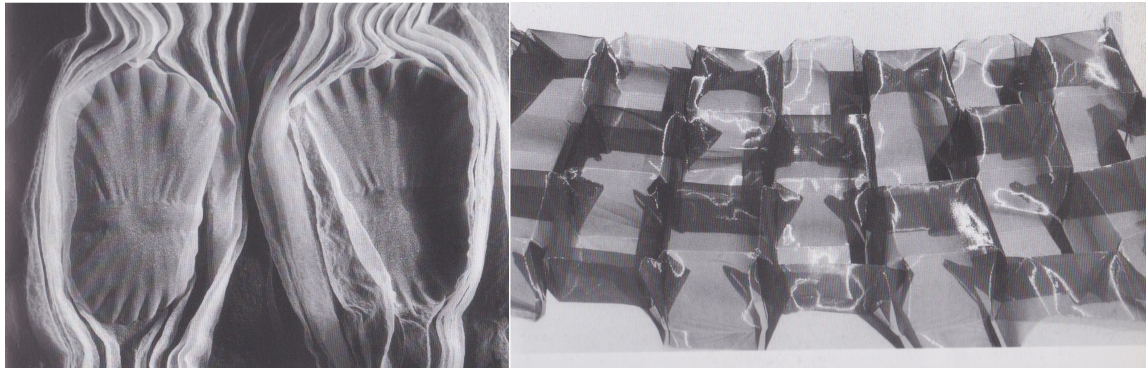


Figure 2.14: Three dimensional pleating by Dr Sharon Baurley done in 1990s  
Images from : Techno Textiles Pg 73

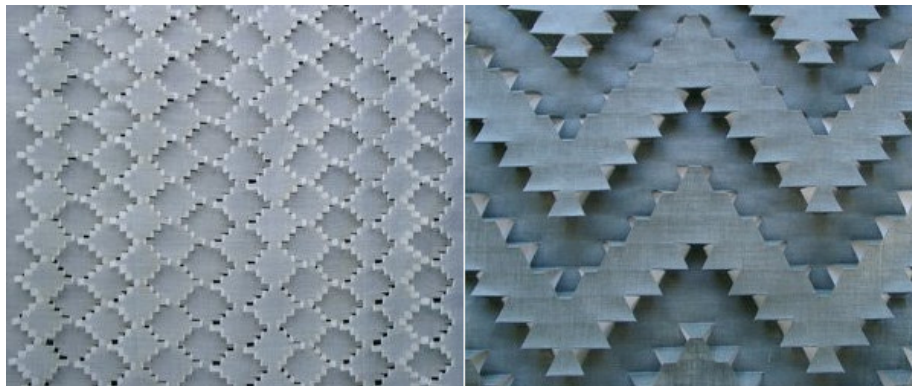


Figure 2.15: Three dimensional laser cut fabric by Dr Janette Matthews done in the 2000s  
Images from :<http://pan-dan.blogspot.sg/2006/10/janette-matthews.html>



In the world of fashion and textiles, famous fashion designer Issey Miyake began his research into pleating of textiles in the late 1980s. He revolutionized the technique of garment pleating by cutting and sewing an oversized piece of cloth into the shape of the desired garment and then sandwiched between two layers of washi paper for heat setting. The heat process sets in the memory of fabric to create permanently pleated garments. In 1993, PLEATS PLEASE ISSEY MIYAKE was launched. Miyake has since developed an innovative process of using heat setting to achieve three-dimensional textiles for his fashion, costumes and sculptural pleated pieces for displays, exhibitions and architecture.



Figure 2.16: Fashion and sculptural pleated pieces by Issey Miyake  
Images from : <http://a133.idata.over-blog.com/1/75/20/03/022/ISSEY-MIYAKE—FALL-WINTER-2013–PHOTOGRAPHY-JULIA-NONI-4.jpg>  
<http://cs.nga.gov.au/Detail.cfm?IRN=5146>

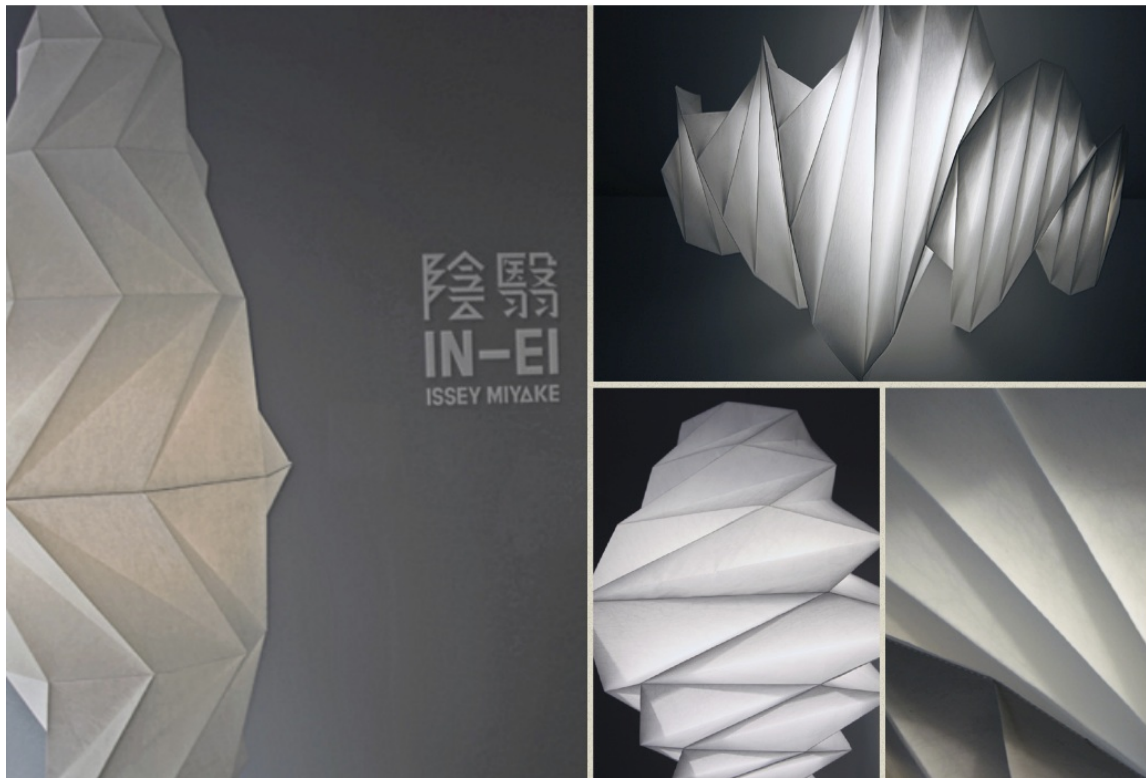


Figure 2.17: The IN-EI ISSEY MIYAKE lighting collection  
 Images from :<http://modernpapercrafts.com/2012/05/pleats-please/issey-miyake/>

The Inoue Pleats Company was the first pleating company in Japan. Established in 1943 in Fuki, Japan; the company started working with synthetics to explore the thermoplasticity of the material since the invention of acetate materials in 1953. With one hundred percent polyester fabrics, textile finishing can be heat set permanently into different pleated patterns. They have the whole range of machineries for pleating, crushing, moulding of fabrics and have supported many designers with their production of pleating and heat setting of fabrics for fashion and interiors.

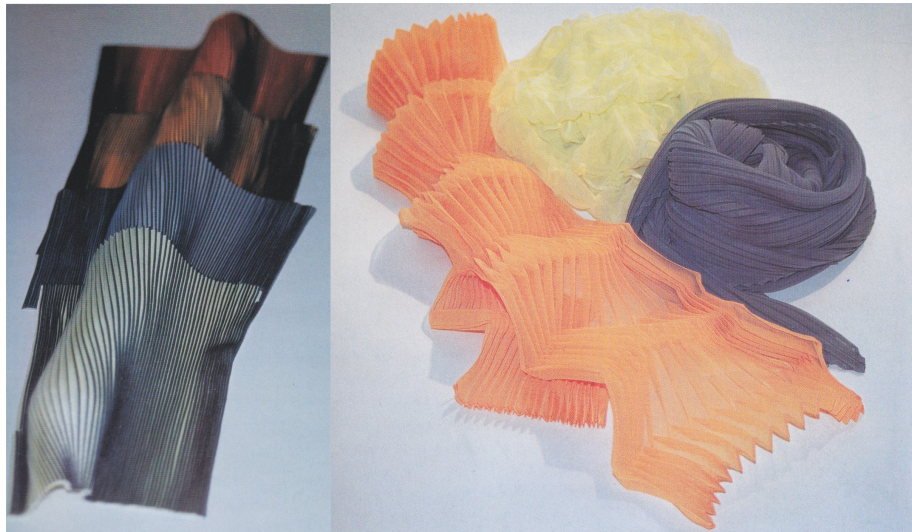


Figure 2.18: Hundred percent polyester pleated fabrics from Inoue Pleats  
Images from : Techno Textiles Pg 74

Another Japanese textile company, Nuno Corporation together with director and main designer Reiko Sudo has successfully presented innovative three-dimensional fabrics by experimenting with the thermoplastic qualities of synthetic fabrics using heat setting techniques. Their patented origami pleat, known as ‘Polygami’ is created by heat setting using one hundred percent polyester, transforming the fabric into geometrical pleats that are permanently stable. This is an example of a combination of traditional Japanese pleating techniques and modern textile production technology to produce ground-breaking fabrics.

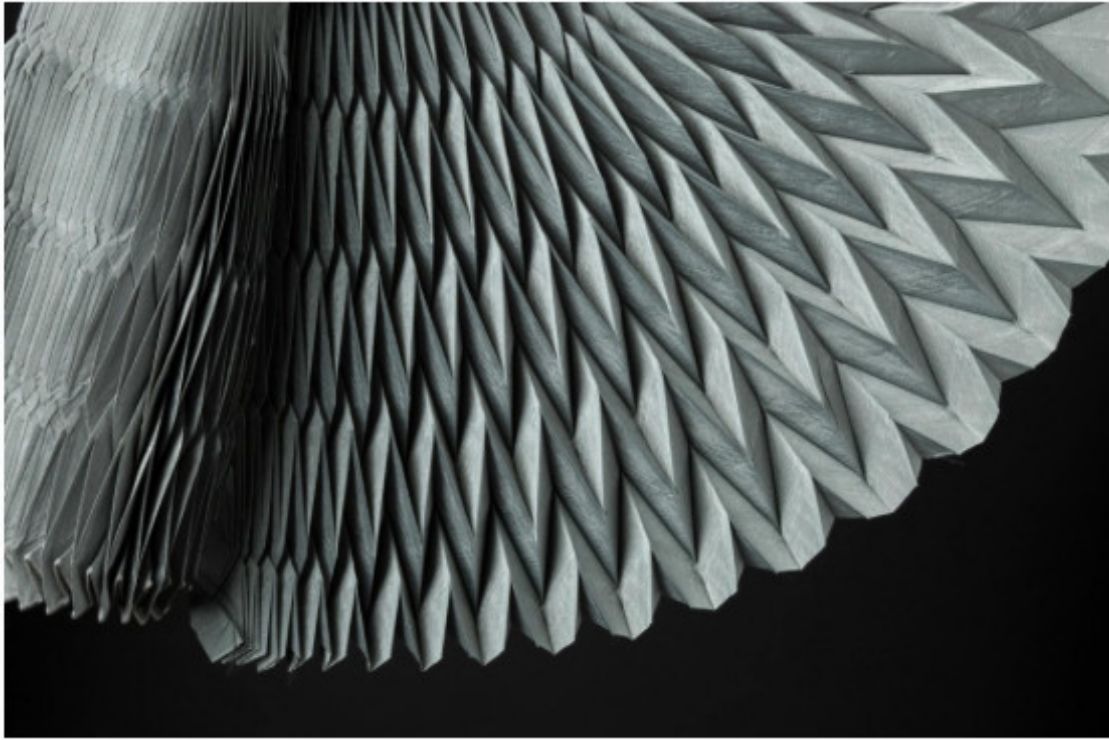


Figure 2.19: Patented Origami Pleat ‘Polygami’ from Nuno Corporation  
Image from: <https://www.nuno.com/textile/polygami/>

Designers of textiles, fashion and costume have explored the shaping and heating of fabrics as an aesthetic feature. The creative process can also be applicable to various creative interiors and lifestyle products. This range of heat set fabrics, with its tactile quality; not only draws the attention of one’s eyes but the hands too and the textures can stimulate our sense of touch. With its multiple functionalities, they can be hung on walls or under a ceiling as sculptures; be framed as screens; as curtains; as cushions and light shades. Heat set Tactile Textiles can be extremely versatile in its form and is very suitable to be developed into Tactile Toys and Tactile Materials. These three-dimensional forms not only conjures the imagery of the natural elements but also intrigues and attracts the

audience to touch and feel the structural forms. With this appealing characteristic, it will provide a variety of tactile sensations and explorations using touch and therefore generate more interest for the children. This will better equip the children with the appropriate therapeutic tactile sensory benefits and hence focus on helping children who are over or under-responsive to step out of their fear of touching textures.

## **2.4. Using Human Computer Interaction Technology in Special Needs Therapy**

The three-dimensional Tactile Textiles will be further designed into Tactile Toys and Tactile Materials and used in sensory integration therapy for children with tactile dysfunction. Tactile Toys and Tactile Materials can help children with tactile dysfunction to overcome and live their life in a functional manner. Tactile therapy through the use of three-dimensional Tactile Textiles will provide a variety of tactile sensations and explorations using touch. The three-dimensional structural textiles will generate more interest for the children to interact with the textiles. This will better equip the children with the appropriate tactile sensory reflexes and hence focus on helping children who are tactile over-sensitive, tactile under-responsive and tactile seeking to overcome their dysfunction and respond appropriately to tactile senses in their daily lives.

Researchers in the field of Human Computer Interaction (HCI) have designed and developed touch-based therapy for children with autism and sensory processing disorders. One example is the design of haptic interfaces developed at the MIT by



Vaucelle et al<sup>30</sup>. They have presented their findings at the SIGCHI Conference on Human Factors in Computing Systems in April 2009. They have created devices that stimulate touch through haptic devices to help clinical therapy; which are non-invasive treatments. They named the prototypes “Touch Me”, “Squeeze Me”, “Hurt Me” and “Cool Me Down” and have tested these devices with a team of mental health professionals. Their devices incorporate smart technology and are designed to be ‘cause and effect’ play objects, these play objects allows the child to understand that an action they do can cause a respond from this device. The embedded technology will include motion sensors, which will detect hand movements on the surface of the fabrics, and other embedded technology such as vibrotactile, pneumatic and heat pump actuation. These devices served as tools for the therapist to communicate better with children and also providing therapeutic comfort to them. They have been successful, as all the prototypes have been evaluated for further development and are used as complementary therapeutic aids.



Figure 2.20: “Touch Me”, “Squeeze Me”, “Hurt Me” and “Cool Me Down”  
Images from : Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 467-470

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<sup>30</sup>Cati Vaucelle, Leonardo Bonanni, and Hiroshi Ishii, “Design of haptic interfaces for therapy,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (ACM, 2009), 467–470.

Another research team, Changeon et al<sup>31</sup> from Sensorial and Ambient Interfaces Laboratory, France has designed a tactile gamepad to give emotional feedback to children with autism. This innovative vibrotactile gamepad can be used as complementary therapeutic aids for transmitting emotional messages to children with autism. The gamepad includes eight electromagnetic actuators embedded in the gamepad shell to provide distributed tactile feedback. The actuators are placed by measuring the contact zones of the users hand and the gamepad. The integrated gamepad has undergone user evaluations to define the tactile patterns needed for control and to test the acceptability and the usefulness of the device for the enhancement of emotional competences of children with autism and has received encouraging feedbacks and results.

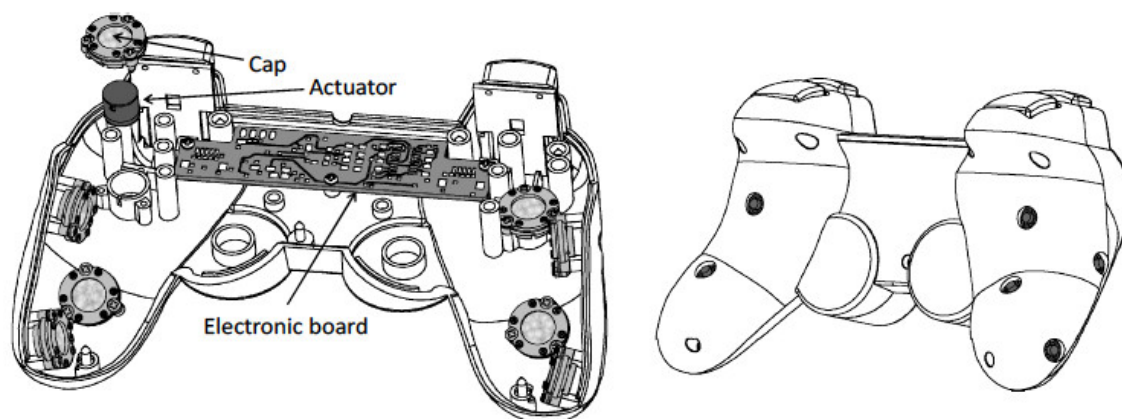


Figure 2.21: The gamepad includes eight electromagnetic actuators embedded in the gamepad shell to provide distributed tactile feedback

Images from : "A vibrotactile tactile gamepad for transmitting emotional messages to children with autism." In *Haptics: Perception, Devices, Mobility, and Communication*, pp. 79-90

<sup>31</sup>Gwénaél Changeon et al., "Tactile emotions: A vibrotactile tactile gamepad for transmitting emotional messages to children with autism," in *Haptics: Perception, Devices, Mobility, and Communication* (Springer, 2012), 79–90.

Research team from Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy led by Garzotto et al<sup>32</sup>, researched into interactive tools that exploit motion-based touchless interaction, where technology can be controlled using body movements and gestures without wearing additional aides. They explore the benefits of motion-based touchless gaming for children with autism showing low-moderate cognitive deficit, low-medium sensory-motor dysfunction, and motor autonomy. Their findings show that motion-based touchless gaming led to improvements of attention skills for the children, and sparked future research directions in interactive technology for children with autism.



Figure 2.22: Motion-based touchless gaming for children with autism  
Images from : "Touchless Motion-based Interaction for Therapy of Autistic Children."  
Virtual, Augmented Reality and Serious Games for Healthcare 1

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<sup>32</sup>Franca Garzotto, Matteo Valoriani, and Laura Bartoli, "Touchless Motion-Based Interaction for Therapy of Autistic Children," in *Virtual, Augmented Reality and Serious Games for Healthcare 1* (Springer, 2014), 471–494.



## **2.5. The Conception and Contribution of Tactile Toys**

With current examples of researches that are done within the field of combining smart technology and therapy for children with autism and sensory processing disorder, the contribution of Tactile Textiles comes in from the research area of creating three-dimensional surface textures that can benefit and assist children to overcome specific reactions to tactile sensations. The Tactile Toys developed from Tactile Textiles can be incorporated into the sensory diets of the children's occupational therapy and home sessions. The areas of research that has been put into this research are firstly, the study of the effectiveness of occupational therapy and the approach of sensory integration therapy. Subsequently, the existing tactile therapy methods and how textiles are integrated within the therapy. Followed by the technique and science of three-dimensional heat setting and its relation with shibori. Last but not least, the development of touch-based therapeutic products in field of Human Computer Interaction for children with autism and sensory processing disorders. The convergence of these main areas to create Tactile Textiles is further developed into Tactile Toys and this will be the contribution of this research project. A tactile defensive child who is under responsive, over responsive or sensory seeking will be attracted to the three-dimensional surface textures and bright colours of the Tactile Toys and Tactile Materials. This will draw them to touch and this interactive play with the toys or materials will gradually allow the child to feel more comfortable in feeling the different textures as he is exposed to a variety of touch sensations that will intensify his touch sensation.

Tactile Toys, with their three-dimensional structural heat set surface textures can assist children to overcome specific tactile reactions due to tactile dysfunctions. This is

done through incorporating these toys and materials as sensory integration therapy during their occupational therapy sessions. As supported by several reviews of researchers in the field of sensory integration therapy, sensory integration approach enhances a child's sensorimotor and motor planning skills, improves his socialization, attention and behavioral regulation, reading-related skills, and participation in active play<sup>33</sup>. Positive trends are supporting the effectiveness of the sensory integration approach, especially when measuring goals customized for the child. This is further supported by the analysis for outcomes of occupational therapy using a sensory integration approach from parents done by Cohn et al<sup>34</sup>. Parents hope that with early intervention, their child can improve in their self-regulation, participation in skilled motor activities and self-confidence.

Tactile Therapy<sup>35</sup> consisting of textile-based toys, materials and equipments that are utilized in the therapy sessions and other textiles related therapeutic products such as the weighted vest<sup>36</sup>, compression vest<sup>37</sup> and compression shirts<sup>38</sup> has also shown positive and effective results to help the child overcome tactile dysfunction. This review reinforces that sensory integration approach is successful with the incorporation of specific equipments, toys and materials, all rightfully prescribed into sensory activities that can assist children

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<sup>33</sup>May-Benson and Koomar, "Systematic Review of the Research Evidence Examining the Effectiveness of Interventions Using a Sensory Integrative Approach for Children."

<sup>34</sup>Cohn et al., "Parents' explanatory models and hopes for outcomes of occupational therapy using a sensory integration approach."

<sup>35</sup>Dunbar et al., "A pilot study comparison of sensory integration treatment and integrated preschool activities for children with autism."

<sup>36</sup>"A Comforting Design: K-State Students Design, Produce Vests For Children With Autism Manhattan – It's a project in which Kansas State University apparel design students have a vested interest" [in English], *M2 Communications*, 2011-06-27,

<sup>37</sup>"Cashing in on the Calming Power of Hug Therapy."

<sup>38</sup>Jacobs and Betts, *Everyday Activities to Help Your Young Child with Autism Live Life to the Full: Simple Exercises to Boost Functional Skills, Sensory Processing, Coordination, and Self-care*.

to overcome specific reactions to tactile sensations. Therefore supporting the claim of this research, which ascertains the design of textile-based sensory toys and materials. ss

In the next chapter, the detailed methods of Tactile Textiles construction will be discussed and the design and creation of Tactile Toys from Tactile Textiles will be explained. How Tactile Toys are to be used as sensory integration approach will also be described. This will set forth the usage of Tactile Toys as tactile therapeutic products for children with tactile dysfunction. Tactile therapy through the use of three-dimensional Tactile Toys will provide a variety of tactile sensations and explorations using touch. The three-dimensional structural textiles will generate more interest for the children to interact with the textiles. This will better equip the children with the appropriate tactile sensory reflexes and hence focus on helping children who are tactile over-sensitive, under-responsive and tactile seeking to overcome their dysfunction and respond appropriately to tactile senses in their daily lives.

## Chapter 3

### Design Concept



Figure 3.1: Tactile Textiles Exhibition in Singapore Furniture Trade Fair 2012  
Image from author

Tactile Textiles are a series three dimensional textile designs created from the heat setting technique. Tactile Textiles are being developed into interior furnishing textiles and has been exhibited internationally in design festivals in Frankfurt, Melbourne, San Francisco, Singapore, Stockholm and Tokyo. During one of exhibitions in Melbourne, a lady identified herself as an occupational therapist working with children with autism. She was very interested in the range of Tactile Cushions and shared that there will be potential possibilities for the tactile surface structures to be developed into toys that can be used as tactile therapy. That triggered the interest in the research of developing Tactile Textiles into Tactile Toys that can be beneficial for children with sensory processing disorder. Why children with sensory processing disorder? My daughter is diagnosed with sensory processing disorder at the age of four. She is auditory and gustatory over responsive and has attended occupational therapy from then. She has improved greatly after two years of occupational therapy and has been able to live her life in a functional manner.

The effectiveness of occupational therapy on children with sensory processing disorder has been proven successful as occupational therapist practices the sensory integration approach on children. Depending on the sensory issues faced by children, occupational therapists will administer specific therapy methods for these children. It is important to note that children who have sensory processing disorder may have one or more sensory issues. These sensory systems include sound (auditory), touch (tactile), sight (visual), taste (gustatory) and smell (olfactory). For this study, it will be concentrating on the touch (tactile) part of the sensory system. Hence, the creation of Tactile Toys will only be addressing the tactile dysfunction aspect of the sensory processing disorder which will be combined into the sensory diets for the child that address this particular disorder. The use of generic textiles and the current textile-based

materials used in tactile therapy for children with tactile dysfunction has also proven its efficacy. Hence, developing Tactile Textiles that uses the fundamentals of the heat setting technique to achieve three-dimensional structural qualities on fabrics into Tactile Toys will be the distinctive feature of Tactile Toys; different from the existing generic textiles used currently. Tactile Toys will contribute to the existing tactile therapy and eventually allow the children to overcome the dysfunction and respond appropriately to tactile senses in their daily lives.

### **3.1. Designing for the Disorder**

Tactile therapy through the use of Tactile Toys can educate children with tactile dysfunction to develop an understanding of tactile sensations using touch. The three-dimensional structural textiles on the toys will generate more interest for the children to interact with the textiles, equipping the children with the appropriate tactile sensory reflexes. Tactile therapy will focus on helping children who are tactile over-sensitive, tactile under-responsive and tactile seeking to overcome their dysfunction and respond appropriately to tactile senses in their daily lives. The value of Tactile Toys will be to assist children with tactile dysfunction to overcome their dysfunction and live their life in a functional manner. Figure 3.2 shows the important attributes and outcomes of Tactile Toys.

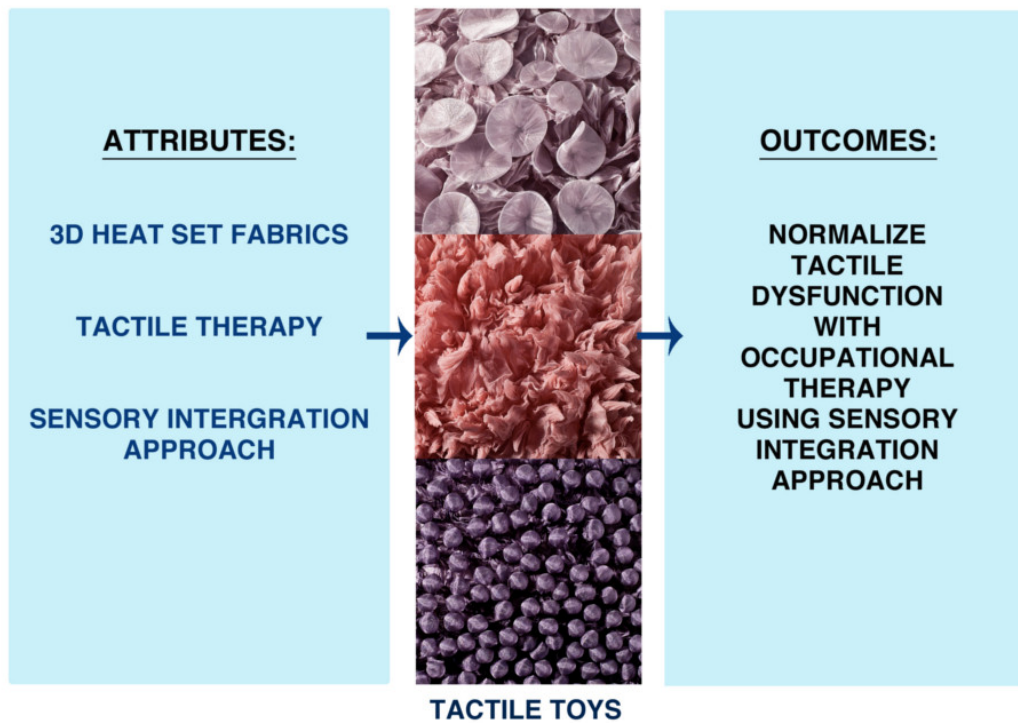


Figure 3.2: Design of Concept : Attributes and outcomes of Tactile Toys Diagram  
Image from author

Tactile Toys are a series of textile-based therapeutic products developed from Tactile Textiles designed for children with tactile dysfunction. The textiles will be aesthetically designed and constructed as three-dimensional forms by utilizing the thermoplastic qualities of synthetic fabrics. Children with sensory processing disorder who are suffering from tactile sensory issues may have difficulty tolerating the sensations generated from the touch of different types of textures on the fabrics. This series of tactile textiles products will be developed, as therapy applications; exposing children to different types of touch sensations within textiles, enabling them to enjoy tactile experiences

together with interactive play which will help them to overcome fear of certain touch sensations.

Tactile Toys will be useful if woven into the sensory diets of children who are sensory over responsive, sensory under responsive and sensory seeking. The treatment for specific tactile defensiveness is through an occupational therapist. According to the child's symptoms, a customized tactile sensory diet will be planned to treat the child. Tactile toys will be tested out on the children. For children who are sensory seeking, tactile toys will provide them with sufficient sensory cravings and the three-dimensional qualities of the textiles would capture their attention more so that they can sit still long enough to go through the sensory therapy. For sensory over responsive children, tactile toys will allow them to practice the feel and touch of different types of fabrics so that they will become more comfortable in feeling the different textures over time. As long as the child has been exposed to a variety of touch sensations, the uncomfortable feel that she has initially will gradually go away. This will be the strategy of desensitization, which is a gradual process whereby the child is introduced to a variety of textures and materials and over time, they will learn to accept the tactile sensation. As for sensory under responsiveness children, they will be able to benefit from the tactile and visual stimulation from the tactile toys. The invigorating three-dimensional structures and the bright vivid colours together will captivate them and make them interested in the toys as well as the therapy materials and will be enough to keep them focused during the therapy session.

Currently there are specific tactile materials and toys available in the market. They are mainly fidget toys made from plastics or PVC. Tactile toys made from fabrics with



three-dimensional forms have not been developed so far. Starting from the creation of the three-dimensional fabrics, the structural surface and the vivid colours of the fabrics will intrigue the children to touch the fabric. Over a period of time, tactile toys will be able to provide specific sensory inputs for the children in each of these categories through therapy and allow them to overcome their tactile dysfunction.

### **3.2. Using an Ethnographic Approach to Design**

Referencing from Chapter 45 of *The Human-Computer Interaction Handbook*, ‘An Ethnographic Approach to Design’ written by Blomberg from IBM Research Center and Burrell from Microsoft Corporation<sup>1</sup>, the ethnographic method of research is adopted to gain an understanding into the world of children with sensory processing disorder. By using this approach, the design of Tactile Toys can provide a perspective on the relationships between children with tactile dysfunction and the existing treatment methods used in occupational therapy session. To start off with the ethnographic method, the research statement will first have to be formulated: Tactile Toys can be integrated as therapeutic products using the sensory integration approach. They can be beneficial to children who are tactile over-responsive, tactile under-responsive and sensory seeking. This statement will act as a beacon to help keep the research on track over the course of this study.

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<sup>1</sup>Jeanette Blomberg and Mark Burrell, “An ethnographic approach to design,” *Human-Computer Interaction*, 2009, 71–94.

The next step will be to identify study participants. As this research is focused on children with tactile dysfunction, the study participants will have to be children who are tactile over-responsive, tactile under-responsive and sensory seeking. Occupational therapists working with the children as well as parents of the children will also constitute to this study. Following this, gaining access to field sites and study participants will be the next challenge. Two occupational therapy centers in Singapore, Hand in Hand Occupational Therapy Center and Ozworks Therapy Center who specialize in working with children are selected. The next step involves observation, as it is important to understand how the children behave in the actual context, both in the therapy center and at home. Interviewing comes next as this is a key tool of ethnographic research. Interviews are critical in developing understanding of children's dysfunction, the therapy methods applied by occupational therapist and how parents cope with the children. Interviews will range from unstructured, by asking questions during the observation of the therapy sessions to formal structured interviews after the therapy sessions. Structured interviews are to further understand the objectives of the therapy sessions as well as thorough understanding of the set up of the play gym of the occupational therapy center. Specific knowledge of the types of equipments and activities needed for improving specific sensory and how these equipments and activities can benefit the children with sensory processing disorder are also being acquired through the observations and interviews.

The observations and interviews will be recorded by audio taping, written records and permitted photography, which will form the primary data of this research. It will include how the occupational therapists work with children, from preparing themselves before the children arrives, to working with the child during the therapy and eventually how the

session ends by interacting with parents of the child. These primary data are then analyzed and Tactile Toys will be prototyped and tested out at these two occupational therapy centers, with the help of an occupational therapist who incorporate these toys into the therapy sessions. The occupational therapist will give feedback on the effectiveness of the toys based on her experience over a sample of children. Based on the feedback, the success of the Tactile Toys can be determined, which will articulate the objectives of this research: Tactile Toys can be incorporated as tactile therapy, for children with tactile dysfunction to develop an understanding of tactile sensations using touch and hence allow them to overcome their tactile dysfunction.

### **3.2.1 Study Participants (Who)**

The three distinct subtypes of children with tactile dysfunction are identified; they are tactile over-responsivity, tactile under-responsivity and tactile seeking. A child who is tactile over-responsive might be fussy about texture of the sheets and pillows on his bed. For a child who is tactile under-responsive, he doesn't seem to feel or respond to anything. If someone touches him, he may not even notice. As for a child who is tactile seeking, he would constantly touch any objects of their interest and he cannot get enough of stimulation. According to Mauro<sup>2</sup>, certain fabrics may feel unpleasant to the child. In her definition, sensory integration disorder is characterized by the inability to accurately process information coming to the brain from the senses, which results in inaccurate judgment of sensory information such as touch, sight, movement, taste and sound. In

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<sup>2</sup>Mauro and Clark, *The Everything Parent's Guide to Sensory Processing Disorder: The Information and Treatment Options You Need to Help Your Child with SPD*.

specifics to the tactile sense, our sense of touch conveys message to our brains about temperature, texture, shape, size and much more. A normal sense of touch will allow a child to do everything from buttoning a shirt to enjoying a hug. As for a child whose tactile sense is not as well integrated with other sensory information, he will feel discomfort in many situations.

In Loop's online article "Tactile Toys and Fun Sensory Ideas for Children", she gives further examples of a child showing signs of tactile sensitivity. A tactile defensive child will get upset when his hands touches sticky glue or paint or when he messes his face with food. He will likely not enjoy finger painting or eating foods like yogurt or pudding. A child who is tactile defensive will also dislike walking barefoot on textured surfaces such as grass, sand or rough carpet. Dressing and grooming can be especially difficult for the tactile defensive child because he may complain about the way certain clothes feel. Normal daily routines such as brushing his hair, brushing his teeth or clipping his fingernails can also be intolerable. A child would be diagnosed of tactile defensiveness when he has some of the above symptoms of tactile sensitivity and amplifies these symptoms more dramatically or more often than other children do<sup>3</sup>.

A child from each of the subtypes: tactile over-responsivity, tactile under-responsivity and tactile seeking will be identified with the help of the occupational therapist. Each of the children will be studied thorough observation and interview process with the occupational therapist before, during and after therapy to gain a better understanding on the characteristics of each dysfunction. The study will also encompass how the occupational therapist first evaluate and identify the various subtypes. Then the specific

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<sup>3</sup>Loop, "Tactile Toys and Fun Sensory Ideas for Children."

therapy methods together with various types of equipments and activities to be used by the occupational therapist in order to achieve a successful outcome. Parents of the child will also be interviewed to find out what are the challenges the child have at home, how parents feel that they need to seek help for their child and eventually how the parents make use of these therapy techniques to help their child at home.

Finally, Tactile Toys will be integrated into the sensory diets of these three children. The design of Tactile Toys will be aimed to assist children who are tactile over-responsive to overcome fear of tactile sensations; heighten tactile awareness of children who are tactile under-responsive and giving the right amount of tactile input for children who are tactile seeking through incorporating these toys into the sensory diets of their occupational therapy. This will help to boost the sensory processing system, allowing the brain to become more receptive to touch in general and learning to manage tactile information better. The proof of effectiveness of Tactile Toys will be further discussed in Chapter 4.

### **3.2.2 Gaining Access (Where)**

Two occupational therapy centers in Singapore, Hand in Hand Occupational Therapy Center and Ozworks Therapy Center are selected and permission is granted to observe and interview the occupational therapists at work as well as to understand the set up of the therapy play gym or 'sensory room'. These two centers focus on providing occupational therapy services for children with autism, sensory processing disorders, attention deficit hyperactive disorder and other developmental and learning disabilities

for children. Through different therapeutic activities, an occupational therapist can help children to work on the skills they need to function properly in their daily lives<sup>4</sup>. The therapy sessions will involve purposeful activities to assist individuals who is limited by cognitive impairment, psychosocial dysfunction, mental illness, developmental or learning disability<sup>5</sup>; to be able to performing their day-to-day tasks independently. For the special needs child, occupational therapy services are set accordingly to the child's needs and desired goals. Occupational therapy services for the child will include evaluation, intervention, and measurement of outcomes. Throughout the process, collaboration with the child's parents, siblings, caregivers and teachers is essential to understanding the daily life experiences of the child and those with whom he or she interacts<sup>6</sup>.

The occupational therapy evaluation process is designed to gain an understanding of the child's skills: his or her strengths and challenges while engaging in daily activities. The occupational therapy intervention process is based on the results of the evaluation and is individualized to include a variety of strategies and techniques that help children maximize their ability to participate in daily activities at home, school and in the social environment. Progress or a successful outcome is noted through improved performance, enhanced participation in necessary or meaningful daily activities, personal satisfaction, improved health and wellness, and successful transitions to new situations and roles. These

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<sup>4</sup>Mauro and Clark, *The Everything Parent's Guide to Sensory Processing Disorder: The Information and Treatment Options You Need to Help Your Child with SPD*.

<sup>5</sup>Kranowitz, *The Out-of-Sync Child Has Fun, Revised Edition: Activities for Kids with Sensory Processing Disorder*.

<sup>6</sup>American Occupational Therapy Association and others, "Fact sheet: Occupational therapy's role with autism," 2011, <https://www.aota.org/-/media/Corporate/Files/AboutOT/Professionals/WhatIsOT/CY/Fact-Sheets/Autism%20fact%20sheet.ashx>.

measures can help the child, family, and occupational therapist appreciate success and refocus and change priorities of the intervention plan as needed<sup>7</sup>.

### **3.2.3 Observation (What) and Interviewing (How)**

Blomberg and Burrell<sup>8</sup> emphasized that it is crucial to combine both observations and interviews to achieve a holistic view in the research process. To obtain this holistic view, combining data from observations and interviews will be important to understanding what occupational therapy entails and how occupational therapy is conducted. Interviewing both occupational therapist and parents can extend and deepen one's understanding of what has already been observed. In this context, both structured and unstructured interviews are conducted prior, during and after observing the occupational therapist at work with the each individual child. The next three sub-sections will explain in details the job of the occupational therapist, the set-up of the therapy play gym and how occupational therapists work with children and their parents. All these descriptions are based on the outcomes of the observations and interviews held at the two occupational therapy centers.

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<sup>7</sup>American Occupational Therapy Association and others., "The scope of occupational therapy services for individuals with an autism spectrum disorder across the life course," *American Journal of Occupational Therapy* 64, no. 6\_Supplement (2010): S125–S136.

<sup>8</sup>Blomberg and Burrell, "An ethnographic approach to design."

## **Job of the Occupational Therapists**

Understanding the job of an occupational therapist is crucial and based on field observations and interviews from occupation therapists from the two centres, the occupational therapist work will be to teach the skills necessary for the child to play, to have the necessary skills for school and daily lives. In this context, it will include daily practical activities such as dressing or grooming and action activities such as playing catch or handwriting. These abilities can be a problem for children with sensory processing disorder. Through occupational therapy, children can improve their cognitive, physical, sensory, and motor skills and enhance their self-esteem and sense of accomplishment<sup>9</sup>.

Occupational therapist adopt a sensory-based approach and will usually try out various types of play activities, working on all the seven senses and then observe the child in play or perform a task to determine the child's abilities and difficulties. The occupational therapist will analyze and identify the area of difficulties that may be preventing the child from performing each specific activity. Next, the therapist will provide strategies that will enable the child to increase their ability to perform that particular activity through the support of a series of therapeutic equipments and products in the therapy play gym. A specific game plan will be made up, as with the progress of every session, the therapist will be able to pick up more information from observation as well as parents verbal inputs and activities will be further tweaked to suit to the child's sensory issues.

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<sup>9</sup>"KidsHealth," [http://kidshealth.org/parent/system/ill/occupational\\_therapy.html](http://kidshealth.org/parent/system/ill/occupational_therapy.html).



The occupational therapist has to prepare and structure the play gym environment in specifics to each child's needs to make the child feel comfortable within the environment. The therapy area ought to be pleasant and motivating to each individual child. When the space and play activities are set up, the child will be brought in and the therapist will lead in the activities and facilitate the play of each activity. A good therapy session may look like play but it is a difficult task, as the therapist needs to provide the child with the right control of sensory inputs so that the child will have the right response from the therapy, which can develop and improve on their daily and functional skills.

### **Set-up of the Therapy Play Gym - the 'Sensory Room'**

Occupational therapy takes place in a large indoor clinic area which is more like play gym with many pieces of equipments such as platform swings, trampolines, ball pit, scooters, ramps, climbing walls, large bolsters and large therapy balls. The set up is appealing to children, inviting them into the fun space to play and interact with the equipments. The occupational therapist will make use of these equipments, which can help to improve the child's sensory processing, and the therapist will have the knowledge of the usage of specific equipments for therapeutic effects for the specific sensory disorder.

The main purpose of the therapy play gym or 'sensory room' is to calm or stimulate the child through each of his senses. It is important to include the other two senses, which is vestibular (balance) and proprioception (body position) in sensory processing to the five common senses, that is; touch (tactile), sight (visual), taste (gustatory), smell (olfactory) and sound (auditory). The vestibular sense refers to the sensory information

one receive from the middle ear that is related to movement and balance<sup>10</sup>. For children without a good sense of balance, activities such as throwing, catching or kicking a ball can be compromised. Their poor sense of balance can cause nausea and headaches and make it difficult for them to concentrate on their daily activities<sup>11</sup>. The proprioceptive sense refers to the sensory information one receives from the muscles, joints and body parts<sup>12</sup>. It is developed by the nervous system as a means to keep track of and control the different parts of the body<sup>13</sup>. Normal sensory processing allows the body to be aware of its position in relation to space and allows one to make suitable actions to balance, to move around or go about daily activities without falling down or knocking into things<sup>14</sup>. This is because the muscles and joints in the body are sending information to the brain to tell the position of these body parts. For children with poor proprioceptive sense, they will feel unsettled, as they are not getting good information from their proprioceptive sense. To counter the unsettling feeling, they may doing actions such as rocking back and forth, throwing their bodies against things or moving in unusual ways like flapping their arms.

In the therapy play gym or ‘sensory room’ there are equipments and play objects and materials that can target the seven senses. One of the most common pieces of equipment to target the vestibular sense is the one plane swing. This swing consists of a flat platform, which allows the child to sit, stand or lie flat on his tummy. The swinging motion can

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<sup>10</sup>Bonnie Arnwine and Olivia McCoy, *Starting Sensory Integration Therapy: Fun Activities that Won't Destroy Your Home Or Classroom!* (Future Horizons, 2006).

<sup>11</sup>Mauro and Clark, *The Everything Parent's Guide to Sensory Processing Disorder: The Information and Treatment Options You Need to Help Your Child with SPD*.

<sup>12</sup>Arnwine and McCoy, *Starting Sensory Integration Therapy: Fun Activities that Won't Destroy Your Home Or Classroom!*

<sup>13</sup>“Sensory Processing Disorder – SPD Australia,” <http://www.spdaustralia.com.au/the-propriceptive-system/>.

<sup>14</sup>Lashno, *Mixed Signals: Understanding and Treating Your Child's Sensory Processing Issues*.

improve the child's sense of balancing and also provide soothing or stimulating sensation depending on the needs of the child. Other equipments that can concentrate on giving good input to the vestibular sense include hammocks, balance boards, balance beams, rotational discs and fitness balls. The to and fro motion can be gentle or vigorous as the therapist can adjust this movement to the child's comfort level to be calming or to raise the child's arousal levels to heighten their senses. There are other play activities that aim to provide vestibular inputs for the child. They include hopscotch, simple skipping and jumping games, which can combine tactile mats as paths on the floor to stimulate both their tactile and balancing sense. The therapist will creatively combine various play techniques to attract the child to perform an activity, which the child will otherwise feel uncomfortable in achieving it. In this way various sensory issues can be mitigated without causing unnecessary stress for the child.

A child's sense of proprioception can be elevated from the usage of equipments such as trampolines, crash pits, ball pits which will help in the sense of body position. The jumping and crashing actions will give the child significant pressure on their muscles and joints which can increase the level of alertness or calmness of the child. The body of the child craves for deep pressure if the child does not have a good sense of proprioception. The child can be squished or hugged by rolling therapy balls on top of them, being wrapped up in lycra swings, having weighted blankets or weighted pillows on them and wearing weighted vest. All these therapeutic methods will have deep pressure inputs on the child and will calm, relax and soothe the child. Making the child perform 'heavy work' can improve his attention, arousal level, body awareness and muscle tone, as well as decreasing

defensiveness<sup>15</sup>. Examples of ‘heavy work’ includes crawling through a resistance tunnel which is made from tight stretchy fabric such as lycra and pushing a ball through the tunnel; stretching and pulling the TheraBand™<sup>16</sup> as well as wearing a body sack made by lycra and then try to walk, jump, roll around and push his body up or out. All these activities can provide good muscle work and input into the sense of body position.

As for sense of touch, many therapy play gyms or ‘sensory rooms’ are equipped with play objects and tactile materials and can provide a whole range of tactile experiences for the children. Some popular tactile input activities include playdoh, shaving foam or cream, textured balls, textured puzzles, textured stepping stones, finger paints and children massagers or vibrating toys. There will be a special tactile wall or boards that consist of different textured fabrics and materials ranging from smooth to rough such as satin, carpet swatches, silk, lambs wool, washcloths, cotton balls, bubble wraps and Scotch-Brite. The therapist will usually prescribe sensory brushing with surgical brush, using Wilbarger brushing protocol as a ‘carryover’ home therapeutic activity. Children who are tactile over-responsive may be more reserved in approaching these tactile activities. Children who are tactile sensory seeking will be immersing themselves into these activities with excess enjoyment. It will be the job of the occupational therapists to modulate the specific child’s reaction and plan innovative ways to engage the child’s tactile sensations.

A good therapy play gym or ‘sensory room’ should consist of controllable light sources and light therapy to produce great visual stimulation. Pastel coloured light tubes, fiber optic lights and rope lights are good examples of basic lighting and can give a

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<sup>15</sup>“Sensory Processing Disorder,” <http://www.sensory-processing-disorder.com/heavy-work-activities.html>.

<sup>16</sup>THERABAND. <http://www.thera-band.com>

peaceful, calming, and soothing effect for the sensory room. Some fiber optic lights come in the form of a curtain and it is designed for children to explore with their hands and eyes. Additional visual stimulus can include lava lamps, special effect projectors and bubble columns. For children with sensory processing disorder, watching the movement of the lighted liquid in the lava lamp or bubble columns can provide a tracking activity that can help improve visual development. They can improve their spatial awareness and visual tracking. Other therapeutic benefits include, strengthening visual motor integration, improving visual motor skills as well as improving the ability to shift gaze quickly<sup>17</sup>.

For children with sensory processing disorder, aromatherapy is beneficial as it can have an amazing, almost sub-conscious stabilizing power over the moods and arousal level of the child. To equip the therapy play gym or ‘sensory room’ with specific scents will target the olfactory input for the children. The room will usually be filled with specific scents for the child to respond accordingly with either the use of scented oils, scented candles, aroma diffusers, scented stuff toys or blankets and scented potpourri. Depending on the effects that the therapist is trying to achieve with the specific child, different types of scents are used. For calming purposes, scents such as vanilla, lavender, peppermint, or jasmine can be used. For stimulating purposes, scents such as cinnamon and spices, strong sweet scents such as floral and sour scents such as citrus scents can be used.

To work on gustatory inputs and oral motor skills, the therapy play gym or ‘sensory room’ will have a supply of fancy shaped drinking straws, a variety of foods, liquids or candy, bubble blowing toys, oral massagers or children’s electric toothbrushes. These

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<sup>17</sup>“Sensory Processing Disorder,” <http://www.sensory-processing-disorder.com/bubble-columns.html>.

products can produce positive inputs for children with oral sensitivities; the two types are the hypersensitive and the hyposensitive. The hyposensitive child will need more oral stimulation activities and the therapist will need to supervise the child to taste, lick, suck or chew a variety of foods to explore new foods and textures. On the other hand, the hypersensitive child is overly sensitive to oral stimulation. The child will feel uncomfortable with certain textures of food, which can lead food aversions and becoming picky eaters. The therapist will need to work on introducing just one new taste or texture at a time and will encourage the child to suck from fancy shaped straws and blowing of bubbles to improve their oral inputs. An oral massager or electric toothbrush is beneficial to both hypo and hypersensitive children as they can stimulate the mouth to decrease hypersensitivities or increase the oral input the child is craving.

Last but not least, to target the auditory sense; the therapy play gym or ‘sensory room’ do come with specific therapeutic products such as sound pillows, sound eye masks, nature sound machines, indoor wind chimes and classical music and these products can be used for calming and soothing purposes. However, children with auditory sensory problems do need help in other sensory inputs in order to improve their ability to receive, interpret and integrate auditory input. Hence the therapist will work on both their proprioceptive and vestibular input, concentrating on giving them the pressure needed for their muscles and joints; together with achieving balance and equilibrium on their sense of movement. With the correct dosage of proprioceptive and vestibular inputs, all the other five senses will be strengthened and this will allow the child to integrate all his senses more effectively. Hence, increasing the child’s well being and allowing him to overcome his sensory dysfunction and live his life in a functional manner.

Children with sensory processing disorder are often delayed in their fine-motor and gross-motor skills. Therapists can use specific equipments or therapeutic products during occupational therapy to work on the children's fine-motor and gross-motor skills. Fine-motor skills are defined as movements that are small and require careful coordinated control, for example writing, cutting or picking up small objects; whereas gross-motor skills refer to movements that are large and involve coordination of multiple body parts such as running, jumping or throwing<sup>18</sup>. Activities and educational products or toys that can be used as fine-motor strategies include wind-up toys, tops, lace-up cards and pick up sticks. These activities can strengthen both a child's fine-motor ability and provide strong sensory inputs. As for gross motor strategies, the therapist can apply certain vestibular, proprioceptive and tactile activities to work on the child's sense of balancing, sense of body position as well as tactile stimulation to improve the child's gross motor skills. Therapy play gym or 'sensory room' are equipped with sturdy tricycles and scooter-boards, the action of pedaling the tricycle or moving around with the scooter-board with hands and feet can give excellent sensory inputs and build up gross motor skills.

Occupational therapy using the sensory integration approach can be advantageous to the child. It is fun, noninvasive and has no negative side effects. The main objective is to intervene through play and the therapist will ensure that play is effective, entertaining and stimulating for the child. The therapist will encourage all senses to be explored and used and very often, working on one to two senses at a time. For example an activity that targets both auditory and tactile senses or a game that aims in providing proprioceptive and visual

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<sup>18</sup>Mauro and Clark, *The Everything Parent's Guide to Sensory Processing Disorder: The Information and Treatment Options You Need to Help Your Child with SPD*.

stimulus. Very importantly, the therapist will not force the child to participate if he is too anxious and not comfortable. The therapist will be creative in activities to allow the child to seamlessly integrate into the activities. The therapy play gym or 'sensory room' can be an enjoyable, pleasurable, calming and exploratory experience for the child with sensory processing disorder.

### **Occupational Therapists working with Children and Parents**

At the beginning of a child's therapy session, it is common for the child to be hesitant to perform certain activities. The therapist will know not to force the child to participate in the activities but to slowly introduce the activities in a different approach until the child is comfortable. It is important to introduce tactile experiences slowly and gradually and only when the child is ready to experience them, so that any defensive reaction can be avoided. A child with tactile defensiveness should never be forced to touch anything they do not want to, as this will cause further apprehension and avoidance. The therapist will need to encourage, explain, understand and communicate with the child as they attempt to introduce touch sensations to them in a safe and non-threatening way. If the child with tactile defensiveness is fearful of any textures, have him play with it in a less threatening way. For example, the child can hold the therapist's hand to start touching the textured objects. He can put objects or his own toys into the textured surfaces, or he can push his toy cars or plastic animals through it. After which, when the child is able to tolerate the right dosage of sensory inputs, slowly encourage him to try other fun ways in which the therapist can model and demonstrate, such as poking, pulling or rolling the textured surfaces. Eventually encourage the use of the whole hand, including palm or even rolling



the body over the tactile textures. The therapist will also be able to determine how much of an activity is enough for each of the different cases of children who are over-responsive, under-responsive or sensory seeking. Therapists are usually very creative and they can redesign play and therapeutic activities to suit to the child so as to keep the child fascinated and interested.

Therapy sessions should be scheduled once a week as this timing is beneficial for the child to learn and adapt the skills or activities being imparted by the therapist. The therapist will usually seek feedback from the parents to check how the child responds at home after the therapy session and monitor if the child is responding well to the therapy approaches. Goals are usually being set based on the child's sensory profile and parents major concerns for the child. The weekly occupational therapy sessions will address these goals with progress documented in writing or sometimes video recordings and once set goals are achieved, the next set of goals are drafted out and the process will start again. Goals and therapy techniques can change constantly as these are dependent on the child's ability to accept or having mastered the specific skill or activity. It is the job of the occupational therapist to determine when the activities need to be changed or to be set at a more challenging level.

Parents are encouraged to be present during the therapy sessions so they can watch how their child reacts in the therapy sessions. The therapist will usually review techniques and strategies that can be carried over to therapy at home. The therapist will teach parents techniques and give guidelines to how to administer, to increase or decrease sensory inputs of each specific child. A home-based sensory diet will usually be devised for the child by the therapist. These home-based activities will extend the benefits of the therapy being

done in the therapy play gym. Parents involvement with ‘carryover’ activities at home will further improve the child’s sensory condition and will also increase the time parents spend with the child in close physical contact. Parents will also be able to observe the child and spot his strengths and weaknesses as well as building rapport with the child and provide sensations and experiences the child needs in a comfortable home context. It is important to work on therapeutic activities with the child both at home and outside the home such as a playground. Parents will be able to understand the special needs of the children better and know ways to accommodate them; and most importantly, bringing their sensory systems back to normal.

In the time span of about six weeks, with weekly occupational therapy and ‘carryover’ therapeutic activities at home, the child should show apparent improvements in his attention span, body awareness, motor planning skills and greater tolerance of sensory input<sup>19</sup>. Although there maybe some children who will not respond positively to the sensory integration approach, majority of children with sensory processing disorder will respond well, which will prove the efficacy of the sensory integration treatment approach.

In any event, weekly visits to the occupational therapist will be constructive for the child, as he will be performing physical exercises in an accepting, encouraging and delightful environment. With every activity being accomplished, he will be receiving praises and will be feeling more confident which will support his morale in performing his daily activities at home, in school or in any environment; hence improving his self-reliance and not to be over dependent on parents or teachers.

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<sup>19</sup>Lashno, *Mixed Signals: Understanding and Treating Your Child’s Sensory Processing Issues*.

### 3.2.4 Ethnography in Action - Description and Mental Model

In this section, each child from three distinct subtypes of tactile dysfunction: tactile over-responsivity, tactile under-responsivity and tactile seeking will be described in detail. The process of Contextual Design, referencing from Beyer and Holtzblatt is being adopted, as this is a ‘customer-centered’ process to find out how people work so as to provide explicit steps and deliverables for the design of a product<sup>20</sup>. Applying the technique of Critical Inquiry from Beyer and Holtzblatt, the first step for design is to understand the customers needs, desires and method of working and this process allows accurate understanding of who the customers really are and how they function on a daily basis.

In this context, it will understand both the needs and the challenges of the children with tactile dysfunction and the occupational therapist’s approach to working with the children. The observations and interviews are recorded by audiotaping and permitted photography. Note taking is also an important process during observation. All these recordings will include how the occupational therapists work with children, from preparing themselves before the child arrives, to working with the child during the therapy and eventually how the session ends by interacting with parents of the child. The work process of an occupational therapist can be mapped out in mental models. As described by Goodwin<sup>21</sup>, people act and react based on mental models and the design of a good product will require the designer to understand a user’s mental model. Relating this into the context, it will be necessary for a designer to understand the occupational therapist’s mental model when he or she works

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<sup>20</sup>Hugh Beyer and Karen Holtzblatt, *Contextual design: defining customer-centered systems* (Elsevier, 1997).

<sup>21</sup>Kim Goodwin, “Designing for the digital age: How to create human centered products and services,” *Wiley* 2, no. 3.1 (2009): 2.

with the child, and through the gathering of information of the child's challenges, the therapist will know what is required for the therapy. Hence, the design of Tactile Toys must relate to the conceptual structure and to function as a system so that it will be easy for the occupational therapist to learn and use, as this will match the mental model of the therapist.

The following 3 case studies are observations from the children who attended therapy sessions at the occupational therapy centers. A child belonging to each of the following subtypes of tactile dysfunction, namely tactile over-responsivity, tactile under-responsivity and tactile seeking, are described. A mental model of the occupational therapist will be explained, deriving from the observation of each of the three case studies. In these case studies, the names of the children, occupational therapists and parents are changed to protect the identity of each child.

### **Victoria Chen - the over-responsive child**

Victoria is an over-responsive five-year-old girl, which causes her to be more alert than a normal child. She will react to normal sounds and other sensations more intensely leading her to respond more dramatically because she is frightened by these different sensations. These sensations include tactile, auditory, visual, olfactory and gustatory. The problem with Victoria is that her sensory system is unable to filter sensations in the way that a typical developing child does. She gets fearful, angry and fussy if either these sensations are too strong for her. In terms of tactile defensiveness, she is extremely sensitive to the types of clothes she wears and textures that she comes into contact with. The bedding, towels, upholstery and even the carpet must be of a certain level of comfort to her. If she

cannot find her comfortable socks and if she walks on the carpet with her bare foot, it will trigger her frustrations and lead to a meltdown.

Occupational therapist Gloria has been working with Victoria for more than one year. Mrs. Chen, Victoria's mother had a strong hunch that something was amiss with her child when Victoria was about 2 years old. However, many friends affirmed her that Victoria was going through the 'Terrible Two' stage, and tempers and tantrums are normal for children at the age. When Victoria turned three, things did not improve. She entered a play school and teachers had told Mrs. Chen that Victoria's behaviour was different from the rest of the children in class. When most children were enjoying the singing and music sessions, Victoria covered her ears with her hands. During art and craft lessons, Victoria refused to participate, as she did not want to have paint or glue on her hands. Through the recommendation of the principal of the play school, Mrs. Chen brought Victoria to an occupational therapy centre and the chief occupational therapist together with Gloria, the therapist assigned to Victoria, assessed Victoria's challenges and evaluated that Victoria has sensory over-responsivity.

To soothe children who are over responsive, Gloria, the therapist will apply deep pressure and proprioceptive stimulation. Proprioceptive information (from the joints and muscles) and deep pressure (from the skin) can calm the child down as these tools utilize mechanical forces to quiet the alarms tripped by over-responsivity. When there is perceived discomfort or danger, the part of the brain that is responsible for arousal and emotions gets activated. Proprioceptive and deep pressure can diminish the activity of the brain, over-riding the danger signals.

During the day of observation, Gloria combined activities that involved vestibular and proprioception inputs for Victoria. Before Victoria came in for therapy, Gloria prepared equipments such as trampoline, ball pit, crash pit, fabric tunnel and lycra swing to work on both vestibular and proprioception inputs. She aligned the trampoline next to the ball pit and the crash pit under the lycra swing. When Victoria came into the therapy play-gym, the first thing she had to do was to take off her shoes and socks. Then, with Gloria's instructions, she hopped onto the trampoline and started bouncing on the trampoline, and after Gloria counted to five, Victoria jumped into the ball pit. Victoria did this activity six times and she enjoyed the jumping and crashing actions as it gave her the right amount of pressure on her muscles and joints, which increased her level of calmness. (Fig 3.3)

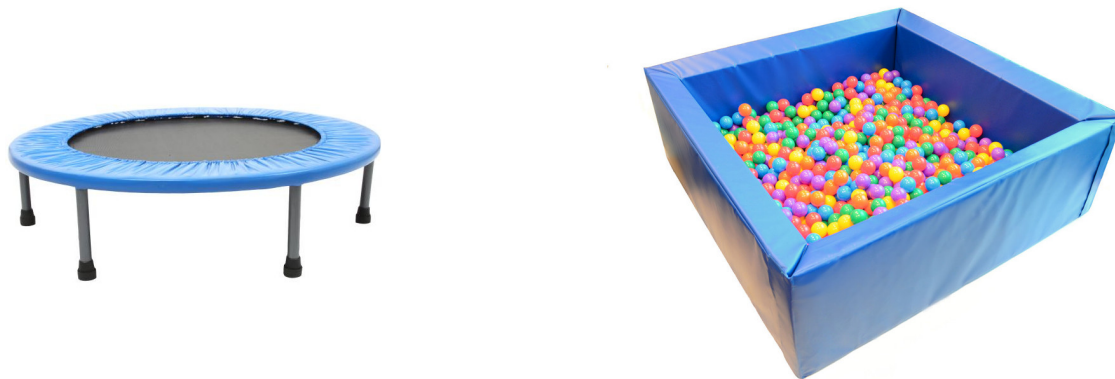


Figure 3.3: Trampoline and ball pit

Images from :

[http://cdn.dealsdirect.net/m/products/240/3240/2/product2\\_3240\\_600x600.jpg?](http://cdn.dealsdirect.net/m/products/240/3240/2/product2_3240_600x600.jpg?file=36in+Duragym+Mini+Exercise+Trampoline)

[file=36in+Duragym+Mini+Exercise+Trampoline and](http://cdn.shopify.com/s/files/1/0531/5189/products/ball_pit_with_balls.jpg?v=1403023613)

[http://cdn.shopify.com/s/files/1/0531/5189/products/ball\\_pit\\_with\\_balls.jpg?](http://cdn.shopify.com/s/files/1/0531/5189/products/ball_pit_with_balls.jpg?v=1403023613)

[v=1403023613](http://cdn.shopify.com/s/files/1/0531/5189/products/ball_pit_with_balls.jpg?v=1403023613)

Then Gloria moved on to the Lycra swing, with the crash pit right underneath the Lycra swing. She made Victoria climb onto the swing and wrapped her up in Lycra swing. Then, Gloria started to swing her to and fro while singing nursery rhymes, and Victoria was giggling and had fun. The swinging motion improved Victoria's sense of balancing and also gave her a soothing sensation. After five swings, Gloria opened up the Lycra swing and Victoria dropped onto the crash pad. The crashing provided deep pressure inputs for Victoria and helped to calm, relax and soothe the child. (Fig 3.4)



Figure 3.4: Lycra swing and crash pad

Images from : [http://www.occupationaltherapychildren.com.au/blog/wp-content/uploads/2012/10/IMG\\_1498-300x225.jpg](http://www.occupationaltherapychildren.com.au/blog/wp-content/uploads/2012/10/IMG_1498-300x225.jpg)  
<http://www.especialneeds.com/images/CrashPadsBlog.jpg>

Next, Gloria lined up the fabric tunnel on the floor and placed a ball at the entrance of the fabric tunnel. Victoria then crawled through the tunnel while pushing the ball to the other side of the tunnel. According to Gloria, the resistive input while crawling and pushing the ball through the tunnel was a form of ‘heavy work’ that could improve Victoria’s attention, body awareness and muscle tone, as well as decreasing her defensiveness. Heavy work activities can also provide good muscle work and input into the sense of body position. (Fig 3.5)



Figure 3.5: Fabric tunnel and therapy ball inside the fabric

Images from: <https://s-media-cache-ak0.pinimg.com/236x/d0/ce/82/d0ce823c3491c6274ba7c06a23974c5b.jpg>  
<https://s-media-cache-ak0.pinimg.com/236x/35/1a/82/351a8278a501b200ddc35b11ae7b8113.jpg>



The next activity Gloria planned for Victoria aimed to stimulate both her tactile and balancing sense. Gloria aligned textured alphabets and numbers rubber mats on the floor and made Victoria hop from one square to another when Gloria shouted out the alphabet or number of the mat. The tactile input that Victoria received came from the textured rubber mat which improved her tactile discrimination, while positioning her body onto the correct alphabet or number square improved proprioceptive, body awareness, motor planning and hand-eye or foot-eye coordination. (Fig 3.6)



Figure 3.6: Alphabets and numbers rubber mat

Image from :

<http://www.rubberflooringinc.com/assets/product/images/912x600/3271.jpg>

As for targeting Victoria's tactile over-responsivity, Gloria brought Victoria towards the tactile sensory wall to work on her sense of touch. Typically, a tactile sensory wall is made up of tiles of tactile materials that consist of different textured fabrics and materials ranging from smooth to rough such as satin, carpet swatches, silk, lambs wool, washcloths, cotton balls, bubble wraps, and Scotch-Brite. Victoria was encouraged to run her hands on these materials and at the same time describe the sensations to Gloria. This activity is aimed at providing a whole range of tactile experiences and to develop tactile awareness. (Fig 3.7)



Figure 3.7: Tactile sensory wall

Image from : [http://4.bp.blogspot.com/-](http://4.bp.blogspot.com/-BZjxMAHl0Hg/T0w88S-YNWI/AAAAAAAAACis/Wb5nLoFvrF8/s640/074-003.JPG)

[BZjxMAHl0Hg/T0w88S-YNWI/AAAAAAAAACis/Wb5nLoFvrF8/s640/074-003.JPG](http://4.bp.blogspot.com/-BZjxMAHl0Hg/T0w88S-YNWI/AAAAAAAAACis/Wb5nLoFvrF8/s640/074-003.JPG)

Continuing with tactile therapy, Gloria moved on to hands-on activity. On the child's table there was a large plastic tray and Gloria squirted out shaving foam onto the plastic tray. Victoria started to write alphabets on the tray. Then Victoria chose her favourite paint colours and squirted the paints on the tray and started mixing up the paints. Throughout the whole session, Victoria was enjoying herself, laughing aloud and singing along with Gloria. (Fig 3.8)



Figure 3.8: Playing with shaving foam and mixing paints into shaving foam  
Images from : <http://therapycenter.org/2010/10/wiggle-room/>  
<http://lectoescrituramendeznunez.blogspot.sg/2013/02/ideas-para-trabajar-la-pre-escritura.html> <http://elementaryartfun.blogspot.sg/2011/08/marbleized-peacock.html>

Gloria shared that this was not the case when Victoria first attended the therapy. Victoria was very reserved in approaching these tactile activities. Gloria had to modulate her reactions and plan innovative ways to engage Victoria's tactile sensations. Gloria had to creatively combine various play techniques to attract Victoria to perform specific tactile activity, which she felt uncomfortable in achieving it. For example, Gloria had to place Victoria's toys onto the foam and pretended that her toys are trapped in the cold arctic snowstorm and encourage her to save her toys. (Fig 3.9) Slowly, Victoria got used to the foam sensation and Gloria then added on another element, which was finger paint.

This method of working allows the tactile sensory issues to be mitigated without causing unnecessary stress for the child.



Figure 3.9: Combining foam with toys

Images from : <http://www.kidsplaybox.com/13-easy-animal-activities/>  
<http://www.kiwicrate.com/projects/Shaving-Cream-plus-Toys-Sensory-Play/377>

At the end of the session, Mrs. Chen came in to the therapy gym. Gloria briefed her on what Victoria had worked on during the one-hour therapy session and had prescribed her with ‘carryover’ home therapeutic activity. Carryover activities will ensure that skills that a child learnt in the therapy sessions will be transferred or generalized out of the therapy session. It is important that increased practice and more time spent will improve the child’s abilities. In Victoria’s case, when she first started therapy sessions, Mrs. Chen was taught by Gloria to give Victoria a firm hug and Victoria had to press hard against her mother’s hands. This is to provide deep pressure and proprioceptive stimulation to calm

the child down as these tools utilize mechanical forces to quiet the alarms tripped by over-responsivity. Victoria's carryover home activities for that day was to continue with the ball catching games with her sibling at home using textured balls to work on tactile, proprioception and vestibular inputs.

### **Jason Wong - the under-responsive child**

Jason is an under-responsive seven years old. He is a contrast to Victoria. He is less alert as compared to a normal child, and he needs sensory messages of great intensity or duration to become aware of them. Jason is slow in everything he does, he cannot respond any faster as his brain is not getting the stimulation it needs in order to get started. He generally seems unaware and unmotivated. He is unbothered by textures of any surfaces, unlike Victoria who is over sensitive.

Jason has been attending occupational therapy sessions for a few months and occupational therapist Charmaine has been working with him. Mrs. Wong, Jason's mother has always felt that she has a good boy as Jason rarely cried during his infant stage. When Jason entered kindergarten, he was very quiet and not active, and there were no dramatic incidents to cause any concerns to teachers. Jason played alone at home and even in school, he did not socialize with friends in school or when he was out at the playground. Mrs. Wong thought that he was not good with socializing as he is the only child the family and there is not much chance for him to interact with other children. Hence, there were no warning signs at all for Mrs. Wong as she thought that Jason was just quiet, shy, a little slow but overall still a good boy with not much mischief as compared to other boys of his age. Only when Jason entered primary one, Mrs. Wong

started to receive calls from his school teacher. According to the teacher's feedback, Jason had trouble staying focused in class and was daydreaming most of the time. He was also slow in writing and hardly had his assignments completed in class. He could not answer most of the questions that he was asked in class and he was never eager to raise his hand up to participate in class like the rest of the children. His teachers all concluded that he was a slow learner, lazy, lethargic and had learning disabilities.

Another area of concern is that Jason does not show any interest in interacting with his friends. He always sits alone during recess and if other kids join him, he does not initiate conversations with them. He does not join the children at the playground and sits alone by himself. With all these feedback from the school teacher, Mrs. Wong knows that Jason needs help. With the recommendation from the school's counselor, Mrs. Wong brought Jason to the therapy center and for an assessment. The chief occupational therapist and Charmaine, who is the therapist assigned to work with Jason evaluated that Jason has sensory under-responsivity. For the under-responsive child, Charmaine, the therapist has to provide frequent, varied and extended opportunities for tactile stimulation. For children like Jason, he has to receive more sensory messages in order to wake up his under responsive systems. He needs bright lights and vivid colours to stimulate his visual sense, louder sounds to arouse his auditory sense and zesty foods to rouse his gustatory and olfactory senses. He needs novel sensations and lots of movement involving proprioception and vestibular inputs as well as tactile stimulation to enable him to increase his alertness in his daily lives. On that observation day, Charmaine shared that when Jason first came to the therapy play gym, he was unlike other kids who jumped for joy or dashed into the ball pit for fun. He was very reserved, and took a few sessions to get used to the fun-filled activities planned by Charmaine.

Charmaine first prepared equipment to work on proprioception and vestibular inputs to wake up his under-responsive systems. One of the most effective pieces of equipment to target the vestibular sense is the one plane swing. The swing consists of a flat platform, which allows the child to sit, stand or lie flat on his tummy. When Jason came into the therapy play gym, he removed his shoes and socks without being told, as this was the routine set by Charmaine right from the beginning. Charmaine prepared a basket of beanbags and got Jason to lie flat on his tummy on the swing. She stationed herself at the further end of the swing and as the swing came towards her, she threw the beanbag to Jason and he caught it with both of his hands. When the swing moved to the other end, he dropped the beanbags into the basket. The swinging motion can improve Jason's sense of balancing and also provide stimulating sensation. The to-and-fro swinging motion raises a child's arousal levels to heighten his senses. Lying flat on his tummy and holding up his head against the pull of gravity improves extension and strengthens his muscle tone. Catching the bean bags with both his hands and aiming the bean bags to be dropped into the basket improves bilateral coordination; keeping an eye to catch and drop the bean bags also strengthens the visual-motor skill of focusing. (Fig 3.10)



Figure 3.10: Throwing bean bags lying tummy down on a one plane swing  
Image from :<http://www.hands2feet.ca/services>

When Jason had completed the task of throwing all the beanbags into the basket, Charmaine then let him to sit on the tire swing and she aligned a crash pad in front of the swing and at the count of three, Jason threw himself onto the crash pad. The action of crashing onto the crash pad provides both vestibular and proprioceptive feedback. At the end of the swinging activity, Jason seemed to be more awake and alert to the instructions of Charmaine as the jumping and crashing actions gave Jason significant pressure on his muscles and joints, which increased the level of his alertness. (Fig 3.11)





Figure 3.11: Tire Swing and crash pad  
Image from :<http://thetherapyvillage.com/gallery/tire-swing/>

Next Charmaine moved on to work on more of proprioceptive inputs. Jason wore a body sack made of Lycra and then imitated movements from Charmaine. He tried to walk, jump, roll around and push his body up and out with the instructions from Charmaine. This form of ‘heavy work’ can improve a child’s attention, arousal level, body awareness and muscle tone. The handling of the Lycra sack material improves tactile sensation and imitating actions improves his focusing attention and motor planning. (Fig 3.12)



Figure 3.12: Lycra body sacks

Images from

[:http://www.skillbuilders.com.au/shop/skills/sensory/deep-pressure/body-sox](http://www.skillbuilders.com.au/shop/skills/sensory/deep-pressure/body-sox)

<http://sensorysparks.com/body-pod-a-sensory-body-sock>

The next activity that Charmaine planned for Jason combined more tactile inputs with both vestibular and proprioceptive activities. Charmaine laid different types of textured fabrics and materials on the floor in a large circle. These are large swatches of velvet, corduroy, satin, chiffon, fake fur, chenille carpet, and raffia mat and terrycloth towels. (Fig 3.13) With Charmaine's instructions, Jason stepped onto the first material and then walked one round. As for the second round, Jason had to jump from one material onto the other. The third round, he got down on the floor and crawled over the materials and for the fourth round, he rolled over the materials. The pressing of a child's feet, hands and body against different textured materials develops tactile awareness and discrimination. The movement from one material onto the other improves his skills of balancing and

movement, kinesthesia and motor planning. Furthermore, the rolling movement provides both proprioception and vestibular inputs.



Figure 3.13: Walking on tactile mats

Images from :<http://www.arktherapeutic.com/blog/post/1297>  
<https://www.mendability.com/sensory-enrichment/the-magic-carpet-to-help-your-child-with-tactile-defensiveness/>

Charmaine continued with the next activity which had a fun name called 'Burrito Roll'. She lined up a comforter on the floor and got Jason to lie tummy down on the comforter, with his head above the comforter. She took a textured therapy ball and started rolling the ball up and down his body with consistent firm pressure and said to Jason that she was preparing the ingredients that go into a burrito. (Fig 3.14) Then, Charmaine continued by pretending to add ketchup and mustard using a large textured bath sponge and pressing it firmly in a downward motion from his chest to his toes. Next, she rolled him gently and tightly in the comforter until the end of the comforter. Charmaine then said to Jason that she had put too much mustard and she needed to squish out the excess mustard and she pressed firmly on Jason's arms, legs and back. When she was done, she grabbed the edge of the comforter and Jason unrolled himself. Jason was giggling as Charmaine was doing this but he looked very comfortable and seemed to enjoy the sensation. The deep pressure from the comforter, textured sponge and Charmaine's hands provided sensory input to Jason's tactile and proprioceptive system. The rotary action of rolling organized Jason's vestibular system. Throughout the whole therapy session, Jason was happy and participated in the activities willingly, he was smiling all the time but as compared to Victoria, he did not laugh or react as loud as Victoria. Charmaine explained his lack of reactions was not due to the fact that he was not enjoying the activities, but he was definitely less responsive as compared to Victoria.



Figure 3.14: Rolling burrito

Image from

<http://www.millionsofmiles.com/2013/03/our-sensory-journey-and-10-fun-sensory.html>

At the end of the session, Mrs. Wong came in to the therapy gym. Charmaine briefed her on what Jason had worked on during the one-hour therapy session and had prescribed him with 'carryover' home therapeutic activity. At home, Mrs Wong should integrate the use of direct tactile stimulation into daily routines, for example drying Jason vigorously after bath with towels of different textures, providing a variety of textures for seats, and choosing clothing with noticeable textures. A range of therapy activities that target the tactile sense should also be included such as popping bubble wraps which gives the child good tactile input; putting hands and feet into sand or rice can also provide a comforting and rich tactile sensory experience. Jason should also be exposed to proprioceptive and vestibular inputs before going to school to wake up his senses and make him more alert

in school. It is recommended for Jason to play in the playground before going to school, which includes movements such as climbing, swinging and sliding. Another activity that Charmaine recommended is to allow Jason to sit on top of the washing machine so that the vibration from the machine can stimulate his under-responsive system.

### **Aaron Low - the sensory seeking child**

Aaron is a sensory seeking six year old. Similar to Victoria and Jason, Aaron has difficulty detecting and turning sensory information into appropriate behaviour. In Aaron's case, this difficulty results in craving and aggressively seeking sensory input. Unlike Jason, who is too slow, Aaron is too fast; instead of being frightened like Victoria, Aaron is thrilled and wants more and more sensory inputs. Fidgeting is common in sensory seeking children. Touching, feeling, stroking, poking, pulling will generate sensations and feed their hunger for sensory input. Sensory seeking shows similar traits to attention deficit hyperactive disorder (ADHD). For a sensory seeking child, after the child gets the amount of sensory stimulation he needs, he will stop. As for ADHD, the child will not stop unless tired.

Aaron started occupational therapy sessions when he was five. On the observation day, Aaron's grandmother, Auntie Ling brought him to the therapy center. Auntie Ling shared that Aaron is a very naughty boy. Since he attended nursery class at the age of four, every teacher that taught him had complained that he had very bad behaviour, he played aggressively, bullied friends, and cannot seemed to listen or understand instructions from teachers. In class, he never sat still to listen to the teacher teaching and he wondered around the classroom opening every drawer, closet that was in the room and touched every single toy or item he could find. A teacher had to be present with Aaron to stop him from



getting up and walk around the class and had to watch him all the time to prevent him from knocking into his friends while playing. At home, he was always bullying his younger sister, snatching her toys, poking her, pulling her hair and Auntie Ling said that neither his parents nor her was able to discipline him. Sometimes, his parents got really angry and will cane him, he will cry and scream very loudly and sat on floor rocking his body forward and backward. It was only a year ago that Aaron had started coming for therapy sessions and it was a recommendation from one of the teachers from school. His school teacher said he has ADHD, and told his parents to seek help from a professional. His parents brought him to the therapy center thinking that he has ADHD, but with the assessment from the chief occupational therapist and Kiayan, the occupational therapist who was assigned to Aaron, Aaron is evaluated as sensory seeking.

Kiayan shared that when Aaron first visited the center, he was overjoyed and plunged himself straight into the ball pit. He tossed out most of the balls out of the ball pit, then jumped on the trampoline and landed himself onto the crash pad. He pushed himself vigorously on the one plane swing; screaming and enjoying himself thoroughly but to an adult he totally seemed out of control and could not stop even when Kiayan asked him to. To calm an over-aroused sensory seeking child, Kiayan, the therapist has to provide stimulation that will have a calming effect on Aaron. On contrary to Victoria and Jason, who needed vestibular and proprioceptive stimulation, Aaron already craves for movements and sensations. Hence, calming his other senses with soft rhythmic music, having soothing lights and diffusing a sweet scent like lavender will subdue his vestibular and proprioceptive cravings. Non-rhythmic vestibular stimulation and non-repetitive activities will help Aaron better. Extended swinging or other intense movements will disorganize him further and make his situation worse. Heavy work activities such as

pushing or pulling and applying deep pressure on Aaron, by covering him with heavy pillows and weighted blanket will help him to self-regulate. In terms of tactile sensation, Aaron should be given textures that provide tactile stimulations in the things that he uses daily. For example, textured bath mats, seating pads, stuffed toys, shoes and socks. The child should have access to fidget toys and a variety of tactile materials and play objects to satisfy his sense of touch.

On the day of observation, Aaron was at the waiting area with his grandmother. He was stomping up and down the corridor impatiently and keeps popping the door open to see if Kiayan was ready for him. Kiayan mentioned that during the first few visits he could not wait at all and dashed right in even when the setup was not ready for him. He has improved tremendously as compared to then. When Kiayan was ready, she opened the door and Aaron placed his slippers on the shoe rack without being told and eagerly skipped into the therapy gym. Kiayan had created an obstacle course for Aaron on that day, the aim was to create an organized movement experiences for Aaron that was goal-directed and purposeful. In this obstacle course, Aaron had to rescue five soft toys from the burning castle to the other side of the river. (Fig 3.15) With Kiayan's support, Aaron had to first climb up the rock wall, which was the imaginary burning castle, then picked up one soft toy and went down the slide. Then he hopped onto the bolster swing, and Kiayan pushed him to the other end and Aaron crashed into the ball pit. Then he got up from the ball pit, walked across the balance beam, which represented the bridge across the river and then finally crawl through the tunnel into the tent and put his rescued soft toy in the tent. To make the obstacle less repetitive, Kiayan arranged the tire swing next to the bolster swing so that Aaron can alternate between those two swings.





Figure 3.15: Equipment for obstacle course  
 Images from : <http://iamhardware.com/2013/08/page/4/>  
<http://www.echan.com.sg/equipment.html>  
<http://thetherapyvillage.com/gallery/tire-swing/>  
[http://kidsfurniturelondon.com/product\\_info.php?products\\_id=30&osCsid=57ca21e7a1d6d8e18ed38ba13098247f](http://kidsfurniturelondon.com/product_info.php?products_id=30&osCsid=57ca21e7a1d6d8e18ed38ba13098247f)  
[http://klrsxejkrz.blogspot.sg/2012\\_08\\_01\\_archive.html](http://klrsxejkrz.blogspot.sg/2012_08_01_archive.html)

A child like Aaron who is constantly craving for movement needs to work on specific objectives like the pretend rescue mission planned by Kiayan. When he is working on a specific goal, he is likely to become less aroused and more organized. In the obstacle

course, Kiayan has included interrupted vestibular input, which is the bolster and tire swing together with proprioceptive inputs, which is the climbing, crashing and crawling. Navigating through an obstacle course allows Aaron to improve motor planning skills, exercise kinesthetic muscle sense and sharpen problem-solving skills. Aaron was enjoying himself thoroughly throughout the 'work out', he was proud of himself when Kiayan praised him for completing his mission of saving all the soft toys.

The next activity was a shopping game and it incorporated heavy muscle work that will get Aaron's proprioceptive system in sync. Kiayan placed different types of groceries around the room; there was a sack of rice, bottles of water, cartons of soft drinks, some canned food and biscuit tins. Aaron had to push the shopping basket around to gather the groceries when instructed by Kiayan. (Fig 3.16) The pushing of heavy loads and feeling the deep pressure of heavy weights provides calming proprioception, while increasing body awareness, gross motor strength, force and kinesthesia. Scanning the room to locate the groceries improves attention and visual skills such as focusing, figure-ground and spatial awareness. Moving around the room to pick up one item after another improves sequencing, motor planning and organizational skills.



Figure 3.16: Pushing a shopping cart: Heavy work activity

Image from :

<http://www.howwemontessori.com/.a/6a0147e1d4f40f970b017c335dae7c970b-800wi>

In the next activity, Kiayan planned to work on tactile sensory inputs for Aaron. The two activities will work on both tactile stimulation for Aaron's hands and feet. The first activity is "What's in the Box", (Fig 3.17) there were five boxes with a small opening, just enough for Aaron's hand to go inside. Kiayan hid a green toy soldier in the first box filled with uncooked pasta. In the second box, a small Mickey Mouse figurine was hidden with beans filling up the box. The third box had a small toy car hidden amongst rice and in the fourth box, there was a button hidden among sand. The last box had a small textured ball hidden amongst coffee beans. Aaron had to put his hand into every box to look for the hidden toys. Aaron was encouraged to identify the toys before taking his hands out of the boxes he did very well in identifying all the toys. The activity helped Aaron to diminish his tactile seeking behaviour as the different textures provide him with a variety

of tactile inputs. By touching the different textures of the dry food, it can promote tactile discrimination and the identification of the toys can promote integration of forms.



Figure 3.17: “What’s in the box”: tactile sensory input activity

Images from :

[https://mymontessorimoments.files.wordpress.com/2011/04/img\\_8722\\_2.jpg](https://mymontessorimoments.files.wordpress.com/2011/04/img_8722_2.jpg)

[https://mymontessorimoments.files.wordpress.com/2011/04/img\\_8701\\_2.jpg?w=201&h=300](https://mymontessorimoments.files.wordpress.com/2011/04/img_8701_2.jpg?w=201&h=300)

[https://mymontessorimoments.files.wordpress.com/2011/04/img\\_8706\\_2.jpg?w=195&h=300](https://mymontessorimoments.files.wordpress.com/2011/04/img_8706_2.jpg?w=195&h=300)

The next activity was similar, each dried food item was put into a plastic container and Kiayan also included other containers filled with different materials such as foam packaging, buttons, beads, fabrics and yarns. (Fig 3.18) All these containers are lined up and Aaron had to step into the container, one after another without stepping onto the floor. Kiayan was giving instructions to Aaron that the containers were islands and there were sharks all around the sea and he was not supposed to get his feet wet. This activity not only helps to improve tactile discrimination, it also develops a child’s motor planning and proprioception. When the child moves his body from one container to another, it will improve his sense of balance and kinesthesia. As he watches where his feet are going, it



will improve his visual skills such as eye-foot coordination, depth perception and spatial awareness.



Figure 3.18: Sensory activity for the feet: stepping on beads and sand in plastic containers  
Images from : <http://littlebinsforlittlehands.com/feet-sensory-play-sensory-bins/>

At the end of the therapy session, Kiayan briefed Aaron's grandmother on the carry-over home activities. As Aaron is always full of energy, Kiayan has prescribed heavy work activities that require whole body movement and resistance. He can help grandma out with housework such as carrying heavy groceries, pushing the grocery cart in the supermarket, pushing a laundry basket helping to move furniture when grandma needs to clean the house and also vacuuming the floor. Kiayan also suggested that he could push his younger sister while she sits in a box. (Fig 3.19) According to Kiayan, heavy work activities can provide the best calming effect on the nervous system for four to six hours with combined benefits of proprioceptive and vestibular stimulation, which is excellent for sensory seekers like Aaron as there will be enough sensory inputs to fulfill his sensory craving for the day.



Figure 3.19: Pushing Siblings sitting in a box: Heavy work activity  
Image from : <http://www.tertia.org/.a/6a00d8341c792353ef0133f383e610970b-800wi>

In terms of tactile sensation, it will be good to provide Aaron with textures that provide tactile stimulations in the things that he uses daily. For example, textured bath mats, seating pads, stuffed toys, shoes and socks. Aaron should have access to fidget toys and a variety of tactile materials and play objects to satisfy his sense of touch if he needs to concentrate on his homework or to focus on his reading. Textured balls or textured shaped toys are common fidget toys to be used for this purpose. (Fig 3.20)



Figure 3.20: Textured shaped toys as fidget toys

Image from : <http://www.childrenstherapystore.com/images/Sensory%20Shapes.jpg>

### **Mental Model of the Occupational Therapist**

As described by Goodwin, it is critical to understand users' mental models of data and processes in order to design system they can understand and use<sup>22</sup>. In this context it is important to understand the occupational therapists' mental models when they are working

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<sup>22</sup>Goodwin, "Designing for the digital age: How to create human centered products and services."



with a child. A simple mental model representing three simple steps of mental model when an occupational therapist first receives a child's case is shown in the Fig 3.21. When the child is brought to the center for assessment, the occupational therapist will find out the challenges of the child through talking to his parents and observing while playing with the child. Then she will analyze and evaluate the child's condition and finally decide on the therapy techniques that will be used on the child.

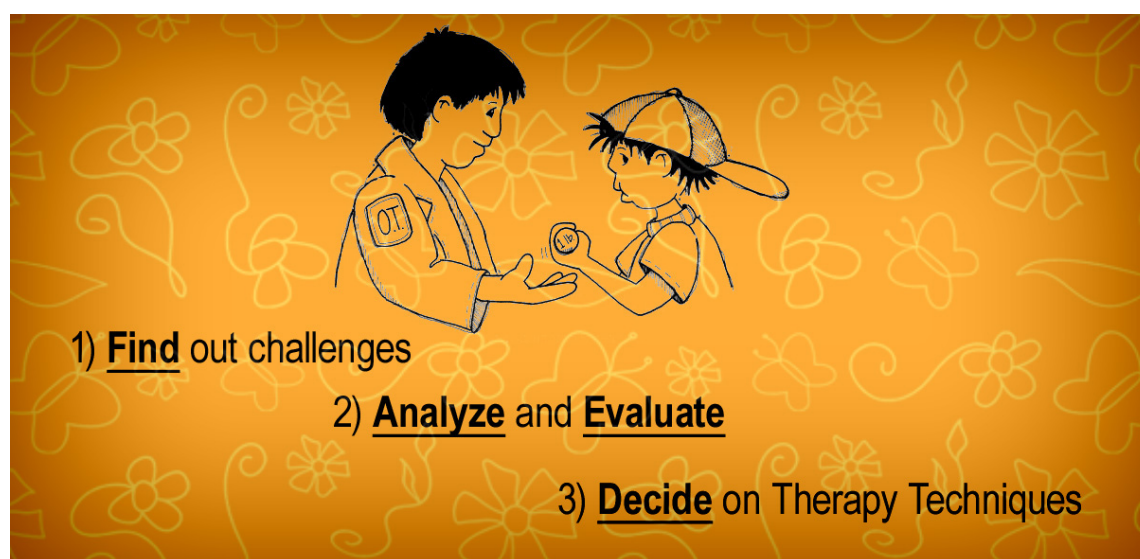


Figure 3.21: Simple Mental Model of an Occupational Therapist Working with a Child

Diagram created by author

A more elaborate mental model in Fig 3.22 shows the questions the occupation therapist will go through and take note when she is finding out a child's challenges from parents and during her observation when playing and assessing the condition of the child. These questions are very important to assess the child's condition and they will provide a fundamental understanding to the child's condition and enable the occupational therapist



to move on to the next stage of analyzing and evaluating of the specific sensory condition that the child possesses.



Figure 3.22: Mental Model of Occupational Therapist: Finding out the Challenges of the Child  
(Questions referenced from Kranowitz's the Out-of-Sync Child Has Fun)  
Diagram created by author

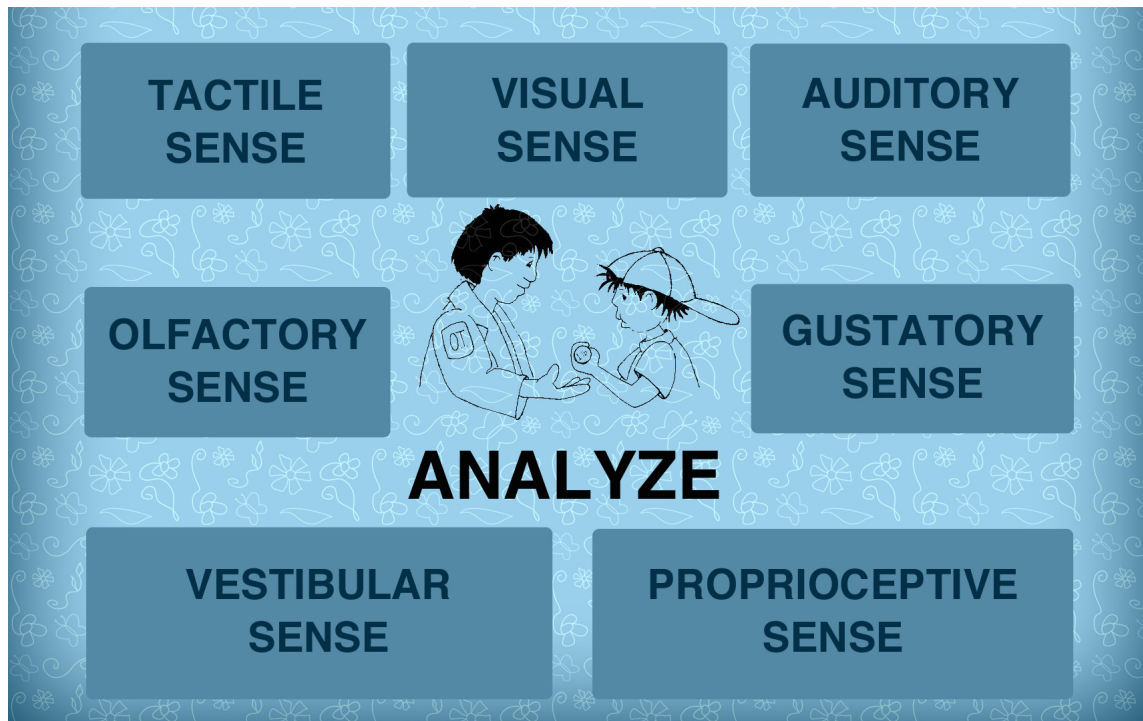


Figure 3.23: Mental Model of Occupational Therapist: Analyzing the Seven Senses of the Child  
Diagram created by author

The next step involves the analysis of the child's seven senses. Fig 3.23 shows the seven senses that the occupational therapist will need to analyze in order to assess a child's specific sensory dysfunction. The occupational therapist will have a checklist of sensory dysfunction characteristics. The following checklists are referenced from Kranowitz's, and it lists down the characteristics of children with sensory dysfunction in the seven different senses; tactile, vestibular, proprioceptive, visual, auditory, olfactory and gustatory respectively. After going through this list, the occupational therapist will be able to evaluate the child's specific sensory dysfunction and this will determine the type

of therapy that the occupational therapist will need to work on for the child. (Fig 3.24, 3.25, 3.26, 3.27, 3.28, 3.29, 3.30)

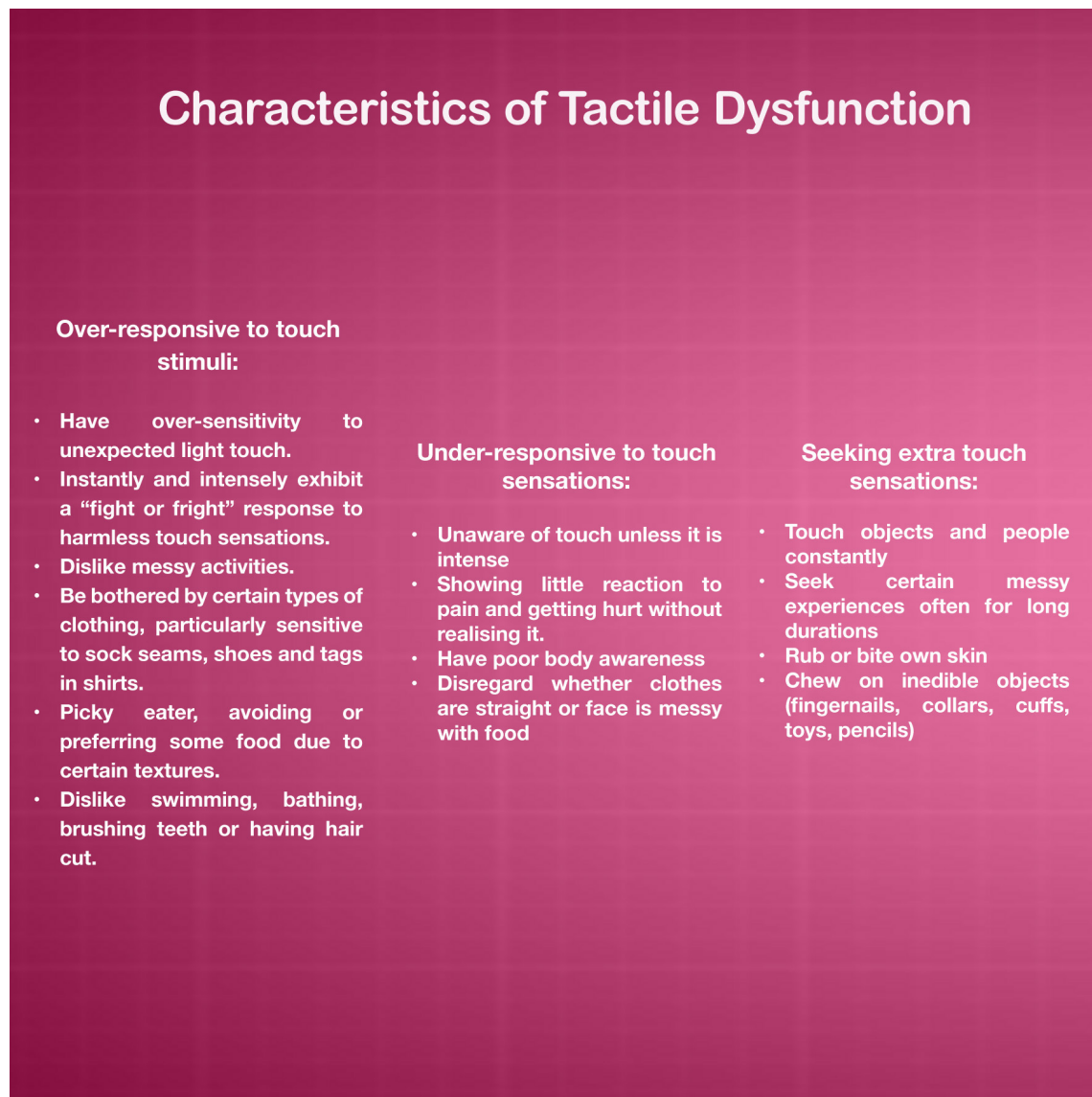


Figure 3.24: Characteristics of Children with Tactile Dysfunction  
Referenced from Kranowitz’s the Out-of-Sync Child Has Fun  
Diagram created by author

## Characteristics of Vestibular Dysfunction

### Over-responsive to movement:

- Overreact, negatively and emotionally to ordinary movement.
- Dislike physical activities such as running, biking or dancing.
- Avoid playground equipment such as swings, slides, and merry-go-rounds.
- Very cautious,hesitating to take risks.

### Under-responsive to movement:

- Lack drive to move actively.
- Swing or spin for a long time without feeling dizziness.
- Not able to feel the sensation of falling or being off-balance and not protecting self well.

### Seeking extra movement:

- Crave intense, fast and spinning movement.
- A thrill seeker and daredevil - enjoy riding over speed bumps and jumping from high places.
- Need to move constantly order to function.
- Have trouble staying seated.
- Enjoy being in upside down position.
- Enjoy swinging very high for long periods.

Figure 3.25: Characteristics of Children with Vestibular Dysfunction  
Referenced from Kranowitz's the Out-of-Sync Child Has Fun  
Diagram created by author

## Characteristics of Proprioceptive Dysfunction

A child with poor proprioception have the following characteristics :

- Have problems with touch, or with balance and movement.
- Have poor sense of body awareness.
- Stiff, uncoordinated, clumsy, falling and tripping frequently.
- Lean, bump or crash against objects and people and invade others' body space.
- Have difficulty carrying out unfamiliar and complex motions.
- Unable to do familiar things without looking.
- Chew inedible objects such as collars, pencils, fingernails.
- Have difficulty ascending and descending stairs.
- Avoid participation in ordinary movement experiences because it makes them uncomfortable.
- having eating or other oral-motor problems.

Figure 3.26: Characteristics of Children with Proprioceptive Dysfunction  
Referenced from Kranowitz's the Out-of-Sync Child Has Fun  
Diagram created by author

## Characteristics of Visual Dysfunction

A child with visual dysfunction may :

- Shield eyes to screen out sights, close or cover one eye or squint.
- Complain of seeing double.
- Have difficulty shifting her gaze from one object to another, such as when looking from blackboard to paper.
- Have difficulty tracking or following a moving object or following a line of printed words.
- Have difficulty with fine motor tasks involving spatial relationships such as fitting jigsaw puzzles and cutting along lines.
- Misjudge spatial relationships of objects in the environment, often bumping into furniture or misstepping on stairs and curbs.
- Uncomfortable or overwhelmed by moving objects or people.

Figure 3.27: Characteristics of Children with Visual Dysfunction  
Referenced from Kranowitz's the Out-of-Sync Child Has Fun  
Diagram created by author



## Characteristics of Auditory Dysfunction

A child with auditory dysfunction may :

- Seem unaware of the source of sounds and may look all around to locate where the sounds come from.
- Have trouble identifying voices or discriminating between sounds.
- Unable to pay attention to one voice or sound without being distracted by other sounds.
- Distressed by noises that are loud, sudden, metallic or high-pitched or sounds that don't bother others.
- Have trouble attending to, understanding or remembering what is read or heard.
- Have difficulty reading aloud.
- Have difficulty speaking and articulating clearly.

Figure 3.28: Characteristics of Children with Auditory Dysfunction  
Referenced from Kranowitz's the Out-of-Sync Child Has Fun  
Diagram created by author

## Characteristics of Olfactory Dysfunction

A child with olfactory dysfunction may have the following characteristics:

- Over-responsive to smells and objects to odours such as a ripe banana, that other children do not notice.
- Under-responsive to smells and ignore unpleasant odours such as dirty diapers.
- Picky eater

Figure 3.29: Characteristics of Children with Olfactory Dysfunction  
Referenced from Kranowitz's the Out-of-Sync Child Has Fun  
Diagram created by author



## Characteristics of Gustatory Dysfunction

A child with gustatory dysfunction may have the following characteristics:

- Over-responsive to tastes and may strongly object to certain textures and temperatures of foods.
- Gags often when eating.
- Lick or taste or eat inedible objects such as play dough and toys or even hair.
- Prefer very spicy or hot foods or refuse to take anything spicy.

Figure 3.30: Characteristics of Children with Gustatory Dysfunction  
Referenced from Kranowitz's the Out-of-Sync Child Has Fun  
Diagram created by author

After going through the checklist and an evaluation is made, the occupational therapist will plan for activities that will give the right amounts of sensory inputs to the child during the therapy sessions. (Fig 3.31) In summary, mental models of the occupational therapists can be defined as representations of how they make sense of and think through the assessment of a child. According to Blomberg and Burrell, mental models can inform the design of products and the insights reflected in such models can help shape numerous aspects of a product<sup>23</sup>. With the mental models of the occupational therapists clearly spelled out, it will help to formulate the design concept of the Tactile Toys.

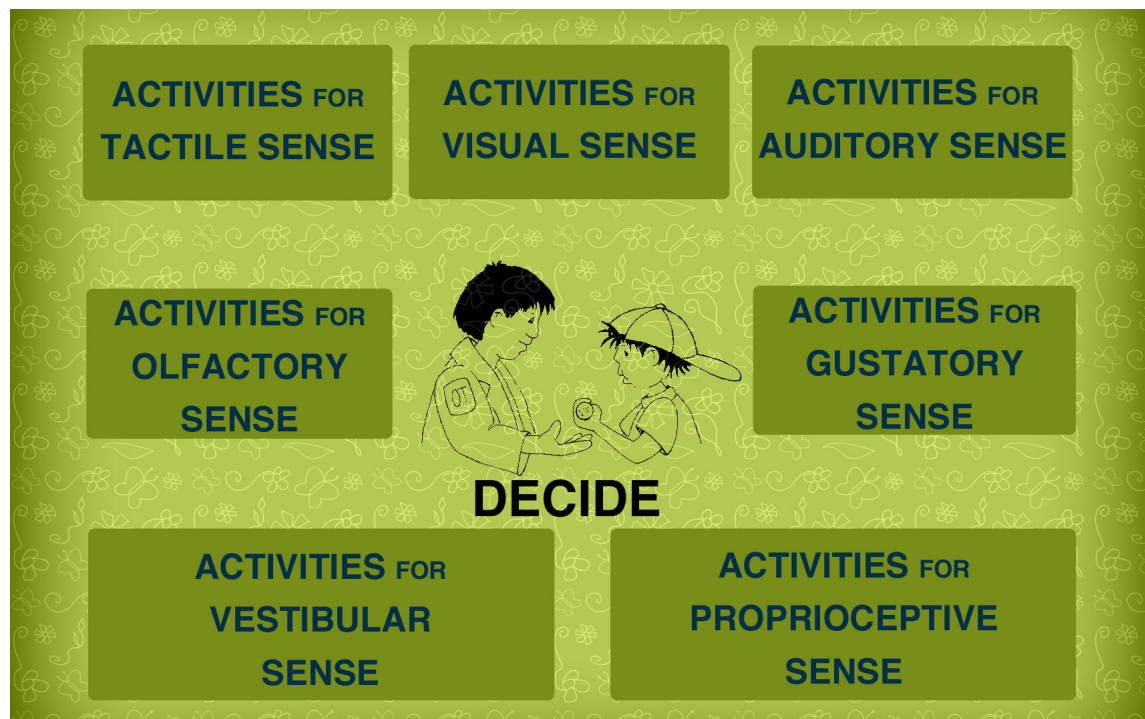


Figure 3.31: Mental Model of Occupational Therapist : Deciding the Activities for Sensory Integration Therapy  
Diagram created by author

<sup>23</sup>Blomberg and Burrell, “An ethnographic approach to design.”

## Personas

Blomberg and Burrell stated that one of the primary challenges in designing is to meet the needs of varying users. Having personas are abstract representations of the users of a product. Personas can help design teams to understand and anticipate how users experience and interact with the designed product<sup>24</sup>. Goodwin also reiterate that personas are helpful in creating and iterating a design, building consensus and marketing the product<sup>25</sup>. In this section, target personas are designed to serve as a reference to the design and development of Tactile Toys specifically for the users for whom the toys are being designed. Three personas are designed, the child, the parent and the occupational therapist; they will be the primary users of Tactile Toys. Their basic profiles, photos and goals are presented in a visual form so that it serves a reference for the developing and design of Tactile Toys. (Fig 3.32 , 3.33, 3.34)

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<sup>24</sup>Blomberg and Burrell, “An ethnographic approach to design.”

<sup>25</sup>Goodwin, “Designing for the digital age: How to create human centered products and services.”



## Kaylene Lim

**Diagnosed with Sensory Processing Disorder at 3**  
**Sensory Over-responsivity**



Auditory Over-responsive - Distressed by noises that are loud, sudden, high-pitched or sounds that don't bother others.  
 Gustatory Over-responsive - Over-responsive to tastes and strongly object to certain textures of foods and gags often when eating.  
 Tactile Over-responsive - Picky eater, avoiding some food due to certain textures.

### Kaylene's Goals :

To overcome auditory over-responsivity and to reduce strange behaviours like covering of ears.

To overcome gustatory and tactile over-responsivity, to eat well and to try and enjoy different types of food.

Figure 3.32: Persona 1 - The Child  
 Created by author





## MRS LIM MOTHER OF KAYLENE

- **Working Mother**
- **Aware that daughter is different from other children of her age**
- **Seeks help from pediatrician who referred her to an occupational therapist**

### Mrs Lim's Goals :

- To understand and learn more about Sensory Processing Disorder.
- To help daughter overcome sensory over-responsivity through learning of therapy techniques from occupational therapist.
- To hope that daughter will be able to overcome sensory over-responsivity before starting Primary School.

Figure 3.33: Persona 2 - The Parent  
Created by author



## MISS JENNA

### OCCUPATIONAL THERAPIST

- Occupational Therapist for more than 8 years.
- Loves to work with children and always encouraging.
- Very patient, understands the needs of every child.
- Always willing to share and teach parents.
- Very creative, able to adapt interventions for each child

#### Goals:

- Be able to help children with various needs to improve their cognitive, physical, sensory, and motor skills and enhance their self-esteem and sense of accomplishment.
- Be able to help children to master the skills that will help them develop, recover or to be independent, functional and improve their abilities to participate in daily lives.

Figure 3.34: Persona 3 - The Occupational Therapist  
Created by author

The three personas are designed to guide the design of Tactile Toys, to be used as tactile therapy for children with tactile dysfunction. Photos are chosen to represent the characteristics of the users and by designing them as a readable poster with strong visual images; it will be easy for the design and conceptualization of the tactile Toys. Children with tactile dysfunction will be the main users of Tactile Toys. The role of the occupational therapist is to make use of the appropriate Tactile Toys for children with specific tactile dysfunction conditions, over-responsive, under-responsive or sensory seeking. The role of the parent is to continue with the usage of Tactile Toys at home after being guided by the occupational therapist as carryover home activity to improve the on the various conditions of the child. This is to achieve the goals of the personas, that is to overcome the children's tactile dysfunction as that they can self regulate and eventually be able to improve their sensory skills and improve on their abilities to participate normally in their daily lives.

As mentioned by Goodwin, personas are incredibly useful tools for product definition and design as personas effectively engage the brain of the designer to think in human terms. When the personas are presented clearly and memorably, it is likely to invoke empathy<sup>26</sup>. In the next section, the concept of Tactile Toys will be outlined in accordance to the designed personas.

### **3.2.5 Concept**

Tactile Toys will be designed for children who have tactile dysfunction. Tactile Toys will be made from fabrics with three-dimensional structural forms that possess different touch

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<sup>26</sup>Goodwin, "Designing for the digital age: How to create human centered products and services."

sensations. As described in the first persona, children who are diagnosed with sensory processing disorder, specifically with tactile dysfunction will benefit from the use of Tactile Toys as tactile therapy. The occupational therapists (third persona) will be able to prescribe the different tactile toys for the different children and to use them during the occupational therapy sessions. Parents (second persona) will also be taught how to make use of Tactile Toys to help their child at home. Over a period of time, Tactile Toys can provide specific tactile inputs for the children in each of the tactile dysfunction categories through tactile therapy and allow them to overcome their tactile dysfunction.

From the primary data collected, it is apparent that tactile therapy is used within the sensory integration approach. Currently there are specific tactile materials and toys available in the market. They are mainly fidget toys made from plastics or PVC. Tactile Toys made from fabrics with three-dimensional structural forms have not been developed so far. The creation of the three-dimensional fabrics, the intriguing structural surfaces and the vivid colours of the fabrics will attract the children to touch the fabric. The study of the effectiveness of occupational therapy on children with tactile dysfunction and occupational therapist practicing the Sensory Integration Approach on children has already been supported by literature reviews. The usage of generic textured objects as therapy and the current textile-based materials used for tactile therapy for children with tactile dysfunction has shown that tactile therapy is at its efficacy. Subsequently, using the heat setting technique to achieve three-dimensional structural qualities on fabrics has been tested by designers in fashion and lifestyle products but has yet to be applied as therapeutic products to serve the purpose as tactile therapy. Heat set fabrics can be extremely versatile in its form and is very suitable to be developed into Tactile Toys. These three-dimensional forms not only conjures the imagery of the natural elements but



also intrigues and attracts the audience to touch and feel the structural forms. With this appealing characteristic, it will provide a variety of tactile sensations and explorations using touch and therefore generate more interest for the children. This will better equip the children with the appropriate therapeutic tactile sensory benefits and hence focus on helping children who are over-sensitive or under-responsive to step out of their fear of touching textures.

The conception of Tactile Toys made from Tactile Textiles for tactile therapy will contribute to the existing tactile therapy and eventually allow the children to overcome the dysfunction and respond appropriately to tactile senses in their daily lives. The creation of three dimensional textiles by heat setting have not been used in the Sensory Integration Approach by occupational therapists or has it been applied as tactile therapy for children with tactile dysfunction. The design of Tactile Toys will be beneficial and valuable contribution to the special needs community specially targeted at the tactile dysfunction child. Different versions of tactile toys targeting respective tactile needs will be included into the sensory treatment sessions of the occupational therapy, allowing the child to learn and become accustomed through exposure of these Tactile Toys.

### **3.3. Design of Tactile Textiles**

The rationale here is to design a product that is beneficial for the child. When a child sees this product, she will be intrigued by the three-dimensional structural forms and colours and will be attracted to touch the fabric. Each of the different three-dimensional textures will have a different tactile sensation when being touched. Hence the textiles used have

to be specially designed and produced before turning them into a useful product. The creation of Tactile Textiles to be developed into Tactile Toys will enable the children to enjoy tactile experiences together with interactive play that will help them to overcome their tactile dysfunction. When processing tactile sensations is the problem, sensory integration based occupational therapy usually benefits the child. Tactile Toys are designed to complement the child's tactile sensory diet during the therapy and to be used at home. The value proposition of Tactile Toys comes in two-folds, for the occupational therapists, Tactile Toys act as an useful tool for them to work on a child's tactile dysfunction. For the children, the tactile over-responsive child will receive the right amount of tactile inputs from the Tactile Toys and eventually, will be able to overcome the various tactile over-responsiveness. The under-responsive child will be able to be more in-tuned to various tactile sensations and the sensory seeking child will be able to receive the right amount of tactile inputs that he craves for.

Referencing to Contextual Design by Hugh and Holtzblatt, the design of Tactile Toys is equivalent to a system. The structure of a system determines how well it supports work<sup>27</sup>. In this context, the structure of the Tactile Toys refers to the components that make up Tactile Toys. The first important component is the three-dimensional structure of Tactile Textiles. It is the unique surface textures created out of heat setting techniques that gives the three-dimensional structural surfaces that provides the tactile sensation for Tactile Toys. The second component is the existence of tactile therapy by using textures of fabrics or materials swatches which is currently used by occupational therapists that proves that the usage of textiles as therapy is indeed being carried out. The third component is the integration of Tactile Toys as tactile therapy into the Sensory Integration

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<sup>27</sup>Beyer and Holtzblatt, *Contextual design: defining customer-centered systems*.

Approach for occupational therapists and parents to use as a sensory diet for the children. These three components put together the structure of Tactile Toys and hence determines how well Tactile Toys supports the work of an occupational therapist and how beneficial Tactile Toys will be for children with tactile dysfunction to improve their ability to regulate, interpret and execute appropriate behavioral responses to touch sensations so that they are able to live their lives in a functional manner. The following sections will discuss the elements that construct Tactile Textiles as the design of Tactile Toys derive from the production of Tactile Textiles. The four basic elements are: the technique of heat setting to produce Tactile Textiles, the type of materials to use in Tactile Textiles, the choice of colours and finally the steps and processes to create the Tactile Textiles.

### **3.3.1 Technique of Heat Setting**

Before creating Tactile Toys, the production of Tactile Textiles has got to be looked into. The main technique used for creating Tactile Textiles is heat setting on fabrics. The fabrics used will be 100% polyester. When heated under a controlled environment, polyester fabrics could be moulded into three-dimensional forms. With the use of different types of moulds, different textures could be formed on the fabrics.

Moulding of the fabric creates structural surfaces on the fabric. Moulds of different shapes and sizes are used to provide the three-dimensional effect of the fabric. Shibori technique is used, objects as moulds are tied to the polyester fabric. Then fabric is then placed into a steamer for the heating process. Once heated, fabric will adhere to the form of the shape of the mould, which is below the melting point of the fabric. Once the fabric

has been heat set, the moulds are removed. This creates an amazing textural, moulded and three-dimensional effect to the fabric. This structural design can be customized to one's liking, whether it's done closed together or further apart, it creates a different form with each individual fabric.

Shibori is a centuries old traditional Japanese textile finishing technique that involves the tying and folding of a fabric before the dyeing process. This technique is originally used on silks and plant fibers, which leads to unique patterns, textures, structural forms and colours after the dyeing process. On natural fibres, the three-dimensional effect will not be permanent. However, on synthetic fibres such as polyesters, when treated with the shibori technique and heat, the fabrics will result in a permanent three-dimensional surface.

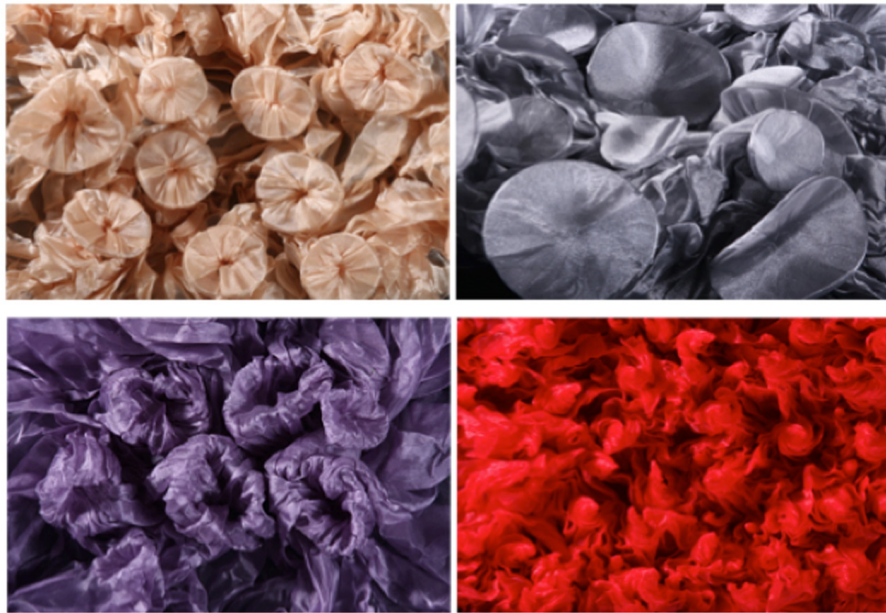


Figure 3.35: Creating the textiles - heat setting on 100% polyester organza  
Images from author

### **3.3.2 Materials Used in Tactile Toys**

The main choice of material is polyester. Polyester is chosen because the three-dimensional structures are able to retain their shapes permanently. In the industry, there are different types of polyester available such as polyester satin, crepe, chiffon, georgette, organza, and netting.

Polyester satin is an opaque and soft fabric. It is too soft and would not be able to give a good tactile sense. This makes polyester satin unsuitable for this project. Similarly for polyester crepe, initial trials conducted prove them to be too soft to give a good tactile sense and unsuitable to be made into products. Polyester chiffon and georgette are soft and translucent lightweight fabrics, which are unable to give the strong three-dimensional structure after heat setting. The most suitable material is polyester organza and polyester netting because after heat setting, the textures created were rigid to give a good tactile sense but remain flexible and tough enough to be made into sensory toys.

### **3.3.3 Colours of Tactile Toys**

The choice of colors for polyester organza chosen is bright colors as they draw interest from children. Young children generally are attracted to bright colors. As explained by Daggett, color used within a learning environment will provide an unthreatening environment that improves visual processing, reduces stress, and challenges brain development through visual stimulation<sup>28</sup>. Visual stimulation allows the brain to make

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<sup>28</sup>W.R. Daggett, J.E. Cobble, and Gertel, "Color in an Optimum Learning Environment," *International Center for Leadership in Education*, 2008, <http://www.leadered.com/pdf/color%20white%20paper.pdf>.

stronger connections while fostering visual thinking, problem solving, and creativity. Color variety reduces boredom and passivity. In this case the choice of colours for the tactile toys should incorporate a variety of colors to reduce monotony and visually refresh perception. Vibrant color used in tactile toys will improve attention span by avoiding a monotonous play and helping the children to stay focused throughout their therapy session thereby providing them with the optimum effects of tactile sensory therapy.

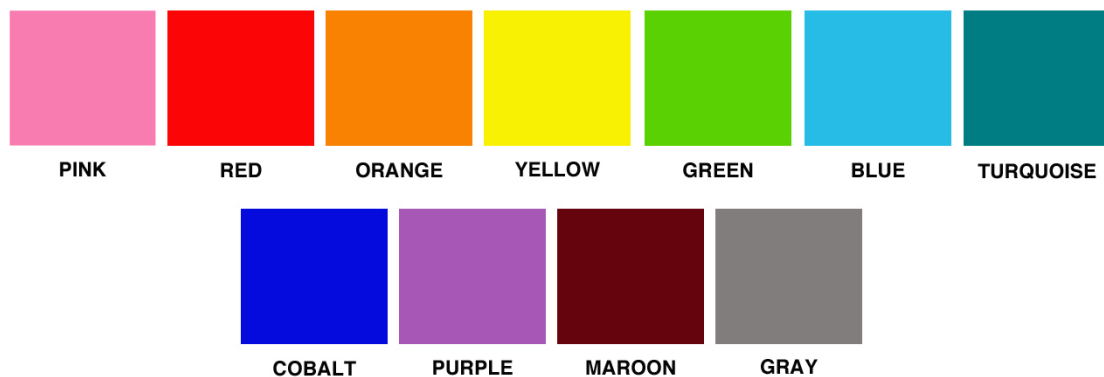


Figure 3.36: Colour palette of the tactile textiles  
Created by author

Daggett further elaborates that bright and intense colors can connect to our “primitive” brain, which is known as the limbic system. It will be through the use of bright and vibrant colours present in tactile toys to communicate the visual stimulation to the brains of the children in order to evoke the children’s visual sensory.

### **3.3.4 Textures of Tactile Toys**

The inspiration of the structural three-dimensional shape comes from simple geometrical shapes used in children's toys. Hence a range of child-like names is given to these different shapes that evokes the children imagination. There are seven styles of fabric formations, namely: 'pointy', 'shroomy', 'twirly', 'blossoms', 'ripples', 'pixels' and 'bubbles'. These moulds are tied and wrapped within the polyester organza then heat set with steam to form the textures. After which the moulds are removed, it will form the three-dimensional textured fabrics. These three-dimensional forms not only conjures the imagery of three-dimensional shapes but also intrigues and induces the children's sense of touch, these shapes, with the texture of the organza fabric, feel interesting to caress and massage over the children's skin.

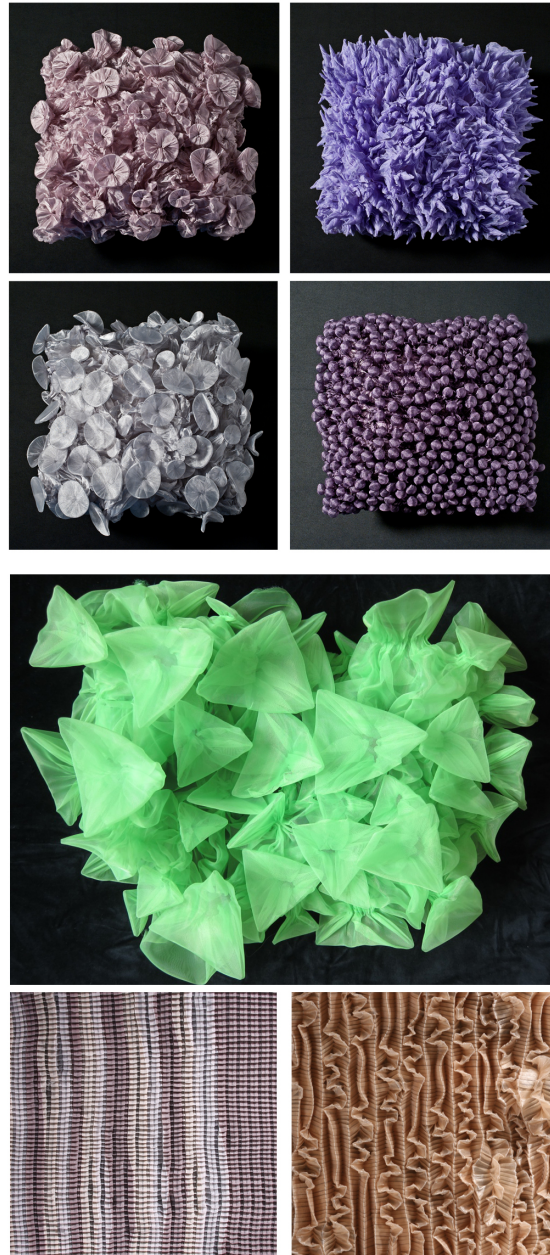


Figure 3.37: Textures of Tactile Toys : Blossom, Twirly, Shroomy, Bubbles, Pointy, Pixels and Ripples  
Images from author



### **3.3.5 Process of Tactile Textiles Creation**

Tactile Textiles are created by a physical binding method, adapted from the traditional ‘tie-and-dye’ or ‘shibori’ which comes from the verb ‘shiboru’, meaning ‘to wring, squeeze, press.’ In shibori, fabrics are tightly folded, stitched or tied and then coloured using dyes. The folded, stitched or tied areas acts as a physical resist, preventing dye colour from entering and hence creating unique patterning effects at the areas of the fabric resist. In binding and tying, parts of the fabric are tied up or bound. Small objects such as seeds, beans, marbles or coins can be used. The object is secured by tying elastic bands or strong thread around the object and the tying has to be tight so that the dye will not penetrate through the tied areas. Once tied, the fabric is dipped into the dye. The fabric will then be removed from the dye bath; washed, rinsed and hanged to dry before removing the elastic bands or thread. The pattern revealed is a soft blurred effect around the bound areas, which gives the ring-like characteristics of this technique. There will be raised textured effects as a result of the bound objects, however, if the fabrics used are natural fibres such as silk or cotton, the raised textures will not be permanent.



Figure 3.38: Binding of beans onto fabric to achieve the shibori effect  
 Images from : Shibori Design and Techniques Pg 28

The creation of Tactile Textiles is quite similar in terms of approach to that of the shibori technique. Fabrics are being ‘tied-and-heated’ instead of ‘tied-and-dyed’ to create unique three-dimensional structures, which can be permanent when synthetic fibres are used. When exposed to heat synthetic fibres will melt, but at the temperature just below the melting point, the fabrics can be heat set into a permanent structure. Applying shibori techniques such as tying, stitching, binding and folding to the synthetic fabrics and then putting the fabrics into an oven or a steamer heats up the fabric to just below its melting point. When fabrics are removed from the oven or steamer, it is allowed to cool and then the tying, stitching, binding or folding is removed to reveal the heat set three-dimensional permanent structures. These three-dimensional shapes will only be destroyed if it is being re-heated again to the temperature close to its melting point.

Tactile Textiles are mainly being created by tying and binding objects onto polyester fabrics. The fabrics used are polyester organza and polyester netting. Objects are used as ‘moulds’, which creates the three-dimensional structural forms in all the range of Tactile Textiles. For the style named ‘Bubbles’, the objects used as the mould are marbles to create the rounded, bubble like effect. Custom made objects such as wooden discs, cubes and prisms are made from the laser cutter using MDF (Medium-density fiberboard) wood and acrylic sheets. ‘Pointy’ are made from triangular shapes. ‘Shroomy’ are made from flat constructed round disc shapes. ‘Twirly’ is done by cone shaped structures using the stitching and binding technique of shibori. Fabrics are pinched upwards and stitched around to create an upward pointing cone shape and then bounded tightly by thread. The round disc with a hole in the middle produces the ‘Blossom’ shapes and finally both ‘pixels’ and ‘ripples’ are made from pleating.



Figure 3.39: Binding of marbles onto fabric and steaming to achieve the ‘bubbles’ effect  
Images from author

All these objects are securely tied by either using elastic bands or thick threads, the spacing between each of the objects are planned so that the outcome will be aesthetically pleasing. The fabrics, together with all these securely tied objects, are being put into an oven or steamer to heat for 30 minutes. When the time is up, the fabrics are removed from

the oven or steamer, and put aside for the fabric to cool. Once cooled down, the objects will be removed by cutting the elastic bands or threads away and what is being revealed will be the three-dimensional structures, which possess the shape of the objects. The next step in the making process will be to carefully plan out the prototyping of various Tactile Toys.

### **3.3.6 Developing Tactile Textiles to Tactile Toys**

With the completion of Tactile Textiles, the fabrics will be developed into Tactile Toys. As mentioned in the beginning of section 3.3, the design of Tactile Toys is equivalent to a system. The three components that makes up the system Tactile Toys are firstly, the three-dimensional structure of Tactile Textiles, secondly the existence of tactile therapy and thirdly the integration of Tactile Toys as tactile therapy into the Sensory Integration Approach for occupational therapists and parents to use as a sensory diet for the children. These three components put together the structure of Tactile Toys and hence determine how well Tactile Toys as a system, support the work of an occupational therapist and how beneficial Tactile Toys will be for children with tactile dysfunction. Elements that constitute to the design of Tactile are: the technique of heat setting, the type of materials, the choice of colours and finally the steps and technical processes to create the Tactile Textiles. Hence the design of Tactile Toys as a system has to be beneficial for children with tactile dysfunction to improve their ability to regulate, interpret and execute appropriate behavioral responses to touch sensations so that they are able to live their lives in a functional manner. Four variations of Tactile Toys are prototyped and the next section will explain the details the making of Tactile Balls, Tactile Touchables, Tactile

Runway and Tactile Wrap. Fig 3.40 below shows the system work model of the development of Tactile Toys.

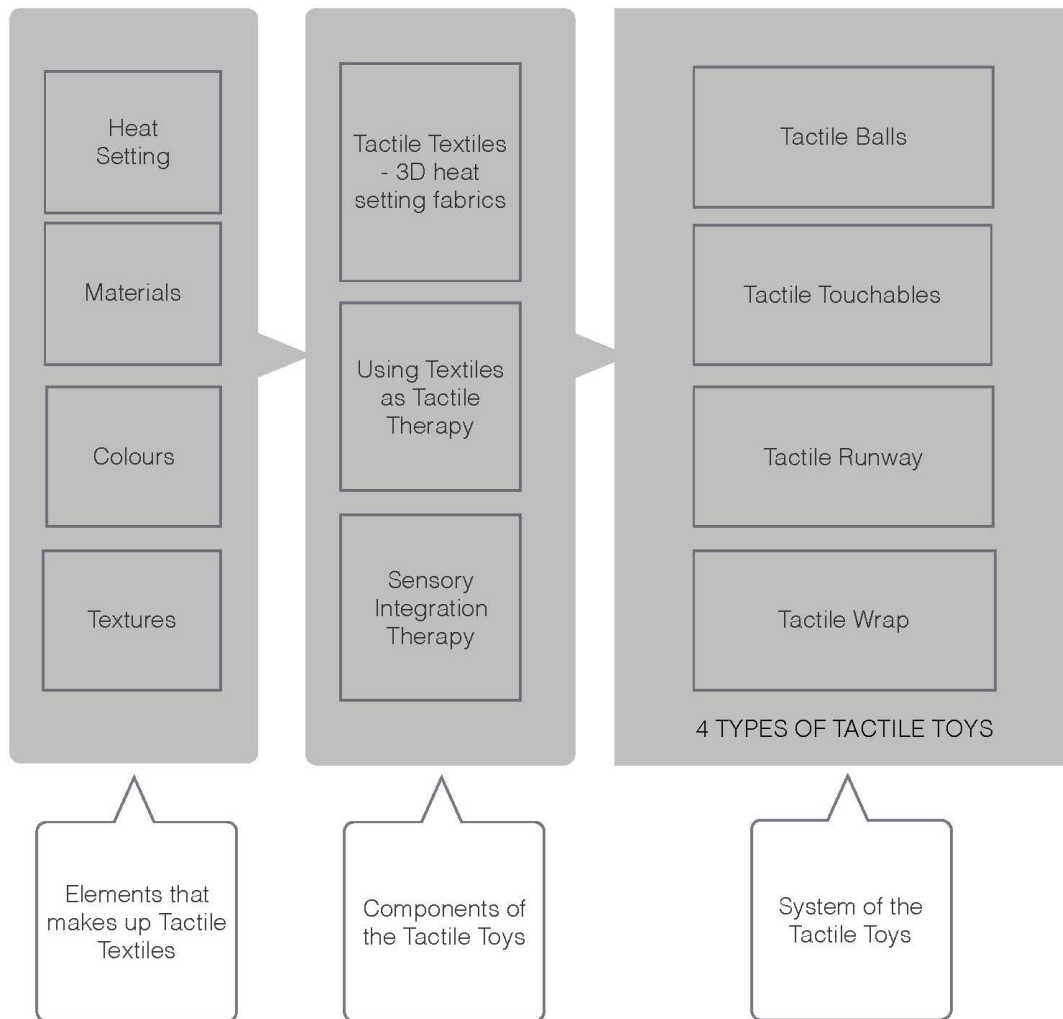


Figure 3.40: System work model of Tactile Toys – The development of Tactile Toys from Tactile Textiles  
Diagram created by author

### **3.4. Prototyping of Tactile Toys**

Tactile Toys can be used in an occupational therapy session, with the help of an occupational therapist who will incorporate these toys into a child's sensory diet. Through tactile therapy, children with tactile dysfunction can develop an understanding of tactile sensations using touch and hence allow them to overcome their tactile dysfunction. There are 4 effective types of toys created that will be incorporated into the sensory diets of their occupational therapy programme to help children with tactile over responsiveness, under responsiveness and sensory seeking. These are Tactile Touchables, Tactile Balls, Tactile Runway and Tactile Wrap. The purpose of designing these series of tactile toys is to help the child to identify and appreciate that different texture can be a joyful experience. These sensory touch toys and sensory teaching supplies can provide a variety of tactile sensations and opportunities for fun learning and exploration using touch.

### 3.4.1 Tactile Touchables



Figure 3.41: Individual pieces of Tactile Touchables  
Images from author

Scratchy, spiky, silky, smooth or soft? Children build tactile awareness and vocabulary skills as they interact with these Tactile Touchables in a variety of "hands-on" fun activities that allows them to understand matching, vocabulary, communication, and tactile discrimination skills. The use of different textures created from the different three-dimensional structures can also encourage interaction using gross motor skills. Tactile Touchables can also calm children who seek sensory inputs. They can feel instant sensory stimulation when they run their palms over these tactile three-dimensional surfaces.

### 3.4.2 Tactile Balls



Figure 3.42: Individual pieces of Tactile Balls  
Images from author

The moulded three-dimensional fabric is sewed on to the surface of the ball to form the complete tactile ball. Within the ball are cotton stuffing and a small bell, which jingles when ball is being touched. These tactile balls come in a variety of textures and bright colors for stimulating play. Tactile balls can invigorate the sense of touch, and allows the child to enjoy new sensations and keep their hands busy! Playing with tactile balls provides an excellent source of tactile input and sensory stimulation. As a therapeutic toy, tactile balls have the ability to stimulate and sooth. Other benefits include improvements in child's developmental focus, gross motor skills, hand eye coordination, socialization, and tactile sensory development.



### 3.4.3 Tactile Runway

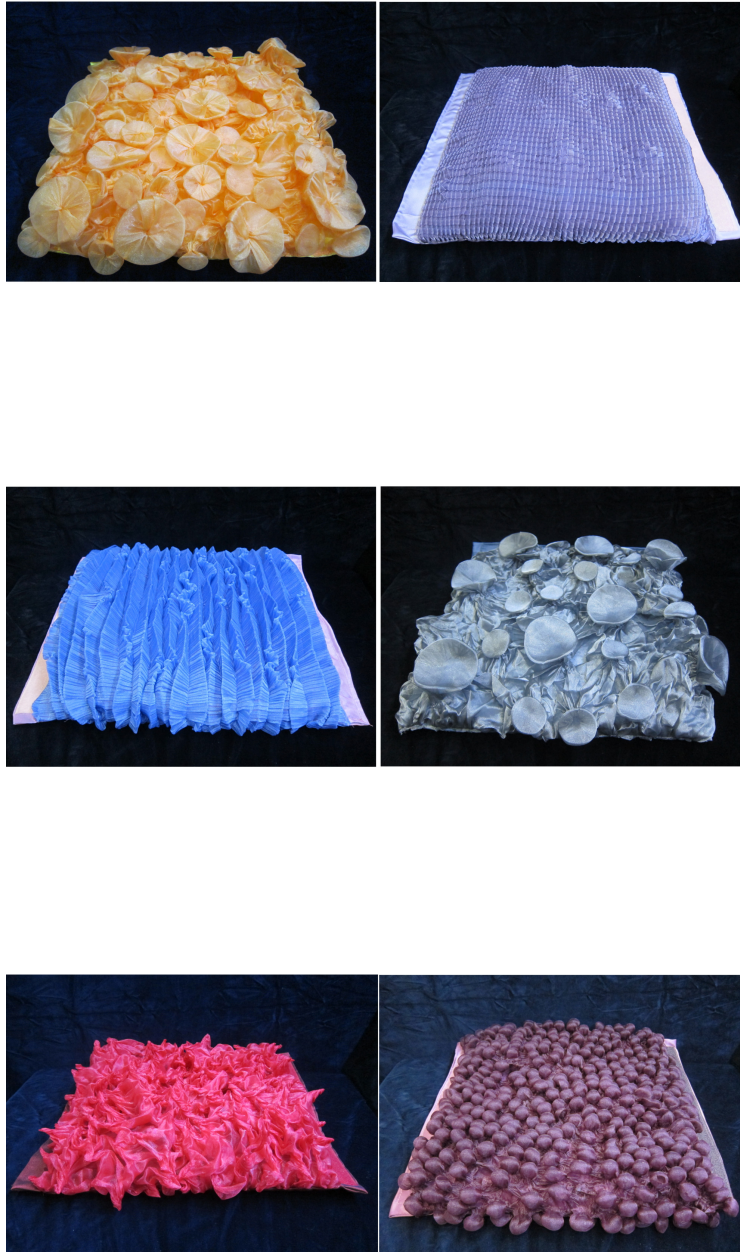


Figure 3.43: Individual pieces of the Tactile Runway  
Image from author

Different textile textures will be attached together to form a walkway with seven different types of textures. It has been known that some tactile defensive children dislike walking barefoot on textured surfaces such as grass, sand or rough carpet. This tactile runway, which has the different types of fabric textures, will encourage these children to try walking on them. The three-dimensional structures could elevate the interest and curiosity of the child while walking and enjoying the interactive play of the runway. Tactile runway can also enhance a child sense of balance and coordination. It can also assists with tactile defensiveness, discrimination, and perception. This tactile walkway provides foot reflexology and a wonderful foot massage all in one! A daily barefoot walk on this path will improve overall physical and mental well being in children seeking sensory input.

#### **3.4.4 Tactile Wrap**

Patchwork of different textures will join together to form this quilted blanket. Children with tactile and proprioceptive dysfunction crave for deep pressure input, which the tactile wrap will be able to provide. While tactile wrap can provide extra calming deep pressure input their bodies crave, their hands can also feel the different textures of the three-dimensional shapes giving extra tactile input. The use of weighted blankets is one of the most common therapeutic interventions in the Occupational Therapy. This is known as proprioceptive input as the weight of the blankets provides deep pressure to the muscles, joints, tendons and ligaments allows the central nervous system to better interpret and integrate both tactile and proprioceptive input. The use of tactile wrap will allow the child to improve on his body

awareness, to calm himself, to improve on his attention and focus as well as to decrease sensory seeking behaviours.



Figure 3.44: Individual patchwork pieces of Tactile Wrap before sewing them all together  
Image from author

### 3.4.5 Prototypes of Tactile Toys

Tactile Toys when being integrated into occupational therapy sessions can help children with tactile dysfunction to overcome their difficulties with touch and textures. Tactile Toys can eventually help these children to learn to interact normally within their surroundings.

All the four complete prototypes are Tactile Touchables, Tactile Balls, Tactile Runway and Tactile Wrap, which are shown in the following images below.



Figure 3.45: Tactile Touchables  
Image from author





Figure 3.46: Tactile Balls  
Image from author



Figure 3.47: Tactile Runway  
Image from author



Figure 3.48: Tactile Wrap  
Image from author

### **3.5. Integration of Tactile Toys into the Sensory Integration Approach**

Tactile Toys will be integrated as therapeutic products using the sensory integration approach. They can be beneficial to children who are tactile over-responsive, tactile under-responsive and sensory seeking. The therapist will be able add on these therapeutic products to their existing list of equipments and products as the design of Tactile Toys are different to the existing list. Tactile Toys can produce good tactile input. It can be utilized in creating tactile awareness and can also be combined in the activities of other sensory

inputs, for example tactile with visual, tactile with proprioceptive and tactile with vestibular. The following sections will demonstrate how Tactile Toys can be used alone and how they can be combined with other sensory inputs for maximum benefits for the child.

### **3.5.1 Tactile Touchables**

Tactile Touchables are designed as individual soft round disc each having a different three-dimensional fabric shape. There are a total of ten discs, five matching pairs of discs bearing the same textures and same colour. The therapist will take the child's hand and encourage the child to feel and stroke the surface of the textures. While the child is feeling the texture, use the opportunity to teach the names of the various textures. This interaction will provide tactile input to the child, allowing him to either calm himself if he is tactile over-responsive or perk himself up if he is tactile under-responsive; or giving the tactile seeking child the stimulation as he craves for the tactile input.



Figure 3.49: Child's hand touching Tactile Touchables  
Image from author

Alternatively, Tactile Touchables can be used as a brush on the hands of the child. This is to increase awareness of tactile input to the hands. The therapist can take the child's hand and brushes the three-dimensional textured surfaces of one disc with deep, firm pressure in one direction, then lifts the disc and starts back at the same spot. The main aim of brushing with the three-dimensional textures is to desensitize and increase tolerance for tactile input for over-responsive child or help alert the under-responsive child to textures with the long-term goal of increasing their participation in play and daily activities.





Figure 3.50: Brushing Tactile Touchables on Child's hand  
Image from author

Another option of using Tactile Touchables in tactile therapy can be to place each disc in a box or bag and ask the child to find the pointy one or the smooth one. This activity can improve tactile discrimination, which can only be attempted after the child is more comfortable with tactile inputs from these textures. If there are specific three dimensional textured discs that the child seems to prefer, the discs can be placed at home so that he can access and parents can encourage the child to feel or stroke the textures throughout the day.



Figure 3.51: Playing matching game using Tactile Touchables  
Image from author

Tactile Touchables can also be used as a matching game, which will work on both tactile and visual sense of the child. The therapist will be sitting opposite the child, and all the discs will be put randomly between the child and therapist. The therapist will pick one disc from the front and place it on her right. The child will need to pick the same disc and mirror the therapist. The therapist then picks up another disc from the front and puts it on her left, and again the child follows. The therapist will go on alternating between placing the disc on right and left, with three discs on her right and three discs on her left until all discs are arranged as if in a mirror so that they are directly opposite each other. The objectives of this game are to improve visual-spatial awareness, proprioception and motor planning of the child. When the child moves his hands from left to right, he is working on his ability to cross the body midline, which is a skill important for smooth movement. His body movements of picking and putting down the discs from right to left

can improve proprioception and body awareness. His ability to match the discs in pairs and tracking the therapist's motion can boost his visual motor skills and hand-eye coordination. Being able to organize his body to do what he needs to do enhances his motor planning skills. The ability to observe and respond to the therapist's motions can develop gestural communication.

### **3.5.2 Tactile Balls**

Tactile Balls can help children to focus while also engaging on their tactile sense. The set of six sensory balls are designed to enhance tactile stimulation. The three-dimensional textured surfaces across the ball are ideal for the tactile seeking child to discover tactile and textural stimulation. The child's sensory awareness can be increased by gently massaging the sensory ball in a rolling motion on a child's arms, hands, feet or back. The child is also encouraged to press and squeeze the balls, which will develop his finger strengths and provide deep touch pressure for the tactile system together with deep joint pressure for the proprioceptive system.



Figure 3.52: Rolling Tactile Balls on child's legs  
Image from author



Figure 3.53: Child pressing and squeezing Tactile Balls  
Image from author

Another alternate activity can be naming and guessing the Tactile Balls. The child is presented the balls and is encouraged to look and feel the different varieties of textures. The therapist can identify the balls and give specific names to the balls, based on the look and feel of the balls, for example, pointy or twirly. The balls can also be placed in a box and the child will put his hands in the box and without looking, he has to guess by its texture, whether it is a pointy or a twirly. The naming and identifying of the textured balls can promote visual discrimination, vocabulary knowledge and word retrieval. The guessing of tactile ball by feeling its texture strengthens tactile discrimination and visualization.

Other game plans for the Tactile Balls can be “Toss and Catch” or “Roll and Goal”. A child can play “Toss and Catch” on his own or play with a therapist or partner to practice tossing the Tactile balls back and forth. With this game, his gross and fine motor skills can be developed and his ability to catch and grasps the ball can improve his hand-eye coordination. “Roll and Goal” requires the child to roll the balls from a distance into a ‘goal post’ which can be made from a paper bag or cardboard box. Playing on his own, the child can either sit on the floor to roll the balls or lie tummy-down to roll the ball. A therapist or partner can also face opposite to roll the ball back and froth. Playing with a partner will stimulate a child’s interest in socialization, aids communication with others while incorporating the game as part of a sensory diet through sensory exploration and play therapy. The action of aiming, rolling and tossing will build up basic eye-movement skills of focusing and tracking, in conjunction with more complex hand-eye coordination and visual-spatial skills. Lying tummy down to roll the ball will enhance upper body strength and motor control. Overall, the use of Tactile Balls can create sensory stimulation, enhance gross motor and fine motor skills, develop socialization skills through play and help with visual tracking and perceptual skills.





Figure 3.54: Playing “Toss and Catch” with Tactile Balls  
Image from author



Figure 3.55: Playing “Roll and Goal” with Tactile Balls  
Image from author

### 3.5.3 Tactile Runway

Tactile runway is designed for the child to expose their bare feet to tactile input. There will be at total of seven different three-dimensional structural textile pieces that can be detachable. The therapist will encourage the child to take off his socks and to walk barefoot on the runway. A tactile seeking child who craves for tactile experience will be eager to step and stomp on the runway. A tactile over-responsive child who shuns tactile experience may refuse to remove their socks. A tactile under-responsive child may not even feel any sensations when walking on the runway. The therapist will need to think of different strategies and to creatively combine other sensory inputs to help each individual to overcome their dysfunction.



Figure 3.56: Child walking on Tactile Runway  
Image from author

The activity of walking on the runway will already give the children tactile awareness and discrimination through their feet. The therapist can add on other activities like putting small toys on the runway and request the child to pick these small toys with his hand and even toes which strengthens his visualization. Picking up small toys with the toes is a fun way to decrease over-responsivity in some children's feet. It will also exercise fine motor muscles in the toes. Next alternative will be to allow the child to crawled or rolled on the runway. Crawling enhances bilateral coordination and kinesthesia, rolling provides vestibular, kinesthetic and proprioceptive input. The pressing of the feet, hands and body on the textured runway can provide many touch experiences, which will promote tactile discrimination.

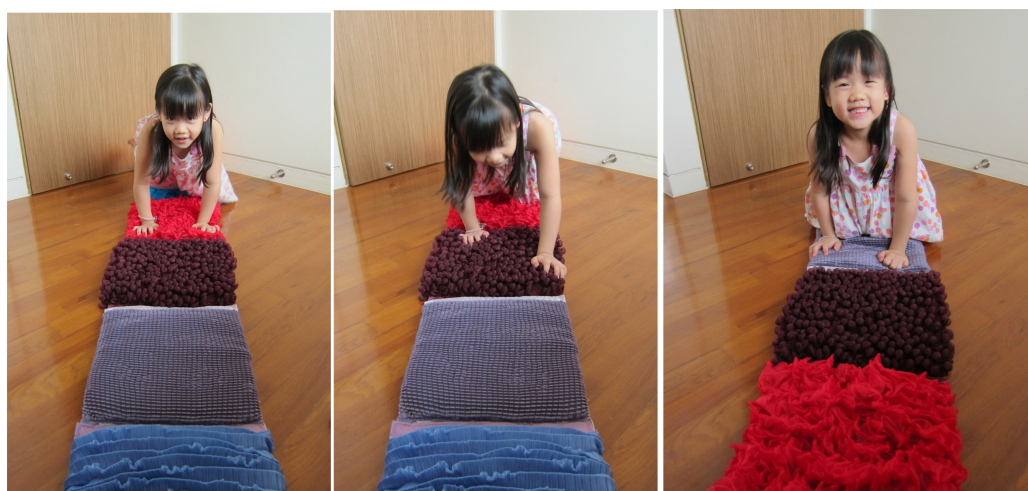


Figure 3.57: Child crawling on Tactile Runway  
Image from author

Tactile runway can also be detached to form individual “step upon” mats. These mats can be lay out on the floor, close together as a start and as the child gains confidence, move them apart to encourage stretching and jumping. The child can walk, leap or jump forward



and backwards or sideways from one mat to another. The child will be able to judge the distances between one mat and the next, which will raise his attention, oculomotor skills and visual-spatial discrimination; he will be able to watch where his feet are going which can improve visual skills such as eye-foot coordination and spatial awareness. The action of jumping or leaping to another mat can develop balance and movement, proprioception, kinesthesia and motor planning.



Figure 3.58: Using Tactile Runway as “Step Upon” mats  
Image from author

### 3.5.4 Tactile Wrap

Tactile wrap is a quilted blanket with different three-dimensional textile textures being joined together on the topside of the wrap. The bottom of the wrap is lined with soft cotton fleece, which will be very comfortable for the child to be covered in. The purpose of the Tactile Wrap is to give uniform, deep pressure, which can calm an over-sensitive nervous

system. When wrapped around the body of a child, Tactile Wrap can organize the tactile system, calm and regulate a child.



Figure 3.59: Child covered with Tactile Wrap  
Image from author

One fun activity will be the “burrito wrap” using Tactile Wrap. Tactile wrap should be placed flat on the floor and the child can lie on Tactile Wrap near one end. The child’s head should not be on the wrap. With consistent, firm pressure, roll the child up in the blanket. As he rolls, the therapist can rock him to and fro for a moment and finally he will be covered by layers of the material and rolled up as a “burrito”. Then when it is time to unroll, the child will roll in the opposite direction. The deep pressure from the floor and the compression from the blanket and the hands of the therapist together with the textured fabric can give the child a lot of good sensory information. It will provide excellent input to the child’s somatosensory system, the feeling of the textured fabrics promotes tactile discrimination and the rotary action of rolling organizes his vestibular system.



Figure 3.60: Playing “Burrito” with Tactile Wrap  
Image from author

Another similar activity with more emphasis on the vestibular system is the “Becoming a Butterfly” game. The starting of the game is exactly the same as the previous one only when the child is rolled to the end of the wrap, he is considered to be a “butterfly cocoon”. Then the therapist will cheer the child on to wriggle out of the “cocoon” to become a butterfly, and flap his wings and fly freely in the room. As above, being wrapped up in Tactile Wrap and rolling gives deep pressure and proprioception as well as vestibular input. The action of rolling, wrapping himself in Tactile wrap and breaking out of the cocoon all contribute to better tactile discrimination, body awareness, coordination, motor planning and kinesthesia.

### **3.5.5 Applications of Tactile Toys at Home and in School**

Tactile Toys can be used in the home environment. After the therapy sessions with the occupational therapist, parents will be provided with recommendations on what activities can be carried out by using Tactile Toys as tactile therapy at home. It is essential that the child use Tactile Toys within his daily routine at home or even in school. Home therapy will also be concentrating on play, together with parents and siblings to foster the child's relationship with family. Similar activities that the child has special preferences to and techniques to enable calmness or alertness used during occupational therapy sessions should be carried on at home. For example using Tactile Balls to provide deep pressure, brushing the hands with various types of textures using Tactile Touchables, or crawling and playing on the Tactile Runway. For maximum benefits, home therapy should be enjoyable and fit into the child's daily routine. The child's tactile dysfunction should get better through the daily sensory input. Both parent and child will feel more confident as the parent will be able to determine which toy or activity is more suitable for the child.

Tactile Toys can also be used in the school environment, some primary schools do allow small fidget toys such as stress balls and squeeze toys for children with sensory disorder to work on their sensory inputs during desk bound class time. Tactile Touchables or Tactile Balls can place on the desk of the child to provide tactile sensory inputs for the child, either to calm or alert the child so that he can stay on tasks during the class period. For the younger child who attends kindergarten, he will probably be seeking sensory inputs by walking around the class and not following the teacher's instructions. A single piece of Tactile Runway can be used as a mat for them to sit on during floor time and this can allow them to stay focus on an activity such as listening to the teacher during story time. Tactile

Wrap can also be used to provide deep pressure, which can calm and regulate the child so that he will have better attention spans in school. For the younger children, school teachers or special needs officers will generally have to be on constant lookout for the children to access their needs for sensory inputs. For the older ones, the goal is for them to perform sensory strategies on themselves after the special needs officers have gone through with them the use of sensory strategies and make the children aware of how and when to use the sensory products and also to explain why the products can help.

Using Tactile Toys in tactile therapy is fun. It is creative and intuitive, carefully planned but flexible enough to adjust to a child's moods and changing needs. It will make the child more comfortable with his body and more willing to try new things. With time, it may be able to effectively resolve some of the child's problems with tactile dysfunction. Other problems may always remain, but therapy will help the child find more acceptable ways to deal with them. As therapy progresses, improvements are likely to show, there will be a general increase in tactile tolerance and control. He will be more independent and able to cope better and this will definitely improve his abilities to participate and learn at school, home and in the community.

### **3.5.6 Testing the Effectiveness of Tactile Toys**

The next chapter will try to prove the effectiveness of the concept of Tactile Toys through testing out the four types of Tactile Toys during an occupational therapy session with children. Specific Tactile Toys will also be tested out in 'carryover' home activities as prescribed by the occupational therapist. Detailed descriptions of how the therapists

made use of the tactile Toys will be explained and the children's reactions to the Tactile Toys before therapy, during therapy and after therapy will be recorded down in notes. Tactile Toys will be used in therapy sessions for about three weeks and observations will be written down in both therapy sessions and home play sessions.

# **Chapter 4**

## **Proof of Concept**

Tactile Toys is a play and therapy system designed to help a special needs child to identify and appreciate different textures. When tactile toys are used, it can be a fun and joyful experience, as it will provide a variety of tactile sensations and opportunities for fun learning and exploration using touch. Tactile Toys are designed specifically for children with tactile dysfunction. These children may be tactile seeking, tactile over-responsive or tactile under-responsive. Tactile Toys can provide stimulation to the under-responsive child, tactile input for the seeking child, and desensitization for the over-responsive child.

The proof of concept here will be to test out the effectiveness of the Tactile Toys prototypes in a real life situation. There are four Tactile Toys prototypes: Tactile Touchables, Tactile Balls, Tactile Runway and Tactile Wrap. These four toys are brought to the two occupational therapy centers, for duration of three weeks. With the help of the occupational therapists, a child from each category of tactile dysfunction is selected for

the test. The following sections will describe the interaction and reaction of each child when presented with the prototypes developed. Specific Tactile Toys prototypes are also on loan to these children and are used by them at home and monitored by parents. Interviews are conducted with parents to gather feedbacks on the prototypes.

## **4.1. Testing of Tactile Toys for Users**

The four Tactile Toys, Tactile Touchables, Tactile Balls, Tactile Runway and Tactile Wrap are prototyped; user studies are conducted to proof the concept. This is needed to examine how effective tactile toys are for children with tactile dysfunction. The proof of concept will allow the development and refinement of the design. This method of the proof of concept is widely being used in specific projects within the healthcare, gaming and interaction design industries. The approach has enabled the design team to improve and develop their designs to enhance user experience and also lead to a more refined product that is relevant for the users.

Tactile Toys will follow this format of proof of concept to assess the strengths and weakness of Tactile Toys for the users. User study will be conducted to proof the concept and evaluate the effectiveness of tactile toys. There will be a three-step approach. The proof of concept approach will start with observation when the child enters the occupational therapy play-gym. Tactile toys will be presented to the child by the occupational therapist. The therapist will introduce Tactile Toys to the child and will incorporate the toys within their therapy. The reactions of the child and interactions with the toys will be written down as observational data. Observation data will be collected on the use of tactile toys



over a period of time to examine the improvement on the child's ability to accept different tactile sensations. Feedback will be gathered from occupational therapists on how effective Tactile Toys are to the children.

Secondly, the implementation of tactile toys into the sensory diet of the child at home with follow up interviews with parents. Face to face or phone interviews with the parent will be carried out. The results from the interviews will be drafted and feedbacks from the parents will be taken into considerations for the refinement of the designs. Both observation data and interview evaluation will ensure that tactile toys can provide and meet the needs of the each child with tactile dysfunction by eliciting feedback from therapists and parents.

Finally, by analyzing the effectiveness of tactile toys used in therapy sessions as well as at home and how has tactile toys helped to improve the child's tactile dysfunction. The proof of concept will ensure the viability of each type of tactile toys being woven into a sensory diet for three specific groups of children. The main aim is to test out the effectiveness of tactile toys and how tactile toys can help children with sensory processing disorder to overcome tactile dysfunctions. The results from the proof of concept will assess the practicability of tactile toys in a real life therapy situation. It will help in the development and improvement of the design and concept further so as to benefit this special needs community.

## 4.2. Evaluation of Tactile Toys from Occupational Therapist

In this section, observation session will be carried in the occupational therapy play-gym with the therapist and the child. A child within each category of sensory over responsiveness, under responsiveness and sensory seeking will be identified. Tactile toys will be given to the individual child and observations will be drawn on the reaction of the child when being first shown the tactile toys and also how the child interacts with the tactile toys with the help of the therapist. All these observations will be recorded before, during and after the therapy session with the occupational therapist. Feedback on how Tactile Toys are beneficial to these three children will also be gathered and occupational therapists will evaluate on the value and effectiveness of Tactile Toys.

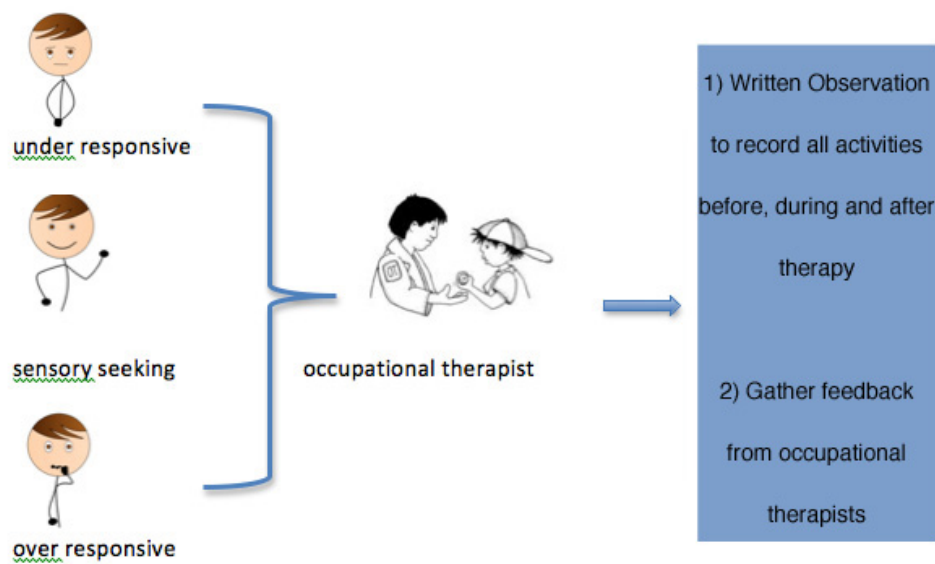


Figure 4.1: Observation and gather feedback from occupational therapists  
Diagram from author

## **4.2.1 Victoria Chen - the over-responsive child**

### **Observation Week 1**

Tactile Toys were brought to the occupational therapy centre and Gloria, the occupational therapist working with Victoria had tested out the toys during the therapy session. Gloria started the session with vestibular and proprioceptive activities with Victoria. When she had received enough of the vestibular and proprioceptive inputs then Gloria moved on to tactile inputs. Victoria was familiar with the tactile sensory wall, but on that day, Tactile Touchables replaced the tactile sensory wall. Gloria had already placed six of the Tactile Touchable discs on the table next to the usual tactile sensory wall. Before Victoria moved on to the table, Gloria told her in advance that she would be playing with some new toys.

When Victoria saw Tactile Touchables for the first time, her first reaction was to ask, “What’s that?” Gloria then put her own hands on the surface textures of Tactile Touchables and explained that those were new colourful toys, which one can touch and play with. Gloria was demonstrating to Victoria how she touched and stroked the three-dimensional surface structures of the Tactile Touchables. Victoria did not touch the toys immediately. Then Gloria asked Victoria which colour and shape she liked best. Victoria answered, “Red bubbles!” Victoria is referring to the ‘bubbles’ shaped Tactile Touchable disc. Gloria asked again, “Do you want to touch the red bubbles?” Victoria held up her little finger and cautiously touched the tip of red bubble. Gloria demonstrated again slowly with her full palm touching the three-dimensional surface. Victoria then followed slowly too, spreading out her full palm and touching the ‘bubble’ Tactile Touchable. Gloria asked again, “Does it

feel smooth or rough? Do you like the feel? Victoria shook her head and said, “tickerish!” Victoria did not seem very eager to touch the rest of the Tactile Touchables. Gloria had to prompt her again, “Which other shape and colour do you like?” Victoria pointed to the ‘blossom’ shape and said “Purple flowers!” She could bring her fingers to touch the ‘blossom’ shaped Tactile Touchables and then she said “rough!”

Gloria then demonstrated touching the rest of the Tactile Touchables, and asked Victoria if she liked the other shapes, Victoria shook her head. Victoria is clearly not keen to play with Tactile Touchables, as she was not familiar with the new toys and the shapes and textures could be too overwhelming to her. Gloria did not force her, and Gloria decided not to continue with the testing of Tactile Runway, which was planned to replace the rubbery tactile mat for Victoria to walk on as she felt that Victoria will not be able to accept the sensation on her feet as she was not as receptive with using her hands to touch the Tactile Touchables. Gloria will continue with the use of the Tactile Toys the next week.

### **Observation Week 2**

The second observation day was one week after the first observation. This time round, Gloria deliberately placed the Tactile Runway together next to the crash pad where Victoria was familiar. Gloria also added some soft toys onto Tactile Runway. Tactile Touchables was stuck next to the tactile sensory wall. Victoria came into the play gym and started with the usual vestibular and proprioceptive activities with Gloria. As Victoria is doing her regular swinging and crashing onto the crash pad, she seemed to be fully aware of the new Tactile Runway that was placed next to the crash pad and she asked Gloria why there were toys on the Tactile Runway. Gloria replied her, saying that the runway will be the fun new game that she will get to play next. Victoria did not show

any hesitation, she continued swinging on the bolster swing and crashing onto the crash pad. Once the activity is completed, Gloria then explained eagerly to Victoria the next activity that involves Tactile Runway. Some of Victoria's favourite toys are on the Tactile Runway, Victoria's task was to step on the Runway to pick up the toys. It was an easy task for Victoria and she did it without any hesitation. Gloria was happy that Victoria did not resist to step on the Tactile Runway to pick up the toys.

She continued on with the Tactile Touchables, which was on the wall together with the existing tactile sensory wall. Victoria brushes her hand through the tactile sensory wall and moved on Tactile Touchables without any reluctance! She willingly touched the surface textures of the Tactile Touchables and giggled to herself saying that they felt ticklish. Gloria was very encouraged with the outcomes of Victoria. She had demonstrated that she became more receptive to new touch sensations. Gloria will continue with the use of the Tactile Toys for one more week.

### **Observation Week 3**

The third observation day was a week later. Victoria came into the playgym and started off with proprioceptive activities on the trampoline. Again, Tactile Runway was deliberately placed next to the trampoline. After the exercises on the trampoline and before Gloria even spoke of the next activity, Victoria pointed to Tactile Runway and expressed that she wanted to play on the runway! Gloria already had plans for activities on the Tactile Runway. The first activity was to walk on the runway, and to pick up bean bags that was scattered on the runway, then to hop like a rabbit on the runway and pick up the toy carrots and finally to crawl on the runway like a cat and pick up toy fishes. Victoria completed the activity without any hiccups and was enjoying herself.

The next activity involves Tactile Touchables as a matching game, Gloria sat opposite Victoria, and all the discs were put randomly between the two of them. Gloria picked up one disc from the front and placed it on her right. Then Victoria picked the matching disc and mirrored Gloria. Gloria then picked up another disc from the front and put it on her left, and again Victoria followed. Gloria went on alternating between placing the disc on right and left, with three discs on her right and three discs on her left until all discs were arranged as if in a mirror so that they were directly opposite each other. Victoria is able to complete the task and has no trouble with touching of the Tactile Touchables. Gloria was very happy with her progress.

### **Evaluation**

The table below shows the reaction of Victoria performing various activities on Tactile Toys with therapist Gloria in the play gym.

	Week 1	Week 2	Week 3
<b>Tactile Touchables</b>	Did not touch the toys immediately, needs to be prompted and asked for favourite colour and shape.  Only touched two shapes: bubbles and blossoms	Put side by side with tactile sensory wall, brushed hand through the familiar items on tactile sensory wall and then moved on Tactile Touchables.	Played matching game. To mirror the placement of Tactile Touchables led by therapist.
<b>Tactile Runway</b>	Therapist did not test as child showed resistance to Tactile Touchables.	Stepped on runway to pick up toys on the runway.	Walked on the runway and picked up beanbags.  Hopped on the runway and picked up toys.  Crawled on the runway and picked up toys.

Table 4.1: Victoria's interaction with Tactile Touchables and Runway in the occupational therapy play gym  
Table from author

It is important to note that occupational therapist, Gloria had to start with the usual proprioceptive and vestibular activities before introducing Tactile Toys during every therapy session. In sensory integration therapy, proprioception is regularly used to lessen overstimulation to touch system. A tactile over-responsive child can restore balance by jumping or throwing herself at something soft. Hence, when Victoria jumps on the trampoline or crash into the crash pad, the vestibular systems can reduce tactile

over-responsivity. However, during week one, Victoria did not show much interest on the Tactile Toys. Familiarity is also an important factor for children with sensory over-responsivity. If a child is being shown a new toy for the first time, she is not used to the new item and will not be proactive to play with unless being prompted or being shown how to play with the new toy. She is usually cautious of what to touch, as she may feel uncomfortable touching a new toy.

During the second week, the Tactile Toys were being placed deliberately next to the usual equipments within the play gym and that reinforced the existence of such toys and made her more aware that these toys are part of the usual equipments within the play gym. Hence, Victoria was able to step onto the Tactile Runway without any resistance. She was able to feel the Tactile Touchables after touching the other familiar items on the tactile sensory wall, which reinforced the factor of familiarity. Although Victoria resisted touching the Tactile Touchables initially, the tactile sensory wall had helped her to slowly begin to tolerate tactile input. The textures on the tactile sensory wall were all different and provided some heavy work to her hands when she touched and pressed on them, which helped to calm and organize her sensory system. The introduction of Tactile Touchables increased Victoria's repertoire of tactile input activities.

On the third week, she had made further progress by playing games on the Tactile Toys. Tactile Toys allowed her to practice the feel and touch of different types of textures so that she will become more comfortable in feeling the different textures over time. As long as the child has been exposed to a variety of touch sensations, the uncomfortable feel that she has initially will gradually go away. This will be the strategy of desensitization, which is a



gradual process whereby the child is introduced to a variety of textures and materials and over time, she will learn to accept the tactile sensation.

On the whole, Gloria felt that Tactile Touchables and Tactile Runway served the purpose of as a Tactile Toy that can help children like Victoria to improve on tactile discrimination. These Tactile Toys worked well when they were being used in a constructive game context. Combining Tactile Toys with other sensory activities that can help with the other senses of the body such as visual, proprioceptive or vestibular and using Tactile Toys to enhance fine or gross motor skills of the child would be advantageous. For example, when Tactile Touchables were being used as a matching game, it would improve visual-spatial awareness, proprioception and motor planning of the child. When the child moved her hands from left to right, she would be working on her ability to cross the body midline, which was a skill important for smooth movement. Her body movements of picking and putting down the discs from right to left could improve proprioception and body awareness. Her ability to match the discs in pairs and tracking the therapist's motion could boost her visual motor skills and hand-eye coordination. Being able to organize her body to do what she needed to do would enhance her motor planning skills. The ability to observe and respond to the therapist's motions could develop gestural communication. In this way, the therapy would be effective, entertaining and stimulating for the child.

#### **4.2.2 Observation on Jason Wong - the under-responsive child**

##### **Observation Week 1**

Occupational therapist, Charmaine prepared the Tactile Toys before Jason came in for therapy. She put the Tactile Balls into a basket, which usually contained beanbags, placed the Tactile Runway on the floor where she usually laid the different types of textured fabrics and materials such as fake fur, chenille carpet, and raffia mat and she combined these three pieces of fabric swatches with the Tactile Runway to form a single line. When the set-up was done, Jason came into play gym. He greeted Charmaine meekly even though Charmaine was full of enthusiasm and greeted him invitingly. Charmaine started working on proprioception and vestibular inputs to wake up his under-responsive systems. She patted on the bolster swing, signalling Jason to climb up the bolster swing and started swinging him. After 5 minutes of swinging, Charmaine showed Jason the Tactile Balls and explained to him that he will be playing with a new toy. When Charmaine handed out one Tactile Ball to Jason, he received it and hold it with his hands willingly. Then Charmaine put the basket of balls in front of him and he started picking them up one by one without any hesitation. He then asked Charmaine how to play with the balls. Charmaine described to him that he could throw and toss them just like any other balls and the next activity he would need to throw the balls into the basket while swinging on the bolster swing. Jason completed the activity, just like how he used to throw the beanbags and he was fine with the Tactile Balls and did not fuss over the new toy. After this activity, Charmaine moved on to other ‘heavy work’ activities, which provided proprioceptive inputs to Jason.

Next, he was introduced to Tactile Runway. The runway was placed between fake fur, chenille carpet, and raffia mat. With Charmaine’s instructions, Jason stepped onto the first material and then walked on the runway without any hesitance. As for the second round, Jason had to jump from one material onto the other. The third round, he got to hop from one material onto the other. He completed all the tasks requested by Charmiane without

showing any resistance. Charmaine continued with therapy working on his other sensory inputs and will test out Tactile Wrap in the next session.

## **Observation Week 2**

Charmaine decided to test out Tactile Runway and Tactile Wrap during the therapy session. She set up the runway like the week before, putting it between other tactile swatches. Then she placed the Tactile Wrap next to the comforter where Jason usually played 'Burrito Roll'. When Jason came in to the play gym, Charmaine again started him with proprioception and vestibular inputs to wake up his under-responsive systems. He sat on the tire swing and then crashes into the ball pit. After several more vigorous exercises, which gave him the proprioception and vestibular inputs, Charmaine then moved him on to the Tactile Runway. With Charmaine's instructions, Jason stepped onto the first material and then the runway and completed the walk. The second round, Jason had to jump from one material onto the runway and the third round, he got down on the floor and crawled over the materials and for the fourth round, he rolled over the materials. Again, he completed the tasks with obedience and did not complain at all.

Charmaine continued with the next activity using the Tactile Wrap. Using similar strategy as the 'Burrito Roll'. She lined up the Tactile Wrap on the floor and got Jason to lie down on the textured side of the Tactile Wrap, with his head above the wrap. Jason seemed all right with this initially, but when Charmaine started to roll him gently and tightly in the wrap, he started resisting and wriggled out of the wrap. Charmaine did not force him, she then asked him how he felt and he commented that the wrap was too rough he preferred the comforter. Charmaine carried on with the 'Burrito Roll' activity using

the usual comforter. Charmaine would try to test the Tactile Wrap in a different way the next week.

### **Observation Week 3**

Charmaine had an idea of working with the Tactile Wrap, instead of letting Jason laid down on the textured side, she would made him lay down on the smooth side. Charmaine started off with the usual proprioception and vestibular activities and finally when it came to ‘Burrito Roll’ time, she tried out the new strategy. Charmaine did something different for Jason; Jason laid on the smooth side of the wrap instead of the textured side. Usually his whole body would be wrapped up in the comforter but during that day, the wrap was up to the armpit level and his hands were outside the wrap. Charmaine instructed Jason to feel the textures with his hands and rubbed his hands all around the textured wrap. That worked brilliantly and Jason enjoyed the activity like previous weeks. Charmaine was happy that Jason could follow her instructions without wiggling out of the wrap like the last week.

### **Evaluation**

The table below shows the reaction of Jason performing various activities on Tactile Toys with therapist Charmaine in the play gym.

	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>
<b>Tactile Balls</b>	Hold the balls when given, touched all the balls in the basket.  Played tossing the balls into the basket on the bolster swing.	Did not test	Did not test
<b>Tactile Runway</b>	Stepped, jumped and hopped onto the normal tactile 'step-upons' and Tactile Runway.	Stepped, jumped, crawled and rolled over the normal tactile 'step-upons' and Tactile Runway.	Did not test
<b>Tactile Wrap</b>	Did not test	Use Tactile Wrap as 'Burrito Roll' and wriggled out of the wrap.  Commented that textures on wrap are too rough.	Use Tactile Wrap as 'Burrito Roll' and wrapped up to the armpit level with hands outside the wrap.  Hands were feeling the textures on the wrap.

Table 4.2: Jason's interaction with Tactile Balls, Runway and Wrap in the occupational therapy play gym  
Table from author

Again in this case, the occupational therapist Charmaine had to start with the usual proprioceptive and vestibular activities before introducing Tactile Toys during every therapy session. For an under-responsive child, proprioceptive and vestibular inputs are required to wake up his under-responsive systems. They need very strong vestibular input

and deep pressure activities to help them organize or alert their sensory systems. The playing and tossing of Tactile Balls together with the swinging action can alert both Jason's tactile and vestibular inputs. The textures on the Tactile Balls can alert his tactile system and allows the skin to gather information through touch. As compared to Victoria, the over-responsive child who had some resistance to the Tactile Touchables, Jason is a lot more receptive as his tactile system is under-responsive and he does not feel pain or hurt when he touches the surface textures of the Tactile Balls. The Tactile Balls are to stimulate his tactile senses to make him respond better to the sense of touch, increases his tactile awareness and discrimination rather than being oblivious to touch sensations.

Jason could also handle the sensation on Tactile Runway when he pressed his feet against the differently textured runway. In comparison with Victoria, who needed the toys to be spread on the runway in order to entice her to step on the runway; Jason willingly walked, jumped and hopped on the runway. His tactile systems were less responsive, unbothered by textures of any surfaces. He needed the various tactile inputs to develop his tactile awareness and discrimination. The movement from one material onto the runway can also improve his skills of balancing and movement, kinesthesia and motor planning.

During the second week, Jason could crawl and roll on the Tactile Runway without hesitation as compared to Victoria. As Jason needed sensory messages of great intensity or duration to become aware of them, the contact of the textures on Tactile Runway can provide the tactile stimulation he needed. Furthermore, the rolling movement provides both proprioception and vestibular inputs, which would help him to adequately register vestibular, tactile and proprioceptive inputs to 'wake up' his sensory systems and to keep

him alert for his daily activities. When Charmaine tested the Tactile Wrap as a ‘Burrito Roll’ on Jason, she was pleased that Jason resisted and wiggled out of the wrap. He could feel the discomfort of the textures rubbing against his body and requested for the usual comforter to be used instead. Charmaine explained that after the various sensory activities that were done during the therapy session, his tactile sense had increased its sensitivity and hence he could discriminate between roughness and discomfort.

On the third week, when Charmaine used the smooth side of Tactile Wrap for the ‘Burrito Roll’ activity, Jason did not resist. As his body was being wrapped up on the smooth side of the wrap, he felt more comfortable and his hand were also out of the wrap, allowing him to be more comfortable and free to feel the textures on the wrap rather than being enfolded within the wrap. In this way, his body could still receive the deep pressure from the snugly wrapped Tactile Wrap and his hands could receive the tactile stimulation he needed from feeling and rubbing on the textured surfaces of the wrap.

Overall, Charmaine, occupational therapist for Jason; thought that Tactile Toys could provide tactile stimulation for a tactile under-responsive child like Jason. As he had to receive more sensory messages in order to wake up his under responsive systems, Charmaine needed to provide frequent, varied and extended opportunities for tactile stimulation, together with deep pressure and vestibular input to alert his sensory systems. Hence, Tactile Toys will need to be combined with the other existing therapy equipments within the play gym to provide maximum benefits for the child. The vivid colours of the Tactile Toys could stimulate his visual sense, the three dimensional textural structures provided him with fresh sensations and tactile stimulation. With lots of movement

involving proprioceptive and vestibular inputs, it would enable him to increase his alertness in his daily lives and be able to perform his daily tasks normally.

### **4.2.3 Observation on Aaron Low - the sensory seeking child**

#### **Observation Week 1**

Kiayan, Aaron's occupational therapist decided to prepare Tactile Touchables and Tactile Balls for Aaron's session on the observation day. During the preparation, Kiayan placed the Tactile Balls into the ball pit and mixed up the plastic balls with the Tactile Balls. Some of the Tactile Balls were also submerged in the ball pit. On the table where Aaron usually practised his fine motor skills, Kiayan laid out the Tactile Touchables. When Aaron came into the play gym, he was thrilled as before, and quickly moved on the tire swing, as Kiayan was standing and signalling to him to climb onto it. Kiayan explained to him that he will be playing with a new toy and the activity was to find all the Tactile Balls in the ball pit. She showed him one Tactile Ball and made him feel and hold the ball and then submerged the ball into the ball pit. He started swinging with Kiayan's help and on the count of three swings; he plunged into the ball pit and started looking for the Tactile Balls. He picked up one Tactile Ball and climbed out of the ball pit and placed the ball into a laundry basket. He alternates between the tire swing and lycra swing, plunges into the ball pit and picked up all the Tactile Balls. He completed the activity with a big smile as Kiayan praised him for a job well done.

Next Kiayan moved on to the Tactile Touchables, she brought Aaron to the table with the Tactile Touchables and before she could start explaining, Aaron already rubbed his



hands on the Tactile Touchables. He was smiling as he moved his hands on the touchables and appeared to be enjoying the sensations of the textures. Kiayan planned a game of identification of shapes of textures with Aaron, while Aaron was feeling the texture of each touchable, Kiayan made him describe the textures and the shapes of each touchable. The five basic shapes were : ‘pointy’, ‘shroomy’, ‘twirly’, ‘dicey’ and ‘bubbles’. Then Kiayan moved on to a matching game. She sat opposite Aaron and all the discs were put randomly between them. She then picked one disc from the front and placed it on her right. Aaron picked the same disc and mirrored Kiayan. Kiayan then picked up another disc from the front and puts it on her left, and again Aaron followed. Kiayan went on alternating between placing the disc on right and left, with three discs on her right and three discs on her left until all discs are arranged as if in a mirror so that they are directly opposite each other. Aaron completed the activity flawlessly, and his hands were still rubbing against the touchable even when the activity ended. Kiayan proceeded to work on other activities with Aaron and would be testing out the Tactile Wrap the next week.

### **Observation Week 2**

Kiayan prepared Tactile Balls and Tactile Wrap for testing during observation week 2. She incorporated the vestibular activity with Tactile Balls in the game “Toss and Catch”; Aaron had to lie flat on his tummy on the one plane swing and Kiayan will toss the ball to Aaron for him to catch when the swing approached Kiayan. When he completed this, he continued with the game “Toss and Goal” and had to stand up on the swing. He had to toss the balls one at a time into a ‘goal post’, which is a laundry basket at a distance away. Aaron missed a few balls but he was still enjoying the game. Kiayan moved on to other activities involving more of proprioceptive and heavy muscle work activities. Towards

the last 15 minutes of the session, Kiayan made Aaron work on his fine motor skills. He needed to colour a picture, and he was not excited about it. Kiayan placed the Tactile Wrap over his laps. She also made him sit on a large therapy ball, and placed her hands on his shoulders and bounced him lightly up and down on the ball. Aaron was able to finish his colouring task independently but he was definitely not as enthusiastic as compared to the other more physical play activities.

### **Observation Week 3**

On the third week of observation, Kiayan had prepared different activities for the Tactile Wrap and Tactile Touchables. Following the usual proprioceptive and vestibular activities, Kiayan decided to test out Tactile Wrap in a heavy muscle work activity. Placing the wrap on the floor, Aaron lie on the wrap at one end with his head above the wrap. Kiayan then rolled him up like a butterfly cocoon. Then she cheered Aaron on to wriggle out of the “cocoon” to become a butterfly, and flapped his wings and flew freely in the room. Aaron thoroughly enjoyed this activity, he repeated “Again! Again!” and Kiayan obliged him and did the game another round.

### **Evaluation**

The table below shows the reaction of Aaron performing various activities on Tactile Toys with therapist Kiayan in the play gym.

	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>
<b>Tactile Balls</b>	Played “Find the Ball”, pick up all the Tactile Balls from the ball pit filled with other plastic balls.	Played “Toss and Catch” and “Toss and Goal”. Did not test.	Did not test
<b>Tactile Touchables</b>	Identifying shapes and textures of Tactile Touchables and played matching game.	Did not test.	Did not test.
<b>Tactile Wrap</b>	Did not test	Put wrap over shoulders for calming during colouring.	Played “Becoming a Butterfly”.

Table 4.3: Aaron’s interaction with Tactile Balls, Touchables and Wrap in the occupational therapy play gym  
Table from author

During the first week, occupational therapist Kiayan integrated the Tactile Balls into Aaron’s proprioceptive and vestibular activities. The aim was to create an organized movement experiences for Aaron that was goal-directed and purposeful. A child like Aaron who is constantly craving for movement needs to work on specific objectives like this planned by Kiayan. When he is working on a specific goal, he is likely to become less aroused and more organized. In the obstacle course, Kiayan had included interrupted vestibular input, which was the lycra and tire swing together with proprioceptive inputs, which was the crashing and crawling out of the ball pit. These activities allowed Aaron to

improve motor planning skills, exercise kinesthetic muscle sense and sharpen problem-solving skills.

The next activity involving Tactile Touchables allowed Aaron to build tactile awareness and vocabulary skills as he interacted with these Tactile Touchables. While he was feeling the texture, Kiayan used the opportunity to teach the names of the various textures. Aaron had no problems interacting with the two Tactile Toys during the first week. Being sensory seeking, the textures of the Tactile Toys can calm Aaron. Aaron would be able to feel instant sensory stimulation when he ran his palms over these tactile three-dimensional surfaces.

On the second week, Kiayan again integrated proprioceptive and vestibular activities together with Tactile Balls. She played “Toss and Catch” and “Toss and Goal” with Aaron while he was swinging on the platform swing. With this game, his gross and fine motor skills can be developed and his ability to catch and grasps the ball can improve his hand-eye coordination. The action of aiming and tossing will build up basic eye-movement skills of focusing and tracking, in conjunction with more complex hand-eye coordination and visual-spatial skills. Overall, the use of Tactile Balls can create sensory stimulation, enhance gross motor and fine motor skills, develop socialization skills through play and help with visual tracking and perceptual skills.

The next activity, targeting Aaron’s fine motor skills, was colouring a picture. He was not excited about it, as he usually did not enjoy desk-based activities. Kiayan’s strategy was to sit him down on a large therapy ball and put the Tactile Wrap over his shoulders. By placing her hands on his shoulders and bouncing him up and down the ball with the wrap over his shoulders provided deep pressure and helped to alert Aaron’s system to follow

directions and engage in the task. With these appropriate inputs, Aaron was able to finish the colouring task independently. Kiayan also shared that the Tactile Wrap could also be placed on his laps, which will also provide him with the deep pressure input to calm him down to complete his tasks.

During the third week, Kiayan continued using the Tactile Wrap in a different activity. As the purpose of the Tactile Wrap is to give uniform and deep pressure to calm the central nervous system, when being wrapped around the body of a child, Tactile Wrap can organize the tactile system, calm and regulate a child. The activity, which involved Aaron being wrapped up as a butterfly cocoon by the Tactile Wrap and then breaking himself free by wiggling out of the wrap to become a butterfly, provided proprioceptive inputs for Aaron. The deep pressure from the floor and the compression from the blanket and the hands of Kiayan together with the textured fabric gave Aaron a lot of good sensory information. It provided excellent input to the Aaron's somatosensory system, the feeling of the textured fabrics promotes tactile discrimination and the rotary action of rolling organizes his vestibular system. The action of rolling, wrapping himself in Tactile wrap and breaking out of the cocoon all contribute to better tactile discrimination, body awareness, coordination, motor planning and kinesthesia.

Generally, Kiayan felt that Tactile Toys could provide tactile stimulation to satisfy Aaron's tactile cravings. Tactile Toys can be incorporated into his daily living environment so that Aaron can use these toys routinely which provides him with tactile stimulation. As Aaron needs access to fidget toys and tactilely diverse materials, Tactile Balls and Tactile Touchables can help him to satisfy his cravings for touch stimuli. When he is over-aroused, the Tactile Wrap can serve to calm him down together with deep

pressure provided by his caregivers. Tactile Toys can be used to support appropriate behaviour, increase his attention and organization skills and prevent overstimulation. Within the occupational therapy environment, Tactile Toys works well when combined with the other existing therapy equipments and planned play activities. The toys together with the other existing therapy equipments and planned play activities will provide the sensory craving child the appropriate proprioceptive, vestibular and tactile input to modulate Aaron's sensory system. In this way, he will be able to engage in fine or gross motor activities in school and will be more prepared to learn and focus as well as to keep him organized.

### **4.3. Evaluation of Tactile Toys from Parents**

Next, the implementation of tactile toys into the sensory diet of the child at home with follow up interviews with parents. The purpose here will be to gather data through conducting interviews with parents on how the child play and interact with tactile toys at home and whether there will be a difference with how tactile toys are being used during the occupational therapy sessions. This approach will look into the possibilities of integrating tactile toys into the sensory diet of the child at home and the effectiveness of tactile toys leading to the improvements of child's tactile dysfunctions. The occupational therapists had given instructions to parents on the usage of Tactile Toys at home. Parents will need to observe how their child interacts with Tactile Toys at home and to give feedbacks on how the Tactile Toys have helped their child in one way or another.

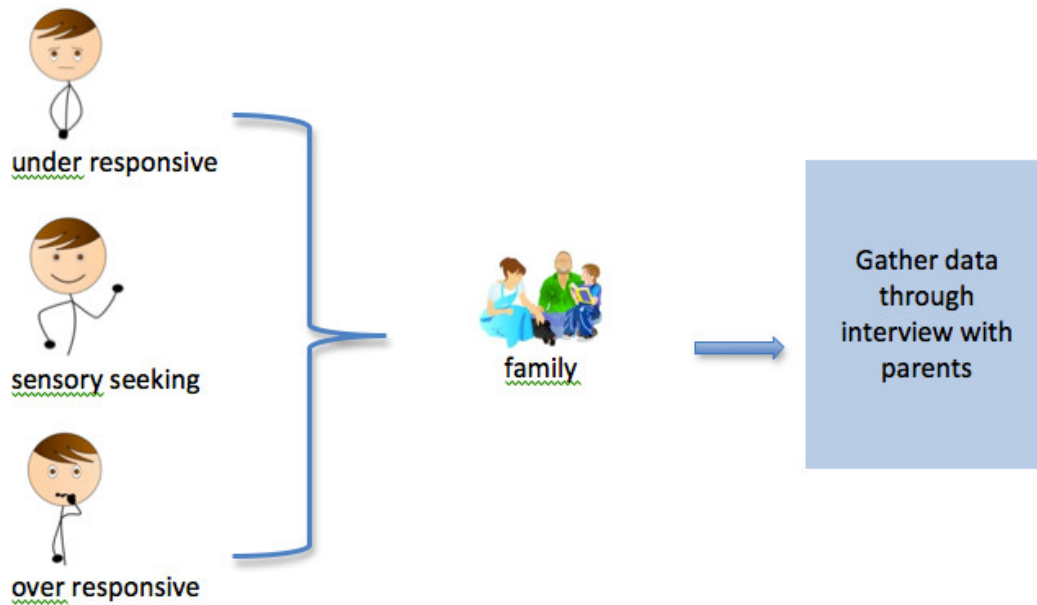


Figure 4.2: Interview parents and gather data from parents  
Diagram from author

### 4.3.1 Victoria Chen - the over-responsive child

During the parents briefing, Gloria advised Mrs Chen to bring home the Tactile Touchables. They are to be used as a brush on the hands and arms of Victoria daily. This is to increase awareness of tactile input to the hands. Mrs Chen can brush the three-dimensional textured surfaces of one disc with deep, firm pressure in one direction, starting from the hands to the arms and then lifts the disc and starts back at the same spot. The main aim of brushing with the three-dimensional textures is to desensitize and increase tolerance for tactile input for an over-responsive child. Mrs Chen can also incorporate Tactile Touchables into games, like the matching game done during the therapy session or a shuttle run game by picking up

a Tactile Touchable. An interview will be carried out with Mrs Chen to gather feedbacks on how Victoria reacts with the Tactile Touchables at home.

As for how Victoria reacts with Tactile Touchables at home, the table below shows the reactions of Victoria when playing with Tactile Touchables at home for a week. The face-to-face interview with her mother, Mrs Chen, was held one week after the 3rd week of observation at the occupational therapy center.

<b>Using Tactile Touchables at Home</b>	
<b>Day 1 - Wed</b>	Did not want to be brushed by the Tactile Touchables. Only touched the touchables with her palm.
<b>Day 2 - Thur</b>	Did not want to be brushed by the Tactile Touchables. Played shuttle run game with her brother by picking up the Tactile Touchables.
<b>Day 3 - Fri</b>	Did not want to be brushed by the Tactile Touchables. Played matching game with her brother.
<b>Day 4 - Sat</b>	Did not play with Tactile Touchables.
<b>Day 5 - Sun</b>	Did not play with Tactile Touchables.
<b>Day 6 - Mon</b>	Did not want to be brushed by the Tactile Touchables. Only touched the touchables with her palm.
<b>Day 7 - Tue</b>	Occupational therapy day

Table 4.4: Victoria's interaction with Tactile Touchables at home  
Table from author

As advised by therapist, Gloria, Mrs Chen tried using Tactile Touchables as brushes on her hands and played games using Tactile Touchables with Victoria's sibling. When being interviewed, Mrs Chen shared that Victoria needs to be prompted at home when playing with Tactile Touchables. Mrs Chen had placed the Tactile Touchables on the child's study



table, which is readily available, but Victoria would not initiate playing with the toys unless her older brother gave her instructions to play or Mrs Chen herself initiates the activity. When Mrs Chen tried to brush the Tactile Touchables on Victoria's hands, she would shout "No" and run away. She will only use her palms to touch the textures on Tactile Touchables. She was happy playing the shuttle run and matching games with her older brother the next two days but still refused to let her mother brush the Tactile Touchables on her hands. During the weekends, Victoria was out of the house most of the time and did have the chance to play with the Tactile Touchables. The following day, Victoria still resisted the brushing. Mrs Chen commented that maybe if Victoria had the brushing done during the therapy session, she would be more receptive to brushing at home. As the brushing was still considered foreign to her and she was not used to activities that were not familiar to her.

On the design and usefulness of the Tactile Touchables for Victoria, Mrs Chen felt that when Tactile Touchables were being used in an activity or a game, the beneficial value would be much better as compared to just using Tactile Touchable as a brush. Victoria was still overly sensitive to the textures of the Tactile Touchables as she might feel that the textures were too rough and her skin might feel painful when being rubbed with the textures. However when being used in a game, her hands, fingers and palms were in contact with the textures which she is more familiar with as she had already done so during her therapy session. Generally, Mrs Chen felt that Tactile Touchables was a good addition to the range of sensory toys as it could provide interesting play alternatives as well as developing their touch sensations and could allow the children to be more open in appreciating textures of different objects without the fear of touching them.

### **4.3.2 Jason Wong - the under-responsive child**

Mrs Wong was advised by Charmaine to bring the Tactile Runway home as ‘carryover’ home therapeutic activity. Tactile Runway can be detached to form individual “step upon” mats. These mats can be laid out on the floor, close together as a start to encourage Jason to walk, crawl and roll on it. The runway can be taken apart to encourage stretching and jumping. Jason can walk, leap or jump forward and backwards or sideways from one mat to another. This will work on Jason’s abilities to judge the distances between one mat and the next, which will raise his attention, oculomotor skills and visual-spatial discrimination. He will be able to watch where his feet are going which can improve visual skills such as eye-foot coordination and spatial awareness. The action of jumping or leaping to another mat can develop balance and movement, proprioception, kinesthesia and motor planning. An interview will be carried out with Mrs Wong to gather feedbacks on how Jason interacts with the Tactile Runway at home.

In terms of how Jason responded to Tactile Runway as a ‘carryover’ home activity, the table below shows how he played with Tactile Runway for a week. The face-to-face interview with his mother, Mrs Wong, was held one week after the 3rd week of observation at the occupational therapy center.

<b>Using Tactile Runway at Home</b>	
<b>Day 1 - Fri</b>	Stepped, jumped and hopped onto the Tactile Runway.
<b>Day 2 - Sat</b>	Stepped, jumped, crawled and rolled over Tactile Runway.
<b>Day 3 - Sun</b>	Did not test due to day out.
<b>Day 4 - Mon</b>	Stepped, jumped, crawled and rolled over Tactile Runway. Sit on a detached piece of Tactile Runway as a mat while doing homework.
<b>Day 5 - Tue</b>	Did not test due to school activities
<b>Day 6 - Wed</b>	Stepped, jumped, crawled and rolled over Tactile Runway. Sit on a detached piece of Tactile Runway as a mat while doing homework.
<b>Day 7 - Thur</b>	Occupation therapy day.

Table 4.5: Jason's interaction with Tactile Runway at home  
Table from author

Mrs Wong did as what Charmaine had suggested on the first two days. Jason did his exercises on the runway for about 10 minutes once a day. He walked, jumped, hopped, crawled and rolled over the runway. Mrs Wong planned the activities to be done before he started doing his homework to alert his sensory system so that he will not feel lethargic when he on the desk doing his homework. Mrs Wong did feel that the activities on the Tactile Runway did helped him in staying focused on his studies for at least half an hour before taking a break. She commented that playing on the runway provided him with the proprioceptive, vestibular and tactile input, the entire three stimuli in one activity whereas she would usually had to do one activity involving proprioceptive and vestibular input and another activity involving tactile input.

On Sunday, Jason did not play on the runway as they had a family outing that day. On Monday, Mrs Wong decided to try something new, after Jason did his activities on the runway, she detached a piece of the Tactile Runway and place it as a mat to let Jason sit on while he his doing his homework. She wanted to try if that could prolong his ability to focus and sit on the chair for longer than his usual thirty minutes before he took his break. She tried this on both Monday and Wednesday, on the first day, there was not much effect. Jason got up the chair thirty minutes after sitting on it. On the second day of trial, Mrs Wong encouraged him to feel, press his hands on the Tactile Runway seat mat when he felt tired. The action not only provided tactile input but deep pressure to Jason's arms. He reacted to this action positively and Mrs Wong could see him doing that and then he went back to writing on his homework book. Mrs Wong was pleased with this strategy. She hopes that with this, it will prolong his study period so that he could finish his homework without taking too much break.

Generally, Mrs Wong was very positive on the design and usefulness of Tactile Runway. She felt that it served the purpose of helping her son to 'wake up' his under-responsive sensory system and was willing to try to use a piece of Tactile Runway as a mat for Jason to test out if he could sit longer on his chair for his homework. If that would work for Jason, she would speak with the school teacher to allow him to bring the mat to school so that he can sit on it during class, as that would definitely help him in staying focused in class.

### **4.3.3 Aaron Low - the sensory seeking child**

Kiayan gave five Tactile Balls and the Tactile Wrap to Aaron's grandmother, Auntie Ling. She explained to Auntie Ling that any adult at home could help to gently massage the Tactile Balls in a rolling motion on Aaron's arms, hands, feet or back to provide tactile stimulations. Aaron could also press and squeeze the balls, which will develop his finger strengths and provide deep touch pressure for the tactile system together with deep joint pressure for the proprioceptive system. Aaron should have access to Tactile Balls as fidget toys to satisfy his sense of touch if he needs to concentrate on his homework. The Tactile Wrap can also be put over his shoulders to clam him down if he is over stimulated and needed to be quieted down to focus on his reading. A phone interview will be carried out with Mrs Low, Aaron's mother to gather feedbacks on how Aaron interacted with the Tactile Balls at home as she would be carrying out these activities at home.

To find out how Aaron interacts with the Tactile Toys at home, a phone interview was conducted with Mrs Low, Aaron's mother. The table below shows the interaction patterns of Aaron with Tactile Toys at home for a week.

<b>Using Tactile Balls and Tactile Wrap at Home</b>	
<b>Day 1 - Sat</b>	Did not test due to weekend activities.
<b>Day 2 - Sun</b>	Did not test due to weekend activities.
<b>Day 3 - Mon</b>	Used Tactile Balls as fidget toy during homework time. Put Tactile Wrap on shoulders before bedtime.
<b>Day 4 - Tue</b>	“Played becoming a butterfly” using Tactile Wrap. Used Tactile Balls as fidget toy during homework time. Put Tactile Wrap on shoulders before bedtime.
<b>Day 5 - Wed</b>	Used Tactile Balls as fidget toy during homework time. Put Tactile Wrap on shoulders before bedtime.
<b>Day 6 - Thur</b>	Used Tactile Balls as fidget toy during homework time. Rolled on Tactile Wrap while Dad piled pillows on top of Aaron.  Put Tactile Wrap on shoulders before bedtime.
<b>Day 7 - Fri</b>	Occupational therapy day.

Table 4.6: Jason’s interaction with Tactile Runway at home  
Table from author

During the phone interview, Mrs Low explained that she was usually busy with work and could not go to the occupational therapy with Aaron. Grandma will usually send him there but therapist Kiayan had always been helpful and will call Mrs Low to explain to her what Aaron needed to work on as ‘carry over’ activities at home. Mrs Low said that they did not test out the Tactile Toys on both Saturday and Sunday due to weekend activities. Aaron only started interacting with Tactile Toys on Monday. For four days, during his homework time, which was between 3pm to 4pm in the afternoon, Mrs Low’s helper put the Tactile Balls on Aaron’s desk. He usually had his fidget toys with him, and it was replaced with the Tactile Balls. While desk-bound, Aaron had one Tactile Ball on his desk

for his hands and one Tactile Ball on the floor for his feet. He will rub his hands and feet on the Tactile Balls occasionally to keep his hands and feet occupied. This action helped him focus and self-regulate to finish his homework. During the evening just before bedtime, Mrs Low covered Tactile Wrap over his shoulders and read together with Aaron. She did this for Aaron every night for four nights and felt that the deep pressure from the Tactile Wrap could really calm him down and get him ready for bedtime.

On Tuesday, Aaron played ‘becoming a butterfly’ using the Tactile Wrap in the late afternoon. Mrs Low commented that Aaron really enjoyed this activity but he seemed to be more hyper after that, so she decided to stop playing the game with the Tactile Wrap the next few days. Mrs Low also shared that Aaron enjoyed having pillows piled on top of him and sometimes Dad would also press on the top of the pillows to exert more pressure. So on Thursday night, Dad tried laying the Tactile Wrap flat on the bed and Aaron laid on the textured side of the wrap and rubbed his hands and legs on the textures. Then Dad piled the pillows on top of Aaron and exerted more pressure. Aaron really enjoyed the activity. It provided him with deep pressure input to his muscles and joints and stimulated his proprioceptors and therefore helped him develop better awareness of his body. The rubbing on the textures also provided him with tactile stimulation.

By and large, Mrs Low felt that Tactile Toys could replace some of the current toys that Aaron has been using. Tactile Balls worked very well for Aaron as a fidget toy and as explained by Kiayan, for sensory seekers like Aaron, Tactile Balls can provide the right amount of sensory input to calm his nervous system. Fidget toys like Tactile Balls can help to maintain regulation at home or in classroom. It allows the child’s brain to filter out excess information in their surroundings and their own body, by focusing on a toy in the

hands. In this way, it can help a child to improve concentration and attention levels. She also mentioned that Tactile Wrap is good for Aaron as it provides deep pressure to clam him down. She noted that Tactile Wrap had to be used in a less vigorous activity for Aaron like wrapping over him for story time rather than using it in the ‘becoming a butterfly’ game as more vigorous games may increase his arousal levels and cause more hyperactivity.

#### **4.4. Effectiveness and Value of Tactile Toys**

Finally, based on the data collected from the therapist and family, the strength and weakness of tactile toys are examined and most importantly, how Tactile Toys have helped to improve the child’s tactile dysfunction and the value of Tactile Toys are discussed. Education on the right usage of Tactile Toys is very important and occupational therapist will need to be involved to guide parents how to make use of the Tactile Toys to provide maximum benefits for the children with tactile dysfunction.

Overall, Tactile Toys have proofed to be effective when they are handled well and strategically used by occupational therapists. With its intriguing textures and structural forms, Tactile Toys attract children to touch them. With the help and supervision from occupational therapists or parents, children can manipulate and explore these toys by rubbing, feeling, squeezing and kneading their hands and having their hands in contact with Tactile Toys in various planned activities and games. On the whole, Tactile Toys do stimulate children’s tactile, proprioceptive, vestibular and visual senses as they offer the children a rich sensory play experience. Their hands, when in contact with the Tactile Toys will heighten the children’s awareness of their body, allowing them to feel their



physical and kinesthetic sensation within their body<sup>1</sup>. This may make them more in tuned with their physical self and they may eventually step out of their tactile dysfunction behaviours.

Tactile Toys are designed to help children with tactile dysfunctions. With the detailed study of children suffering from sensory processing disorder focusing on types of tactile dysfunctions; the technical understanding of the construction methods of three-dimensional textiles and the thorough study of sensory integration approach, Tactile Toys are created as a means of tactile therapy. Tactile therapy through the use of three-dimensional structural textiles will provide a variety of tactile sensations and explorations using touch. The implementation of three-dimensional structural forms into Tactile Toys will generate more interest for the children and focus on helping children who are over-responsive, under-responsive and sensory seeking to acquire the appropriate tactile sensory inputs for their tactile dysfunctions. This will better equip the children with the appropriate therapeutic tactile sensory benefits and hence focus on helping children to improve their ability to regulate, interpret and execute appropriate behavioural responses to touch sensations so that they are able to live their lives in a functional manner. The goal of tactile therapy for children is to help them develop appropriate responses to touch sensation so that daily tasks can be competently performed. As these competencies will increase with effective tactile therapy, the child's self-esteem and self-regulation will also improve.

Tactile Toys can calm children and regulate their stress levels. When working with their hands, the kinaesthetic hand movements such as pressing and squeezing can help

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<sup>1</sup>Caroline Lowe, "The importance of sensory play with tactile toys," [http://www.adoptresources.co.uk/articles/AR\\_article1.pdf](http://www.adoptresources.co.uk/articles/AR_article1.pdf).

children to release their physical energy or tension<sup>2</sup>. These experiences are important for the children to build up their emotional well-being and regulate their sense of emotions. When combined with guided activities and games, Tactile Toys can engage children's fine and gross motor skills. The children will be able to control their motor movements during directive play, which will prove beneficial in improving their self-control. Occupational therapists will know when to increase the challenges of the activities when children have accomplished certain levels and this will allow children to feel successful and elevate their sense of achievements. This will greatly help to strengthen their self-esteem and increase their confidence level in performing their daily activities. Hence allowing them to step out of their tactile dysfunction and to be more competent and independent in allowing them to live their life to the fullest.

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<sup>2</sup>Christine Snyder, "Providing Sensory Experiences That Meet the Needs of All Infants and Toddlers," 2011, [http://www.highscope.org/file/NewsandInformation/Extensions/ExtVol25No5\\_low.pdf](http://www.highscope.org/file/NewsandInformation/Extensions/ExtVol25No5_low.pdf).

# **Chapter 5**

## **Conclusion**

Textiles now have a new potential beyond fashion and aesthetics. For this research, it is found that textiles can be used as a source of new textures that could be added to the current range of sensory toys and products that can help children who are suffering from tactile sensory dysfunction. Tactile Toys may very well be a new start for tactile therapy to infiltrate everyday lives of children with sensory processing disorder. Specifically in this research, Tactile Toys are designed to aid children suffering from tactile sensory dysfunctions. Tactile therapy is effective when Tactile Toys are used during occupational therapy sessions using the sensory integration approach to help children to improve their ability to regulate, interpret and execute appropriate behavioural responses to touch sensations so that they are able to live their lives in a functional manner.

The four Tactile Toys prototyped are: Tactile Touchables, Tactile Balls, Tactile Runway and Tactile Wrap. The creation of Tactile Toys involve two stages of production,

stage 1 of the production involves the heat setting of the polyester organza into the different three-dimensional structures. These three-dimensional fabrics are known as Tactile Textiles. When the completion of Tactile Textiles, stage 2 of the production involves the transformation and creation of these fabrics into the four types of Tactile Toys. The final stage involves the testing of Tactile Toys in occupational therapy sessions and it has been proofed that tactile therapy through the use of Tactile Toys will provide a variety of tactile sensations and explorations using touch. The three-dimensional structural textiles will generate more interest for the children to interact with the textiles. This will better equip the children with the appropriate tactile sensory reflexes and hence focus on helping children who are tactile over-responsive, tactile under-responsive and tactile seeking to overcome their dysfunction and respond appropriately to tactile senses in their daily lives.

The sense of touch is the first to develop in the human fetus<sup>1</sup>. Touch is an ability that is important in early human development; it is crucial in the early development of a child's motor, communication and social skills. These are the fundamental skills that a child with Sensory Processing Disorder commonly lacks. As a result, these children will show behavioural, emotional, motor or cognitive difference<sup>2</sup>. To address these issues faced by a child, sensory integration therapy has become a prominent approach used by occupational therapist, focusing on sensory-based interventions. During therapy, the child is guided by the therapist through a series of fun and challenging play activities that combines both sensory stimulation and movement. There are equipments and products that a therapist will be using during the therapy that will aide the process of play. These equipments and

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<sup>1</sup> Ashley Montagu, "Touching: The human significance of the skin.," 1986,

<sup>2</sup> Matthew J Hertenstein and Sandra Jean Weiss, *The handbook of touch: neuroscience, behavioral, and health perspectives* (Springer Publishing Company, 2011).

products are designed specifically to be used on the targeted seven senses: proprioceptive, vestibular, tactile, visual, auditory, gustatory and olfactory. Specific to the sense of touch, there are tactile therapeutic approaches such as the Wilbarger protocol, weighted vests and basic textured fabrics and materials available for the therapist to work on for children with tactile dysfunction. Adding on to the existing range of tactile therapeutic products will be Tactile Toys, a series of toys designed specifically for their usage as therapy to enhance, improve and encourage the sense of touch.

The contribution of this research is to create original Tactile Textiles that has three-dimensional surface structures, which will be further designed into Tactile Toys. This will be integrated as sensory diets within a child's tactile therapy session, coordinated by an occupational therapist. The design of Tactile Toys with three-dimensional surface textures can assist children to overcome specific reactions to tactile sensations through incorporating these toys into the sensory diets of their occupational therapy. It is through tactile therapy that a child can improve his ability to regulate, interpret and execute appropriate behavioral responses to touch sensations so that they are able to live their lives in a functional manner.

## **5.1. Future Developments of Tactile Textiles into Therapeutic Products**

Tactile Textiles has also been developed into Tactile Smart Cushions using similar three-dimensional structural surfaces and embedded technology. Tactile Smart Cushions being

prototyped and tested out by a group of elderly in O'Joy Eldercare Centre Singapore as tactile therapy. These interactive cushions have been designed for the elderly and focused on the therapeutic abilities of tactile textiles for the use of the elderly in Singapore as a form of touch therapy, especially for those with deteriorating senses. The main aim of this project is to use the technique of heat setting to form Tactile Textiles to stimulate the sense of touch. With the use of embedded technology, a series of textile-based cushions with tactile surfaces responding to the patient's sense of touch and sight have been developed and tested by the elderly.

Tactile Smart Cushions incorporates smart technology to produce 'cause and effect' upon touching of the cushions. The textiles will be aesthetically designed and constructed as three-dimensional forms by utilizing the thermoplastic qualities of synthetic fabrics during the first stage. The design of the three-dimensional forms will attract the users to feel and touch the textiles and with the seamless incorporation of smart technology such as motion sensors, that will detect hand movements on the surface of the fabrics, sensory outputs such as light and heat will produced.

The main target groups of end users are the elderly patients who are suffering from deteriorating sense of touch. One of the common consequences of aging is a decline in the sense of touch. Schmall<sup>3</sup>, elaborates that touch sensitivity decreases with age. Some older persons find it difficult to distinguish textures and objects on the basis of touch alone. Some may experience a delayed reaction to being touched. To prevent further deterioration of the touch sensitivity, the design of the tactile textiles with its distinct textures created from

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<sup>3</sup>Vicki L Schmall et al., *Sensory changes in later life*, technical report ([Corvallis, Or.]: Oregon State University Extension Service;[Olympia, Wash.]: Washington State University Cooperative Extension;[Moscow, Idaho]: University of Idaho Cooperative Extension System;[Washington, DC]: US Dept. of Agriculture, 2000).

three-dimensional structural forms will provide haptic sensations during the therapeutic interventions.

With the focus in stimulating the sense of touch for this particular group of end users, the elderly will be able to practice their tactile responsiveness on the three-dimensional tactile fabrics and hence becoming a necessary therapy in enhancing their tactile sensation. The use of embedded technology incorporated into these textiles will help maintain touch sensitivity and at the same time allow them to enjoy interactive play or providing comfort. It will also allow the elderly to experience both tactile and visual sensory at once.

For example, an elderly in a nursing home could be covered with a Tactile Smart Quilt or hugging a Tactile Smart Cushion. Light will be triggered when the elderly touches or strokes the surface of the Tactile Textiles. This is made possible by attaching motion sensor systems linked with LED lights woven onto the base fabric of the material. Other possibilities can also include the emission of heat or even triggering of vibrating motor while the surface is being touched. The outcomes of light, heat or vibration will be beneficial to the sensory responsiveness of the elderly. These outcomes will be fun examples of cause and effect play for the elderly, which will stimulate all of the senses, and essentially lead to a more fulfilled, worthwhile and happier quality of life.

There are different types of therapy that Geriatric Day Care and Eldercare Centers in Singapore provide. Some are enjoying sessions of art as therapy which includes simple basic Chinese paintings and easy to manage handicraft making. Hands-on activities like these allow the elderly to maintain their visual skills, sensory skills and well as motor skills. It has been proven from research by the hospital that weekly arts and crafts sessions can reinforce motor skills and challenge the patient's creativity. Besides Art Therapy, simple

materials and play objects are available for the patients to work on their motor skills. There are several boards with bolts fastened on and patients will practice their motor skills by screwing the lock nuts onto the bolts. However, these materials lack visual interests and interactivity to further stimulate the patients. Using this as a starting point, a series of visually stimulating and interactive set of materials can be designed for the patients.

There are ongoing projects in Europe that combine smart materials within textiles. Swedish Re-form Design Studio<sup>4</sup> at Goteborg invented an Interactive Cushion. The cushions come in pairs, the idea is that when one is touched or squeezed, the other glows dynamically. The designers of these cushions believed that by hugging these interactive cushions, long distance relationships can be more bearable. It is also proven by scientific research that animal-assisted therapy<sup>5</sup> is a respected therapeutic intervention. Holding, petting and simple grooming tasks can enhance motor skills lost through injury, disease or the aging process. With this study, the use of the tactile qualities of fabrics is also similar. It will allow patients to utilize their sense of touch and further illustrates the therapeutic abilities of the project's hypothesis.

Tactile Smart Cushions incorporates smart embedded technology within the cushions. The scientific definition of "Smart Textiles" as defined by Stylios<sup>6</sup>, are materials that can sense mechanical, thermal, chemical, magnetic or other environmental conditions and respond in a controlled and predicted manner by changing their colour, permeability, porosity, rigidity, shape, size or other physical/chemical characteristics. As explained by

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<sup>4</sup>"Design Goteborg, Technology as Design Material. Interactive Pillows," <https://dru.tii.se/reform/projects/itextile/pillow.html>.

<sup>5</sup>Mauren Mcinaney, "Pet-therapy project launched in geriatric psych unit," <http://news.stanford.edu/news/1997/august27/paws.html>.

<sup>6</sup>George K Stylios, "Editorial: Smart textiles special issue," *Transactions of the Institute of Measurement and Control* 29, nos. 3-4 (2007): 213-214.



Langenhove and Hertleer<sup>7</sup>, the term “Smart Textiles” is derived from intelligent or smart materials. The concept of “Smart Material” was, for the first time, defined in Japan in 1989. Generally, “Smart Textiles” are able to sense stimuli from the environment, to react to them and adapt to them by integration of functionalities in the textile structure.

In Tactile Smart Cushions, motion sensors are embedded onto the Tactile Textiles. The stimuli in this case will be the touching or stroking of the surface of the Tactile Textiles. The reaction output will be light emitting out from the tactile textiles. This is made possible by attaching motion sensor systems linked with LED lights woven onto the base fabric of the material. The other possibility includes the emission of heat while the surface is being touched. The outcomes of light and heat will be used as a form of tactile touch therapy that could be integrated into current tactile treatments for the elderly.

The main application for this range of heat set fabrics will be to develop them into cushion covers. With its tactile qualities, it will encourage users to feel and stroke the cushions. As one of the common consequences of aging is a decline in motoric and sensory functions, patients or the elderly will be encouraged to feel and touch the tactile material to enhance their tactile sensory input. The addition of embedded technology incorporated into these textiles will allow patients or the elderly to experience different sensory inputs. The use of embedded technology incorporated into these cushions will allow the elderly to enhance their sensory experience. The main objective will be to incorporate and weave both tactile qualities with the SMART technology seamlessly. With the outcomes of the experimentations, a series of visually stimulating and interactive set of cushions are designed for the elderly. When the tactile surfaces of the

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<sup>7</sup>Lieva Van Langenhove and Carla Hertleer, “Smart clothing: a new life,” *International journal of clothing science and technology* 16, nos. 1/2 (2004): 63–72.

cushions are being stroked, cushions with LED lights embedded will be lighted up. This is made possible by having custom-made LED Lights placed underneath the 3D surface with 4 motion sensors. The LED lights will be lighted up when the 3D surfaces are being stroked.

Tactile Smart Cushions are also being embedded with a heated material, which could provide warm to the user, to be used in an air-conditioned room or in cold countries. The bases of the cushions are installed with a lightweight textile heating system produced by SEFAR. The product is known as SEFAR PowerHeat and it is a light and highly air permeable heating fabric<sup>8</sup>. The cushion will emit heat at the base, which will provide warmth to the patients when needed, and at the same time, patients can enjoy the different tactile sensations when they stroke the surfaces of the cushions.

The heated cushions prove to be the most useful when tested on the elderly. Most of them commented that the heat not only provides them with warmth, they are able to ease their joint pains and rheumatism. Many of them wished to own a heated cushion, and to use it during bedtime as the heat will be effectively soothing as most of them face joint pains at night. The lighted cushions offer the elderly an interactive play of the 3D tactile surfaces. Many of them commented that they do like the 3D tactile qualities of the cushions. While stroking, it will evoke different sensations and allows them to play and stroke the tactile surfaces. The lighted LED gives them an element of surprise and fun, and to keep stroking the cushions.

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<sup>8</sup>SEFAR. SEFAR PowerHeat.  
<http://www.sefar.com/en/609/SEFAR-PowerHeat.htm?Folder=1484711>

These cushions will serve to allow the three-dimensional Tactile Textiles to be integrated as much as possible into the everyday lives of the elderly; and in doing so, making the therapy more effective. They are designed in such a way that it will be touched and used as much as possible without having to be forced onto the elderly patients. The user experience is fun, interactive as well as effective to treat the ailments as well as to address the sense of touch especially those with deteriorating senses. Its main focus will be to stimulate the sense of touch. It is apparent that the products designed can serve everyday functions so that the elderly can use them as much as possible without having to actually “be in” therapy; they simply have to go through their daily routine and still be treated.



Figure 5.1: Heated and Lighted Tactile Therapy Cushions for the Elderly  
Image from author

## **5.2. Potential of Tactile Toys and Tactile Products**

The main social impact that these tactile products have is that it will be beneficial for selected groups of users who need tactile sensory inputs in order for them to improve and enhance their daily lives. Different ranges of textiles and tactile products can also be made in future to aid children with tactile sensory dysfunctions. These new developments will also be tested out on children with the aid of occupational therapists who are experienced in prescribing sensory diets and dealing with tactile sensory dysfunctions. This will ensure the success of the textiles and the products. The flexibility of textiles, allow new frontiers in the development of Tactile Toys and other tactile products. The future implementation of SMART embedded technology into Tactile Toys and other tactile products will therefore generate even more interests from the users.

Going forward, there is definitely potential for Tactile Toys and tactile products to be commercialized, mass-produced and distributed to special needs schools, children's hospitals and occupational therapy centres. Singapore will be a good base where research & development capabilities can be established for future developments of Tactile Toys and tactile products. This coupled with the Singapore government promoting entrepreneurship and local enterprises, Small and Medium Enterprises (SMEs) can explore tapping on available government grants and incentives to help develop their capabilities and internationalization efforts. With foreseeable growth opportunities within the region, there is consideration to also seek and explore financial funding support via seed funding, crowd funding or private source of funding. Hopefully these parties will be able to support the establishment with their network, professional know how to value-add to the venture. As operating cost environment continue to increase in the region, there is

possibility to explore migrating the certain production activities to a neighboring country such as Thailand or Vietnam where the creative culture and people's skills can improve the profitability margins and product quality. Singapore will continue to operate as its International Headquarters (IHQ) and will remain to be a showcase platform to market and profile the end product while leveraging on the made in Singapore brand.

In summary, tactile therapy through the use of three-dimensional structural textiles will provide a variety of tactile sensations and explorations using touch. Tactile Textiles, with its unique three-dimensional structural surface textures can be developed into Tactile Toys and other tactile products for the use of specific target market. Tactile Toys is specifically designed and dedicated to help both children with sensory processing disorder to overcome tactile dysfunctions. The three-dimensional surface textures which can be found on such toys, can help attract the children to touch as well as enjoy tactile experiences leading to them receiving appropriate sensory inputs for different types of dysfunction. This will better equip the children with the appropriate therapeutic tactile sensory benefits and hence enhance holistic approaches that improve both the well-being and quality of their lives.

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