Space Affordances, Adaptive Responses and Sensory Integration by Autistic Children

Paramita Atmodiwirjo

Department of Architecture, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia

This paper presents the findings of a study on the interrelationship between space, bodily actions and the sensory integration of autistic children. In particular it addresses the role of the spatial environment in promoting the development of the sensory integration of autistic children, using J. J. Gibson's concept of affordances, which places an emphasis on the transactional relationship between an individual body and its environment. This study examines how the body-space transaction occurs to promote sensory integration, based on a series of unobtrusive observations on spatial actions performed by autistic children during sensory integration therapy sessions. The study found multiple affordances of spaces and objects for various sensory-related actions. The child's interaction with spaces and objects reflects the relational character of various affordances. The multiplicity and relational characteristics of affordances are manifested through the presence of the spaces and objects of possibilities, to which the child may respond through various actions. The findings suggest that the physical layout of the environment that could enhance sensory integration should be designed by considering physical spaces as a body-environment system with a multiplicity of affordances that eventually could enrich the child's adaptive responses.

Keywords **–** Adaptive Responses, Affordances, Autism, Multiple, Relational, Space.

Relevance to Design Practice **–** The findings suggests some implications for designing spaces for autistic children based on the understanding of multiple affordances and adaptive responses.

Citation: Atmodiwirjo, P. (2014). Space affordances, adaptive responses and sensory integration by autistic children. *International Journal of Design, 8*(3), 35-47.

Introduction

The human body exists in its space as an active, living entity with capabilities to relate to its surroundings through the senses and movements. The human body should be considered as an integral part of its environment; the body and space are not separated entities (Franck & Lepori, 2000) and their relations are manifested through human spatial experience. Space becomes the setting where the human body performs various movements and actions, and at the same time it evokes various bodily sensory experiences (Tuan, 1977). There is an interdependent relationship between the body and the space that surrounds it, and only by understanding such interdependence could we comprehend the existence of the human body in space and the role of space for bodily experience.

For certain groups of individuals, especially those with certain forms of impairment, sensory experiences that emerge from body-space interaction may play a particularly important role. This study addresses the role of sensory experiences for individuals with autism. Autism is a form of developmental disorder which is often characterized by deficits in communication abilities and social interaction, and the demonstration of repetitive behaviour (Schaaf & Miller, 2005). A key problem in autism is related to sensory processing, particularly the inability to correctly register and process the sensory input received from the environment (Ayres, 2005). Autism may cover a broad spectrum, with different kinds of symptoms identified in different individuals, due to their different responses to sensory input; some might be hyposensitive or hypersensitive towards certain stimuli (Rie & Heflin, 2009). The opportunities for experiencing rich sensory experiences could offer benefits to improving the condition of autistic individuals, especially when these experiences are correctly suited to the needs of each individual and these in turn promote the correct sensory processes.

Ayres (2005) developed an intervention approach based on the understanding of the role of sensory integration, which is defined as the "organization of sensations for use" (p. 5). Basically, sensory integration is an unconscious process consisting of organizing information detected by the senses, giving meaning to what is experienced, and then acting or responding to the experienced situation in a purposeful manner (Ayres, 2005). In principle, the sensory integration approach is practiced by offering sensory-rich activities for children. Through these activities, "the child is guided through challenging and fun activities designed to stimulate and integrate sensory systems, challenge their motor systems, and facilitate integration of sensory, motor, cognitive, and perceptual skills" (Schaaf & Miller, 2005, p. 144).

Various activities are designed in the sensory integration approach to help the children to regulate their sensory systems. In the practice of sensory integration, the physical environment

Received June 5, 2013; **Accepted** September 7, 2014; **Published** December 31, 2014.

Corresponding Author: paramita@eng.ui.ac.id.

with various spatial features plays an important role in providing a setting for activities. The main principle of sensory integration therapy is "to provide and control sensory input... in such a way that the child spontaneously forms the adaptive responses that integrate these sensations" (Ayres, 2005, p. 142). Therefore, the design of the physical environment becomes important to ensure the provision of rich sensory input and to promote the child's adaptive responses towards the environment.

This paper examines the body-environment transactions that occur between the autistic child and the objects or spaces during the sensory integration activities. The study draws on a transactional perspective that considers a person and the environment as separate units, with human beings as active agents (Altman & Rogoff, 1987). In particular, this paper analyzes various forms of body-space transactions and the relevance of such transactions in the process of the adaptive responses of autistic children, based on Gibson's theoretical framework of environmental affordances (Gibson, 1986; Heft, 1988). Although there is a broad spectrum of autism with different problems of sensory processing and various levels of severity, this paper discusses the role of the spatial environment in sensory processing for autism in general. The term 'spatial environment' here refers to both the spaces where the activities take place and the objects that are present within the spaces. The term also refers to the physical properties of the spaces and objects as well as the arrangement of the spaces and objects. In addition, the discussion in this paper is limited to physical bodily responses from an individual towards the environment; it does not include emotional responses which could not be directly observed during the body-environment transactions. The knowledge on body-environment transactions will become the basis for designing spaces and objects that could enhance the autistic children's sensory integration.

Body-Space Relationship, Sensory Integration and Adaptive Responses

Understanding the relationship between a child and a space should take into account the existence of a child's body as an active entity in space. Tuan (1977) proposes an experiential perspective as a way to understand the relationship between the human body and its space and place. This experience involves "various modes through which a person knows and constructs a reality" (p. 8). Experience does not imply passivity, and thus the experience of the human body in space is an active one. The human body becomes a subject that actively senses the world, moves, changes and acts with intention and initiative (Franck & Lepori, 2000). Experience involves "acting on the given and creating out of the given" (Tuan, 1977, p. 9). Thus, there is a reciprocal relationship between the body and space, in which one relates to, affects and influences each other.

Paramita Atmodiwirjo teaches architecture at Universitas Indonesia. Her research interest is on the relationship between architecture and its users, especially children, young people and special needs.

Such a reciprocal relationship becomes important when considering the role of physical space as a setting where sensory experiences take place. The body communicates with its surroundings through the mediation of different sensory systems (Ayres, 2005). Exteroceptors are the senses that become a means to communicate the external stimuli that are coming into our body, consisting of visual sense (sight), auditory sense (sound), gustatory sense (taste) olfactory sense (smell) and tactile sense (touch); while proprioceptors are the senses that become a means to communicate about the existence of our body in space, consisting of proprioceptive senses (position and movement) and vestibular senses (gravity, head movement and balance).

By using sensory systems, the body perceives different kinds of information from the environment, which are essentially complex bits of information consisting of visual forms, colour, light, texture, tone, smell, taste, tactile sensations and others (Caan, 2011). Different sensory systems provide different kinds of information to the body about its surroundings, but kinesthesia, sight and touch are the ones that enable the human body to comprehend space and spatial qualities (Tuan, 1977). Through movement, the human body develops awareness of space and acquires a sense of direction, while sight provides the human body with an understanding of space in three-dimensions and touch allows the manipulation of spatial objects with various physical properties.

For children with autism the sensory integration approach involves an interaction between children and the physical environment that provides various kinds of sensory input: "Natural interactions with typical environments provide the sensory experiences and opportunities to make adaptive responses that are sufficient to develop the brain in most young children" (Ayres, 2005, p. 140). Adaptive response is one of the key principles in the sensory integration approach, along with three other principles: just right challenge, active engagement and child directed (Schaaf & Miller, 2005), and these are implemented through a series of play actions. "An adaptive response is a purposeful, goal-directed response to a sensory experience ... play consists of a series of adaptive responses that make the sensory integration happen. In turn, as sensory integration develops, better organization and more complex skills are possible" (Ayres, 2005, p. 7). During sensory integration activities, the child is presented with a series of challenges, and in response to these challenges, "the child adapts their behaviour with new and useful strategies, thus furthering development" (Schaaf & Miller, p. 144).

The emergence of the adaptive response factor during sensory integration activities cannot be separated from the physical environment where the activities are performed. The design of the physical environment becomes crucial to ensuring the provision of rich sensory inputs that eventually promote the child's adaptive response. It is important to provide the amount of sensory experiences and the types of sensory input that are appropriate to the child's condition and needs (Rie & Heflin, 2009; Kinnealy & Miller, 1993). Sensory integration intervention requires physical space and elements that can provide various opportunities for the child to do things and to interact with the

environment (Roley & Jacobs, 2008). This suggests the important role of the physical environment for sensory integration activities where challenges are presented and physically manifested, and this will become the main focus of this paper.

Space Affordances and Possibilities for Actions

The presence of the body in space, as an active entity, suggests the responsiveness of the human body towards its surrounding environment. The responsiveness of the body happens because the body has capabilities to respond to the cues presented by the environment (Franck & Lepori, 2000). Moreover, it has the capabilities to respond to whether the environment is open for engagement or the other way around. It is further explained through the transactional view in environmental psychology that "Even though environments are open systems, they present physical limits which can be primarily described as 'resistant', 'supportive' or 'facilitative' with regard to the participants' behaviours" (Bonnes & Secchiaroli, 1995, p. 161).

The idea of the physical environment that could support or restrict certain behaviour, and that the environment and behaviour has a reciprocal relationship has its underlying foundation based on J. J. Gibson's (1986) concept of affordances, as follows: "The affordances of the environment are what it offers the animal, what it provides or furnishes" (p. 127). By understanding the affordances of objects or spaces, the primary attention is on what the environment could offer to individuals rather than focusing on common properties that are often used for describing the environment, such as form, colour, texture, or the name of particular objects (Heft, 1988). For example, a flat surface may afford some activities of 'standing on' or 'walking on', while a space behind another object may afford 'hiding behind'. The concept of affordances extends the comprehension of space beyond the common label of the space and beyond the common function or use of space; rather it allows for various possibilities that spaces and objects could support bodily actions and activities. In the process of perceiving objects or spaces, an individual perceives the affordances of the objects or spaces, and then they could determine what could be done with them. This process of perception demonstrates the idea of transactional perspective that considers the body and space as integrated entities.

The possibilities offered by a physical environment for the human body should be understood in terms of relations between the body and the environment. Basically, affordances are not only properties of the environment but also they are located within the body-environment relations (Chemero, 2003). An object may possess an affordance, not only because of its certain physical properties, but also because of the relations between the object's properties and the human body's properties that allow possibilities for actions or activities. Another aspect of affordances is their multiplicity. Since affordances are relative to individuals, certain environmental features might afford different actions or activities and, thus the environment might have multiple affordances (Heft, 1988).

The concept of affordances has been acknowledged as a useful conceptual framework in studying the relationship between the physical environment and its users. This concept might explain the potential of the physical environment to support certain bodily skills, such as in the study on affordances of the home environment for infants' motor skills (Gabbard, Cacola & Rodrigues, 2008) and affordances of landscape features that invite certain types of child's play and thus promote certain developmental skills (Fjortorf & Sageie, 2000). This concept could also explain the extent to which certain environmental features could be engaged by the users (Broberg, Kytta & Fagerholm, 2013) or how the perception of environmental features could differ across different users (Niklasson & Sandberg, 2010). Knowledge on affordances is very relevant to architecture and other design disciplines (Maier & Fadel, 2009). It addresses how the built environment could be designed in such a way that it is meaningful for human actions and activities.

The understanding of affordances is important in understanding the possibilities that are offered by space for the human body. Space "initiates, directs and organises... frames, articulates, structures, gives significance, relates, separates and unites, facilitates and prohibits" (Pallasmaa, 2012, p. 68) and all these possibilities depend on the nature of body-environment relations. Eventually, designing space thus becomes a way to create possibilities, either to encourage or discourage certain spatial uses (Franck & Lepori, 2000).

Within the context of the physical environment for autistic children, the presence of the environment needs to be considered as an affordance for actions and activities that could support the child's sensory integration development. The concept of affordances demonstrates the transactional nature of body-environment relations (Bonnes & Secchiaroli, 1995), and it also involves the ideas of the human body responsiveness towards the surrounding environment (Franck & Lepori, 2000). This paper argues that the understanding of affordances is an important key in explaining the possibilities of spaces and objects for the child's adaptive response as a form of its body responsiveness towards its environment. The findings from an observational study of the children's uses of spaces and objects during sensory integration activities will provide illustrations on how the space affordances are manifested and the adaptive responses are experienced within the context of sensory integration.

Method of Study

The study was conducted through a series of unobtrusive observations of sensory integration therapy sessions for children with autism. The observations took place in a sensory integration therapy centre for children with developmental disorders, particularly autism. The therapy sessions were held in two different types of indoor spaces. There were a total of 19 children observed in 19 individual sensory integration therapy sessions in these two spaces, with the session duration ranging from 20 to 70 minutes, and the total duration of observation was approximately 1,150 minutes. During the observation period, all

activities conducted by the children were recorded as 'activity units'. The number of activity units in each session ranged from 3 to 46 activity units, with a total of 466 activity units from the whole observation period.

The focus of the observation was on the kind of activities conducted by the child and the particular spaces or objects that the child interacted with in each activity unit. In particular, the analysis was focused on the primary spatial properties of the spaces or objects. In this study, the terms spaces and objects, could not be separated since the human body experience of space is closely related to "the material presence of things" (Zumthor, 2006, p. 21), which we often encounter as visible objects and their physical properties. In reality, the human body-space experience occurs within a spatial environment that is complex, but it is possible to trace back the nature of such interaction by considering the most basic forms (Caan, 2011). Since there was a wide variety of spaces and objects that were involved during the observation sessions, for the purposes of this study, the analysis was limited to the primary spatial properties of the spaces and objects that allow the child's body to be "contained" in or on it. For that reason , we excluded small objects in which interactions happen through hand manipulation only, such as small toys, small containers etc.

The analysis was conducted by categorising the spaces and objects based on the primary spatial properties that were defined as the "surfaces that support actions" (Turvey, 2004, p. 25), in particular, those surfaces that trigger or invite the child's responses through movements. The analysis resulted in a list of primary spatial features found in various objects and spaces and their affordances for child's actions that are relevant for the development of the child's sensory integration. The list of space and object affordances reflect the different forms of interaction between the child and the physical environment, and this becomes the basis for further discussion of their relevance to the child's adaptive responses.

Affordances of Spaces and Objects for Sensory Integration

Multiple Affordances of Spaces and Objects for a Child's Actions

During the observed sensory integration sessions, the children interacted with different kinds of spaces and objects that were present in the activity setting. These spaces and objects could be categorised in terms of their functional properties (Heft, 1988). Table 1 illustrates different primary spatial features of the spaces and objects that were involved in the children's interaction with the environment during the observed sensory integration sessions.

A variety of uses of these spatial features by the children suggests different kinds of affordances. Some types of spaces and objects may have affordances for only one or a few activities, while some others might have affordances for many activities. This finding indicates that the combination of space and objects could have multiple affordances to support different sensory integration activities. The following discussion will explore the relationship between affordances and the process of sensory integration, by referring to the number of types of primary spatial features in Table 1.

Affordances are essentially the possibilities of action that are present in spaces or objects. Therefore, the multiplicity of affordances might indicate the range of possibilities that certain spaces or objects could allow for a child's actions. There are at least three ways in which there could be multiple affordances of certain objects or spaces.

First, an object or a space may have multiple affordances because **its primary spatial property affords many actions**. For example, the slanted surface of the slide (No. 2) afforded sliding, walking, and crawling, either upwards or downwards, while the bouncy spherical surface (No. 8) of a large ball afforded sitting, lying down and climbing (Figure 1). In these examples, certain primary spatial properties of the objects afford different ways of usage by the children.

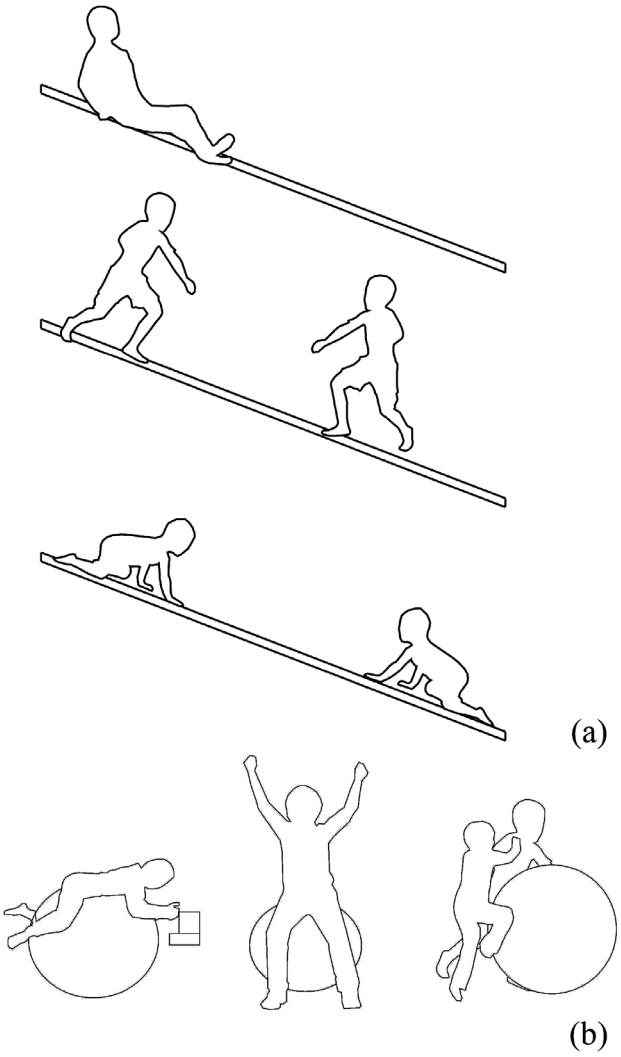

Figure 1. Multiple affordances of: (a) slanted surface (b) bouncy spherical object.

Table 1. Multiple affordances of spaces and objects.

No.	*Types*	*Primary spatial properties*	*Affordances for activities*[a]	*Examples*
1	Raised surface	Horizontal surface, flat, hard, broad (forming an area), elevated from the floor level to child's height	Sitting on (1,2,11,10,15); Sitting on while playing with objects (2,10,15); sitting on while watching surrounding (1,2,11); Walking along the periphery (1,3,6,7,8,10,13,15); Throwing /catching object to and from the lower level (3)	Wooden platform
2	Slanted surface	Slanted surface, flat, hard, long (forming a path)	Sliding downward (6,8,13,21,22); Walking upward (3,4,5,7,8,11,12,13); Walking downward (10,18); Crawling upwards (15); Crawling downwards (2,12,15,17)	Wooden slide, triangle soft block
3	Vertical surface	Vertical surface, flat, hard	Leaning on (14); Drawing on (15) – with foam	Wall, vertical side of objects
4	Stepped surfaces	Series of flat surfaces arranged one on top of the another vertically or diagonally	Stepping up (1,4,5,6,7,8,11,13, 15,16,18,19); Stepping down (10)	Wooden steps, stepping soft blocks
5	Surface with low height	Horizontal surface, flat, elevated slightly from floor level	Sitting on (14); Stepping on to reach higher (16); Spreading something on (2); Playing something on (15)	Soft blocks
6	Soft surface	Horizontal surface, thin, soft, broad (forming an area)	Landing on (1); Hitting with hand (17) or touch with body (18); Standing on (3,14); Sitting on (1, 8, 14,18); Lying on (14); Crawling on (14); Walking on a circle (18); Spreading something on surface (8)	Mattress
7	Bouncy surface	Soft surface, bouncy (thus unstable), broad (forming an area)	Landing on (1,2,3,7,11,3,4,5,6,7,8,9,13,15); Stepping on to reach higher (1,2,3,10,12); Walking (4,5,6,7,13,19); Climbing and Creeping (11); Crawling (19); Jumping (10,8,9); Rolling (2,9,17,18); Pressed from above or in between (2,3,8,9,17,18); Shaking (19); Sitting on (8,19)	Large cushion, sets of large cushions
8	Bouncy sphericalsurface	Sphere surface, bouncy, diameter height = child's chest	Climbing on (12); Sitting and bouncing (12); Rolling on (12); Running after rolling ball (12); Laying on (15)	Large plastic ball
9	Hung surface	Horizontal surface, hung, long/ broad (forming a path or area), flat/curved, hard/soft	Swinging (2,12,13,15,16,18); Sit on, sleep on (3); Walking on (4,5,6); Climbing onto (2,4,5,12,13,16)	Swing with cloth surface, hard surface, hung cylinder
10	Open path	Flat surface, long (forming a path)	Running (13,19); Riding on a vehicle (1,3,8,13,19); Walking while pushing a vehicle (1,19); Throwing objects from one end to target at another end - bowling (18)	Space along wall, space along row of objects/ furniture
11	Raised path	Horizontal surface, flat (or slightly curved), hard, long (forming a path), elevated from the floor level	Walking along (3,8); Walking along – slightly curved path (4,5,6,9,10,12)	Balance beam, set of blocks in linear arrangement
12	Enclosed path	Flat surface, long (forming a path), enclosed on sides and top	Crawling into and along (7, 17, 19, 10, 18); Creeping into and along (11); Staying inside and being dumped with objects (19)	Cloth tunnel, with straight or curved path
13	Hung path	Horizontal path, hung on a height above child's head	Swinging (1,7,8,11,13); Swinging while sitting on the hung surface (2,8); Hanging (3)	Flying fox
14	Small space	Relatively small area, bounded by other objects	Sitting on or standing on while playing with objects (2,3,6,7,9,13,16)	Space between objects/furniture
15	Sheltered space	Space with enclosure on top, broad (forming an area)	Crawling into (18); Walking underneath (6) with bending body	Space below raised platform, space below hung surface
16	Hollow cylinder	Curved, thick surface forming a hollow in the centre, with height 1.5 x child's body and width = child's body	Sitting on (1, 10); Standing on (10); Shaking (1); Hitting, tapping (9); Crawling along (1,10); Walking/balancing (9); Getting inside (7,8,15), hiding (12,18); Stay inside and being stuffed with object (18); Running surrounding it (17); Stepping on to reach higher (6,16); Collecting stuffs from inside (15)	Soft cylinder block
17	Donut-shaped object	Curved, thick surface forming a hollow in the centre, with height = child's foot and width = child's body	Climbing on (1); Stepping on to reach higher (2); Collecting stuffs from (1); Crawling across (12); Running surrounding it (12)	Donut shaped soft block, half circle soft block

Note: [a]The number in the brackets indicates the session number in which the affordances were found.

Secondly, an object or a space may have multiple affordances because it might be **positioned in different ways**. For example, the hollow cylinder (No. 16) when positioned horizontally could afford walking/balancing on and crawling along or when positioned vertically could afford sitting on and getting inside from the top (Figure 2). In contrast to the examples illustrated in Figure 1, these examples indicate that the change of object position could essentially change the primary spatial features of the object and thus could generate different affordances.

The findings in Table 1 also illustrate that some primary spatial features seem to offer more possibilities for different actions, as indicated by its frequent use by the children during the observed sessions. For example, the raised surface (No. 1), the slanted surface (No. 2) and the bouncy surface (No. 7) were used more frequently than the vertical surface (No. 3) or the sheltered space (No. 15). This indicates that a certain degree of possibility for actions offered by certain objects or spaces that seems to depend on the potential afforded by its primary spatial property, as well as the potential for the objects and spaces to be positioned in different ways.

Thirdly, an object or a space may have multiple affordances when it is **complemented with additional elements**. For example, when a slanted surface (No. 2) was complemented with a cloth tunnel, it had an additional affordance for crawling (Figure 3a); when it was complemented with a cushion it had an additional affordance for walking and balancing (Figure 3b); when it was complemented with foam spread on its surface, it had an additional affordance of sliding, whilst erasing the foam (Figure 3c). In these examples, the additional elements complemented the spatial property of an object or a space and thus created other possibilities of actions. This finding also suggests that the affordances of an object or a space might be extended by introducing additional spatial properties, such as texture or other tactile elements on the existing surface. The presence of such additional elements increases the complexity of the object and space and thus creates additional affordances.

The nature of multiplicity of affordances that was found in the objects and spaces suggests a wide range of possibilities in which the child's action utilises the available environment. In relation to the development of a child's sensory integration, these possibilities of actions suggest a wide range of opportunities for the child to receive different kinds of sensory inputs and to respond appropriately to them. Depending on the child's needs, sensory input might be presented to the child in the form of an excitatory or an inhibitory input (Kinnealy & Miller, 1993) and certain types of sensory input might be appropriate for either a hypoactive or hyperactive child (Rie & Heflin, 2009). The presence of multiple affordances for various actions, as demonstrated in the examples above, allows these different forms of sensory input to be presented to the child and then in response to the child's actions.

As an example, when a child was presented with a slanted surface on which s/he could slide downward (Figure 3), this offered an experience that was beneficial for the development of body perception, balance and gravitational comfort. When the foam was added to a slanted surface, the experience of sliding on

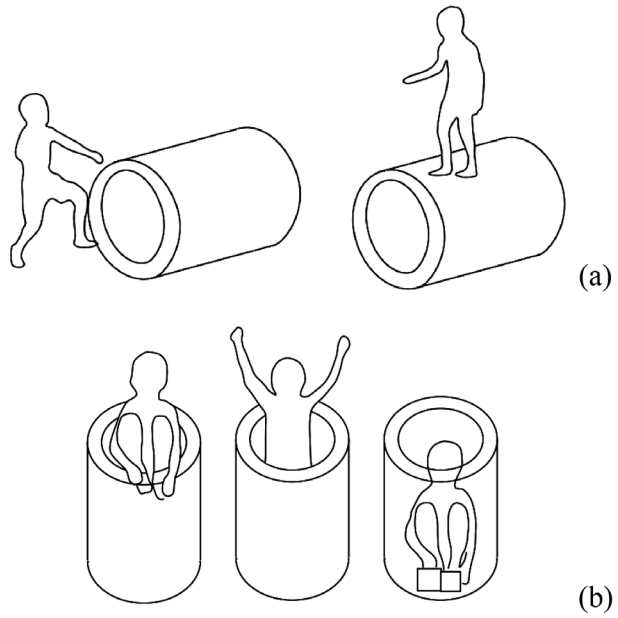

Figure 2. Multiple affordances of an object due to (a) horizontal position (b) vertical position.

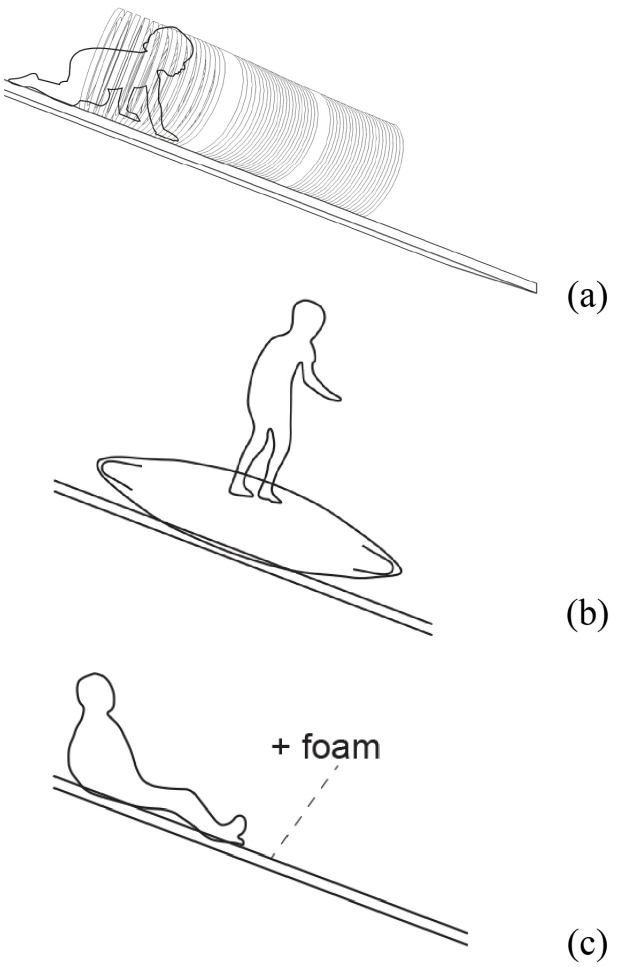

Figure 3. Additional elements extend affordances for actions.

top of the foam provides an additional tactile experience. Another example was a variety of experiences offered when a child was presented with a hollow cylinder (Figure 2). The experience of balancing on an unstable surface is important for the development of body balance; consequently, the experience of crawling along the cylinder was an opportunity to exercise coordination of hands and feet and in addition the experience of being inside the hollow cylinder was important to develop the child's awareness of boundaries surrounding his/her body.

These examples illustrate that the presence of multiple affordances also mean multiple possibilities for sensory inputs for the child. It is important, then, to understand the nature of how the interaction occurs between child's body and spatial features through the child's variety of actions, as will be discussed in the following section.

Relational Character of a Child's Body-Space Interactions

The list of affordances in Table 1 illustrates the affordances that are found in spaces and objects that support a child's various actions. However, Chemero (2003) emphasised that affordances are not properties of the environment only, but they are essentially located in the relations between the body and environment. Affordances depend on both the properties of the person as a user and the properties of the environment or its artefacts (Maier & Fadel, 2009). Therefore, the discussion of affordances should not be limited to the facts that different spaces and objects allow the emergence of a certain child's actions, but it is necessary to look into the relations that occur between the child's body and these spaces or objects.

The activation of the affordances of spaces and objects depend on their relationship with the child's body, in at least three of the physical aspects: dimensions, position and parts of objects. An object or space can afford certain actions, due to the suitability of its dimension to the body utilising it and in particular in relation to the suitability to the dimension of the body parts that are involved in the body-object or body-space interaction (Heft, 1988). This study found some occurences that illustrate how the relationship between the dimensions of the child's body and the space/object makes it possible for the child to perform actions that utilise each specific affordance. For example, the stepped surfaces might afford stepping up or stepping down, due to the height of the step relative to the child's feet. This suitability of the dimensions between the child's feet and the step's height then afford the child's ability to raise his foot to step on either the higher step or the lower step (Figure 4).

The **position** of the child's body to a space or an object is also important in the activation of affordances. An affordance of an object could be activated when the object is reachable and located in the person's peripersonal space (Constantini et al, 2010), or positioned in appropriate orientation for the person's response (Humphrey, 2001). There are various occurences in this study that demonstrated the activation of an affordance based on the positioning of the child's body in relation to the space or an object. For example, the tunnel, as an enclosed path, (No. 12) afforded crawling into, but this could only happen when the child's body position was at one end of the tunnel and when the tunnel was beyond his/her reach, allowing him/her to crawl into it. Another example was found in the slanted surface (No. 1) of the slide that afforded walking upward as well as downward and the activation of any of these affordances depended on the child's position. The affordances of walking downward could be activated only when the child was at the top of the slide, while the affordances of walking upward could be activated only when the child was at the bottom part of the slide. Similar things also happen when on stepped surfaces (No. 4). These examples suggest the role of an object's position in relation to the child's body in the process of activation of certain affordances (Figure 4).

The child's interaction with an object or a space also depends on the part of objects that are involved: the child may interact with the object or space as a whole or only with a certain part of it. The concept of affordances may apply in various scales, from large macro-scale projects to more human-scale objects to smaller micro-scale elements (Maier & Fadel, 2009). Such complexities of object and space suggest that where and how affordances emerge become important. Gibson (1986) explained the nesting principle, in which smaller units of an environment are part of a larger unit, and then the affordances might be present in both the smaller and larger units. Ellis and Tucker (2000) also suggested the presence of micro-affordance which affords specific components of action. It seems that the activation of affordance needs to consider a specific component or part of an object or space. In other words, it is necessary to analyse which parts of an object or a space have affordance and which parts are utilised.

An example found in this study was the multiple affordances of the raised surface (No. 1); it allowed static action (sitting), dynamic action (walking along the periphery), as well as action that relates to its surroundings (throwing and catching ball). The

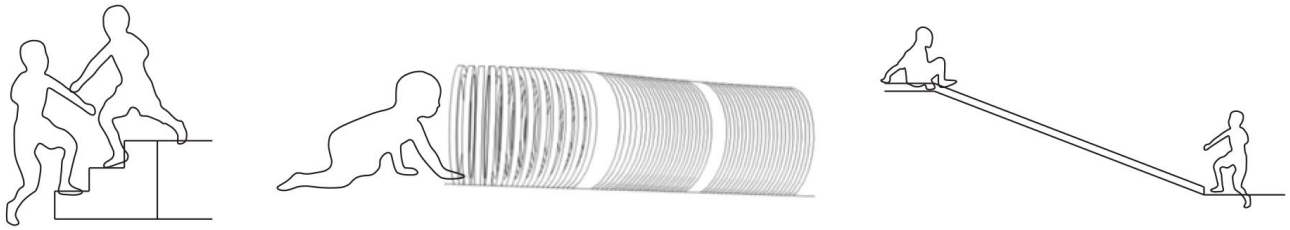

Figure 4. Activation of affordances due to dimension and position.

activation of these various affordances occurred at different parts in each one of the platforms. Under such circumstances, each one might have different spatial properties and thus each one would interact in different ways with the child's body. The full range of activites includes: sitting which occurs at the centre of the platform or that which occurs on a flat surface that afforded sitting or that which involved walking along the periphery or that which occurs at the periphery of the platform or on which a surface forms a path surrounding the platform. Meanwhile, throwing and catching a ball occurred not due entirely to the property of the surface, but this activity was related to its position at a level higher than the floor level, thus allowing the child to catch and throw a ball between the platform and the floor level (Figure 5).

The body-space relations illustrated above could also be explained by considering the affordance relationship as a system consisting of structure, behaviour and purpose. "Systems afford behaviours via their structure for a purpose... *Structure* determines what *affordances* exist. The *affordances* indicate what *behaviors* are possible... the ultimate usefulness of the affordance to the users ... is the *purpose* of the system and its organization" (Maier & Fadel, 2009, p. 398). In the above examples, the structure of the affordance relationship is manifested in the various forms of body-space relations, in which the aspects of dimension, position and parts of an object play a role in the activation of affordances, which ultimately serve the purpose of sensory integration.

So far it is clear that the activation of affordances could be seen in terms of its relational character, thus demonstrating the relational nature in the interaction between the child's body and the environment. However, within the context of affordances of spaces and objects for sensory integration of an autistic child, it becomes necessary to consider how such a relational nature of various affordances could contribute in promoting the sensory integration. We will now turn to the relevance of the idea of multiple affordances and their characteristics in relation to the process of adaptive response, as a key concept in the sensory integration of an autistic child.

Affordances of the Physical Environment and Adaptive Responses

To understand the role of physical environment in supporting the process of adaptive responses within the context of an autistic child's sensory integration, it is important to discuss the mechanism of how the body responds to the affordances offered by the physical environment. Affordances of spaces and objects not only offer possibilities for various actions and activities, but also they may trigger and invite certain actions (Withagen et al., 2012). This is also relevant to the idea of exploring different forms (Hertzberger, 2000) that could encourage the users to conduct certain activities utilising the environmental features.

For an autistic child, the presence of affordances could create certain sensory challenges, in the form of action possibilities that are ready to be used and responded to by the child. Since there are multiple affordances that are offered by the various spaces and objects, it becomes necessary to understand how the activation of affordances happens. The activation of affordances depends on the task and situation (Borghi et al., 2012), in which an affordance might be activated when there is certain task assigned for utilising the affordance and the situation that also allows for activation. The activation also depends on whether the affordances are perceptible or in particular whether the attributes of the object that are relevant for an action to be perceptible (Gaver, 1991).

In addition to the situation that allows for the emergence of affordances, the active role of the human body as the user of an affordance also needs to be taken into account, since "affordances are not passively perceived, but explored" (Gaver, 1991, p. 82). This active perception of affordance is explained by the role of exploratory behaviour in the process of perceiving the affordances (Gibson, 1986, 1988). The human body, in the process of perceiving an affordance, also involves an awareness of the relational character of the body and space from which the possibilities of action could emerge. The idea of space as a possibility for actions suggests that the human body as an active actor that could adapt his/her action in order to respond to the situation offered or presented (Turvey, 2004). Turvey describes an example of a person changing his/her action from walking to running in response to the presence of a gap in space. The role of a human in detecting the properties of the body-environment relations is integrated with the exploitation of such properties through "adaptive action" (Stoffregen, 2003).

The process of adaptive action becomes invariably possible with the presence of multiple affordances of objects and spaces. An illustration evident in this study was in various occurrences of a child moving along a path. In general, movement along a path

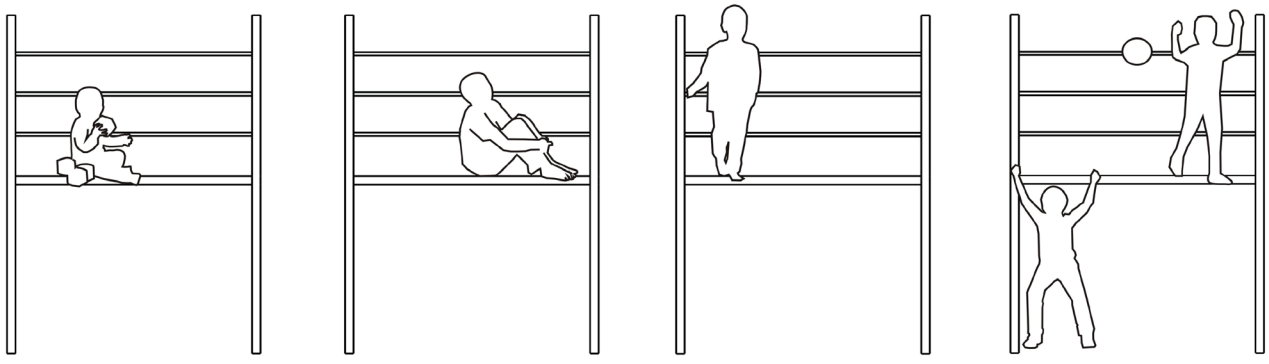

Figure 5. Activation of affordances in certain parts of objects or spaces.

could be undertaken by different possibilities: walking, running, and crawling. However, the child's response of whether to walk, run or crawl is also related to the primary spatial properties that are involved in such action. The open path (No. 10) was present as an empty space with no obstacles and thus this type of spatial property might encourage the child to run along the path. Meanwhile, when the child was presented with an enclosed path (No. 12) with an enclosure on all sides, the child adapts his body posture into a crawling or a creeping posture, since walking or running with straight posture was not possible (Figure 6).

These illustrations suggest that the mechanism of adaptive action by the child in response to the environment is important for understanding how the process of adaptive response occurs during the autistic child's body-space interaction. They also demonstrate how the process of adaptive response is essentially a combination of adaptation and assimilation, in which the child accommodates him/herself to the environment and assimilates the environment to him/herself (Ayres, 2005). This process is manifested through the interaction of the child's body with the spaces and the objects that are used during the respective actions.

Further explanation on the process of the child's adaptive response towards the sensory input presented through the spaces and objects is by considering the affordances as functional properties of the environment (Heft, 1988). For example, this study found that there were various kinds of surfaces that the child utilised as being walk-on-able surfaces, such as a flat surface, a raised path, a slanted surface, a bouncy surface, a hung surface as well as the curved surface of the cylinder. All of these spatial properties allowed the child to walk on or within them, but the specific properties of each kind of surface made them represent different kinds of walk-on-able surfaces that could promote different adaptive actions (Figure 7).

The raised path (No. 11) offers opportunities for the action of walking along a narrow surface, which triggered the child to coordinate his/her body to balance in order not to fall. The raised surface (No. 1) offers possibilities for the child to walk along a periphery, thus following a certain direction of movement. The slanted surface (No. 2) offers possibilities for walking upward or downward, but at the same time this spatial property triggered the child to respond to a gravitational challenge created by the slanted surface. The bouncy surface (No. 7), the hung surface (No. 9) and the curved surface of the cylinder (No. 16) were also walk-on-able surfaces, but due to the unstable properties of the surfaces, the child needs to adapt his/her body posture and actions to achieve balance while walking on these surfaces.

The illustration in Figures 6 and 7 indicates that both the multiplicity and relational character of the affordances seem to play an important role in supporting the process of adaptive response. We will now turn the discussion to how these characteristics are manifested in the physical layout of the environment.

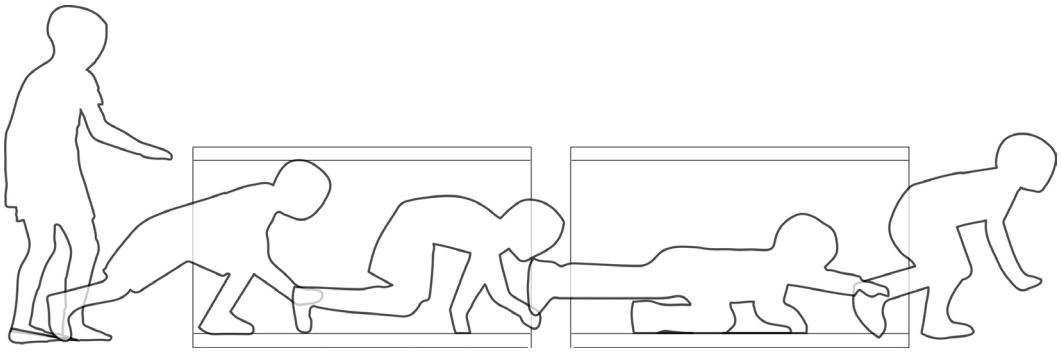

Figure 6. Adaptive action triggered by the spatial properties of objects or spaces.

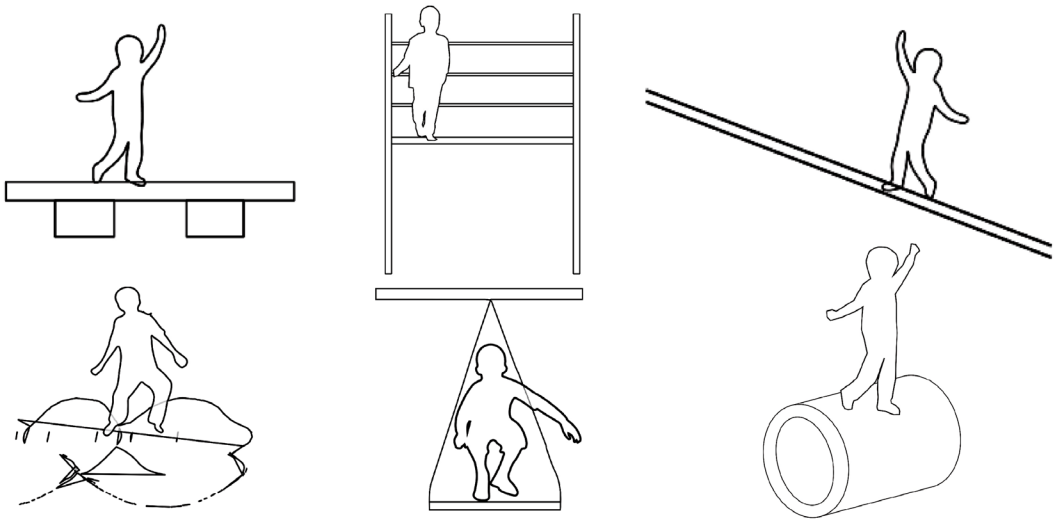

Figure 7. Different possibilities offered by different walk-on-able surfaces.

The Role of the Physical Layout

The physical layout of spaces and objects becomes an eventual purpose of providing the environment which supports sensory integration. The development of the physical layout involves an understanding of how certain categories of actions could be selected and controlled, and this process becomes particularly complex when an environment consists of multiple objects (Humphreys, 2001). The findings of the study suggested that the development of the physical layout may generate the multiplicity of affordances when considering at least two aspects: **positioning** of spaces and objects in relation to the child's body and a **combination** of several spaces and objects to form a set of affordances in a sequence of affordances.

The **positioning** of spaces and objects in relation to the child's body is important since the affordance could only be activated when the space or object is positioned within reach of the body. In addition, the position of the body in relation to the spaces and objects might also suggest the direction of movement for the actions to be activated, for example, whether the child would step up or step down, or whether the child would enter a tunnel or not (Figure 4). The activation of affordances is also related to a specific part of the space or object that the body interacts within a particular occasion (Figure 5). Other findings suggest that certain objects might be positioned horizontally and vertically, and each position allows different actions (Figure 2). From these findings, it becomes clear that the physical layout of the environment could generate multiple affordances when the spaces and objects are positioned appropriately in relation to the child's body. Therefore, it is possible to develop certain physical layouts of spaces and objects in order to allow various possible patterns of actions and direction of movements.

In relation to the positioning of spaces and objects, some findings in this study also suggest that the spaces and objects need to be considered as dynamic elements. Another possibility of multiple affordances might happen when an object or space in a certain position is perceived from different points of view and therefore this tendency woud lead to the emergence of different affordances. For example, a raised platform, when considered as a raised surface (No. 1) provides certain affordances, but the same surface also could be considered as a surface enclosing its bottom part, thus creating a sheltered space (No. 15) with different affordances (Figure 8a). Similarly, a hung surface (No. 9) provides certain affordances, but at the same time, the space underneath the surface becomes a sheltered space (No. 15) with affordances for crawling into or walking in a bending posture (Figure 8b). Multiple affordances could also be created when a set of objects with certain heights is combined together in a linear arrangement, thus forming a raised path (No. 11) for walking and balancing, and the empty space next to this line becomes an open path (No. 10) that allows for more free movement (running, riding in a vehicle etc.).

These examples illustrate that the arrangement of objects and spaces to allow for the emergence of different affordances, especially when a certain object is not considered as a single entity on its own, but is considered from a different point of view and in relation to other objects or spaces. In this possibility of a physical layout, the positioning of objects in relation to the body (Constantini et al., 2010; Bernston & Cacioppo, 2009; Humphrey, 2001) and the understanding of the parts of objects (Gibson, 1986; Ellis & Tucker, 2000) become particularly important.

The positioning of spaces and objects is also important, not only in relation to the child's body, but also in relation to other spaces and objects. **Combining** different spaces and objects one with another would also extend the possibilities of actions and sensory experiences offered to the child. The combination of objects, as already illustrated in Figure 3, suggests how certain objects when complemented with certain additional elements could extend the possibilities of actions. Therefore, it becomes important to consider various possible combinations of spaces and objects. This is also important since each child has different needs of sensory inputs, and the correct combination of objects and spaces might help to present appropriate sensory inputs for the child. In the example in Figure 3, the addition of a tunnel to the slide might be appropriate for the child who needs to develop coordination of hands and feet through crawling downwards, while the addition of foam might be appropriate for the child who needs certain tactile experiences.

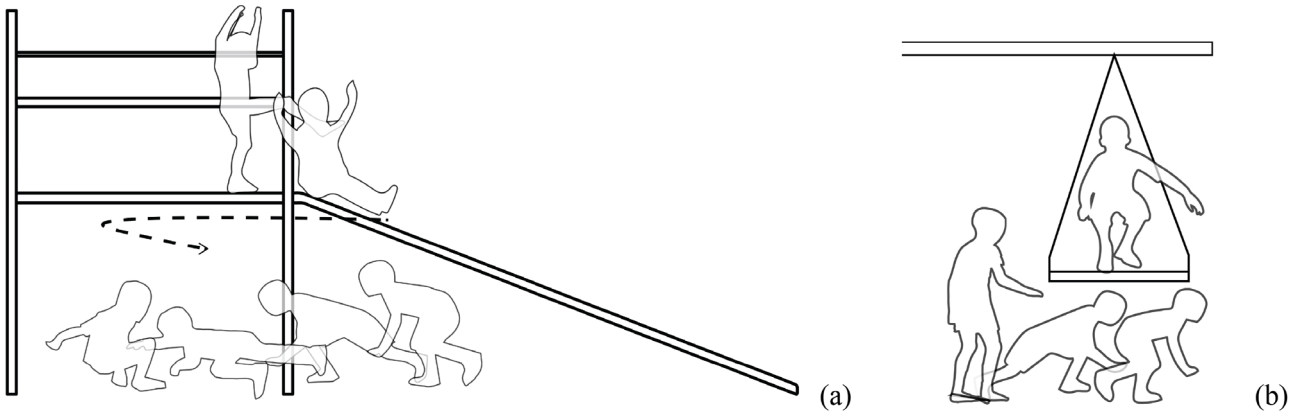

Figure 8. Different affordances emerged in certain physical layout.

Spaces and objects could also be combined with one another to create a set of affordances which allow for the experience of sequential affordances (Gaver, 1991; Lu & Cheng, 2013). This could be achieved by creating "situations in which acting on a perceptible affordance leads to information indicating new affordances" (Gaver, 1991, p. 82). Some examples were found in this study when several objects were combined to form a series of possibilities of actions.

The combination might be created by a set of similar objects. For example, a number of bouncy surfaces arranged together could create affordances for jumping from one part to another in a continuous manner, thus providing opportunities for a series of actions: jumping, landing (also balancing), jumping, landing and so forth (Figure 9a). The combination might also involve different kinds of spaces and objects, thus further extending the possibilities of action as illustrated in some examples found in this study. A slanted surface followed by a raised path, another slanted surface and an enclosed path offered possibilities for a series of actions: walking upward, balancing, walking downward, and crawling along (Figure 9b). A series of steps followed by a raised surface and a slanted surface created a sequence of affordances for stepping upward, balancing, and sliding down (Figure 9c). A slanted surface followed by a series of vertical steps, a raised surface and a pile of cushions created a sequence of affordances for walking upward, walking, jumping and landing on (Figure 9d).

The set of affordances that triggers various actions in a certain sequence is important in the process of adaptive response, since the child could be involved in "physical activities that produce sensations that lead to adaptive responses that provide more sensations that elicit even more complex adaptive responses" (Ayres, 2005, p. 141). Providing a physical layout that allows for continuous actions seem to be beneficial to promote the process of adaptive response.

Those four examples of combination in Figure 9 are only few among many other possibilities of combinations that might be created from various primary spatial properties identified in Table 1. The way these spatial properties are arranged could determine the types of sensory experiences to be presented to the child, depending on the needs of each individual child. The combination of objects and spaces could create a sequence of experiences that involve sensory inputs that are inhibitory or excitatory (Kinnealy & Miller, 1993), or a combination of both.

The above possibilities of physical layout, manifested through certain forms of positioning and combining of spaces and objects, become important to understand how the spaces and objects could be designed in order to promote the process of adaptive response for an autistic child's sensory integration. Although the arrangement of physical layout as demonstrated above could also be relevant to normal children, the process of adaptive response that could be promoted through theses affordances become particularly relevant for autistic children to improve their sensory processing. The correct arrangement of spatial environment through correct utilisation of affordances that promote correct sensory processing could be beneficial for autistic children.

Implications for Spatial Design

From the point of view of affordance-based design, design is basically a process of creating an environment that "possesses all the desired affordances" and "does not possess any undesired affordances" (Maier & Fadel, 2009, p. 405). Therefore in designing the space to promote sensory integration, the key is in understanding how the knowledge of affordances could be relevant. In particular, based on the findings of this study, the design of spaces and objects needs to be based on the understanding of the multiplicity and relational character of affordances and their role in supporting the process of adaptive response.

Designing based on the understanding of multiplicity and relational character of affordances is quite different from simply designing the physical objects and spaces. To design physical objects and spaces means to design the physical features of objects and spaces by considering how they are used by human. Meanwhile, our findings here suggests the needs for the design that focuses on how the physical features of objects and spaces might be used in different ways for body actions, and how they might trigger adaptive actions as a way of responding to different sensory inputs through various action strategies. In this way, the physical features present challenges and opportunities for the

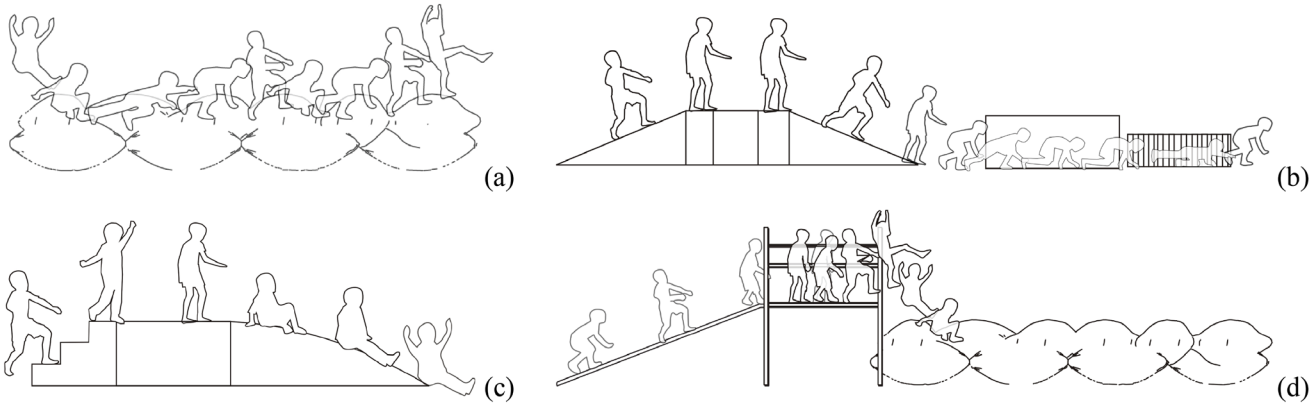

Figure 9. Sequences of affordances created by: (a) similar objects (b), (c), (d) different kinds of objects.

development of sensory integration, not only the challenges to achieve certain goal, but also the challenges to act on the physical environment in different ways.

The findings of the study indicate various types of affordances that could be utilised in order to form a rich sensory environment that could in turn promote the process of sensory integration and adaptive responses for autistic children. However, the arrangement of spaces and objects to form a certain set of affordances, and the choice of affordances to be included in such set should consider the different individual needs of each child. Therefore, the design of spaces and objects for sensory integration should consider the issue of how the child would respond to certain forms of affordances. In addition, the design should also ensure that the positioning of spaces and objects allows the therapist to easily manage the process depending on the goals of intervention. What is also important is the development of sets of affordances and how to position them in relation to the child's body in such a way that they could invite the autistic child to engage in meaningful actions.

The concept of affordances contains the key idea of relations - that affordances are relations between the abilities of individuals and features in the environment (Chemero, 2003) and that affordances are "emergent properties of animal-environment system" (Stoffregen, 2003, p. 116). Thus designing affordances for the child's sensory integration is essentially designing for the body-space relations or, more specifically, designing the properties of the systems that promote body-space interaction that is meaningful for the development of sensory integration. While the final outcome of the design inevitably consists of the physical objects and spaces, the process needs to embody the understanding of how multiplicity and relational characteristics of affordances are created. In this way, the design integrates our understanding of how the child's adaptive response occurs as a manifestation of the body-space transaction.

The findings of this study indicate that the understanding of multiple affordances and their relational character in terms of body-space relations would lead to the design of physical layouts for autistic children that would consider thoroughly the positioning of spaces and objects in relation to the child's body. It also suggests the needs for the design that are based on the combination of physical properties of spaces and objects that form a meaningful set or sequence of affordances. Any spatial elements that are included within the design should become an integral part of the system where body-space interactions take place. Thus they would form an integrated physical setting where the body-space interactions are manifested through various meaningful actions. While the idea is important in the context of promoting the autistic child's sensory integration, it also prompts the need for more attention in designing spaces and objects as a part of the body-space system for more general purposes of spatial design. Designing by understanding multiple affordances and their relational characteristics would lead to spatial design that not only provides possibilities for actions, but also enhances meaningful purposes of the spaces for the body.

Acknowledgments

This research was funded by Universitas Indonesia Research Grant 2012.

References

1. Altman, I., & Rogoff, B. (1987). World views in psychology: Trait, interactional, organismic and transactional. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology* (Vol. 1, pp. 7-40). Malabar, Australia: Krieger.
2. Ayres, A. J. (2005). *Sensory integration and the child*. Los Angeles, CA: Western Psychological Services.
3. Bonnes, M., & Secchiaroli, G. (1995). *Environmental psychology: A psycho-social introduction*. London, UK: Sage.
4. Borghi, A. M., Flumini, A., Natraj, N., & Wheaton, L. A. (2012). One hand, two objects: Emergence of affordance in contexts. *Brain and Cognition*, *80*(1), 64-73.
5. Broberg, A., Kytta, M., & Fagerholm, N. (2013). Child-friendly urban structures: Bullerby revisited. *Journal of Environmental Psychology*, *35*, 110-120.
6. Caan, S. (2011). *Rethinking design and interiors: Human beings in the built environment*. London, UK: Laurence King Publishing.
7. Chemero, A. (2003). An outline of a theory of affordances. *Ecological Psychology*, *15*(2), 181-195.
8. Costantini, M., Ambrosini, E., Tieri, G., Sinigaglia, C., & Committeri, G. (2010). Where does an object trigger an action? An investigation about affordances in space. *Experimental Brain Research*, *207*(1-2), 95-103.
9. Ellis, R., & Tucker, M. (2000). Micro-affordance: The potentiation of components of action by seen objects. *British Journal of Psychology*, *91*(4), 451-471.
10. Fjortoft, I., & Sageie, J. (2000). The natural environment as a playground for children: Landscape description and analyses of a natural playscape. *Landscape and Urban Planning*, *48*(1-2), 83-97.
11. Franck, K. A., & Lepori, R. B. (2000). *Architecture inside out*. West Sussex, UK: Wiley Academy.
12. Gabbard, C., Cacola, P., & Rodriques, L. P. (2008). A new inventory for assessing affordances in the home environment for motor development (AHEMD-SR). *Early Childhood Education Journal, 36*, 5-9.
13. Gaver, W. W. (1991). Technology affordances. In S. Robertson, G. Olson, & J. Olson (Eds.), *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 79-84). New York, NY: ACM.
14. Gibson, E. J. (1988). Exploratory behavior in the development of perceiving, acting, and the acquiring of knowledge. *Annual Review of Psychology*, *39*, 1-42.
15. Gibson, J. J. (1986). *Ecological approach to visual perception*. Hillsdale, NJ: Lawrence Erlbaum.
16. Heft, H. (1988). Affordances of children's outdoor environments: A functional approach to environmental descriptions. *Children's Environments Quarterly*, *5*(3), 29-37.

17. Hertzberger, H. (2000). *Space and the architect*. Rotterdam, the Netherlands: 010 Publisher.
18. Humphreys, G. (2001). Objects, affordances ...action! *The Psychologist*, *14*(8), 408-412.
19. Kinnealy, M., & Miller, L. J. (1993). Sensory integration/ learning disabilities. In H. L. Hopkins & H. D. Smith (Eds.), *Willard and Spackman's occupational therapy* (8th ed., pp. 474-489). Philadelphia, PA: Lippincott.
20. Larkey, S. (2007). *Practical sensory programmes for students with autism spectrum disorder and other special needs*. London , UK: Jessica Kingsley Publishers.
21. Lu, J., & Cheng, L. (2013). Perceiving and interacting affordances: A new model of human–affordance interactions. *Integrative Psychological and Behavioral Science, 47*(1), 142-155.
22. Maier, J. R. A., & Fadel, G. M. (2009). An affordance-based approach to architectural theory, design, and practice. *Design Studies*, *30*(4), 393-414.
23. Niklasson, L., & Sandberg, A. (2010). Children and the outdoor environment. *European Early Childhood Education Research Journal*, *18*(4), 485-496.
24. Rie, G. L. V., & Heflin, L. C. (2009). The effect of sensory activities on correct responding for children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *3*(3), 783-796.
25. Roley, S. S., & Jacobs, E. (2008). Sensory integration. In E. B. Crepeau, E. S. Cohn, & B. A. B. Schell (Eds.). *Willard and Spackman's occupational therapy* (11th ed., pp. 792-817). Baltimore, MD: Lippincott Williams & Wilkins.
26. Rose, J., & Rosenow, N. (2007). Positive strategies for children with sensory integration challenges. *Exchange*, *Sept/Oct*, 40-44.
27. Schaaf, R. C., & Miller, L. J. (2005). Occupational therapy using a sensory integrative approach for children with developmental disabilities. *Mental Retardation and Developmental Disabilities Research Reviews*, *11*(2), 143-148.
28. Stoffregen, T. A. (2003). Affordances as properties of the animal–environment system. *Ecological Psychology*, *15*(2), 115-134.
29. Tuan, Y. F. (1977). *Space and place: The perspective of experience*. Minneapolis, MN: University of Minnesota Press.
30. Turvey, M. T. (2004). Space (and its perception): The first and final frontier. *Ecological Psychology*, *16*(1), 25-29.
31. Withagen, R., de Poel, H. J., Araujo, D., & Pepping, G. (2012). Affordances can invite behavior: Reconsidering the relationship between affordances and agency. *New Ideas in Psychology*, *30*(2), 250-258.
32. Ye, L., Cardwell, W., & Mark, L. S. (2009). Perceiving multiple affordances for objects. *Ecological Psychology*, *21*(3), 185-217.
33. Zumthor, P. (2006). *Atmospheres: Architectural elements, surrounding objects*. Basel, Switzerland: Birkhauser.