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The Role of the Senses in Children's Perception of Space

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Abstract

While we humans exist in space through our bodies, we experience it via all our senses and build up an integrated knowledge of the world in our memories. However, children's conception of the world differs from adults due to their developmental stages. This study aims to examine human-space interaction with a new approach to reveal the effects of sensory stimuli on children's perception and memory of space. The case study was conducted in a theme park that offers various sensory stimuli with particularly designed spaces and activities. For the behavioral data, the spatial preferences of the participants (33 children, age 10) were recorded during the tour, and for the memory data participants were asked to draw pictures (cognitive maps) afterwards. The data sets were redefined by the main sensory stimuli offered by the spatial units (spatial data), and the number of stimulus experiences and the number of stimulus recalls were analyzed comparatively. Contrary to popular belief, the results show that (1) all of the senses take part in perception depending on the existing stimuli in the space, vision does not have any precedence; (2) the functioning of the senses during an experience changes depending on how much stimulus they are exposed to and how much the body participates in the perception process; (3) kinesthetic stimuli come to the fore as the best stored stimuli in memory, whereas the taste stimuli remain in the background as the least remembered ones. The case study group was limited, the subjective aspects of perception, and the age and gender differences that may exist are ignored. With the inclusion of age and gender factors precisely, this methodology could reveal promising alternatives for design methods and guide the production of all types of architectural spaces, including the children's spaces. This study proposes an original perspective that regards both the physical and social components of the space as the source of perception; and it attempts to make up for a deficiency by regarding the children who are mostly neglected in other studies, yet are active users of the space.

Keywords:
Children, cognitive map, memory, multi-sensory perception, perception of space

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INTRODUCTION

Human beings exist in space. During this existence, our bodies are tools for establishing a relationship of physical and sensory integrity with the environment (Merleau-Ponty, 1964), and our experience is the foundation of the reciprocally ongoing human-space interaction. In this context, human senses are one of the main means of interaction. They are the bodily functions that provide people with cognitive data about the experienced environment and internal or external situations, i.e., the information needed to understand the world, life, and to survive as active social beings (Ingold, 2011; Üstündağ, 2011; Kranowitz, 2014).

The perception and learning processes via the senses never actualize through a single sensual modality; many senses such as vision, hearing, touch, smell, and balance work together (Gibson, 1950). In the perception of space, the physiological qualities of the body and its movement in space shape a holistic perception with the addition of the information of physical components of that space, its participants and their activities. For instance, disabled, pregnant or child participants interact with different components of an environment through their experiences depending on their bodies, their cognitive characteristics, and their physical and social needs. At the end of their subjective evaluation of the collected information from those differing sources, a unique spatial memory that belongs only to the perceiving individual is built.

Among the former studies related to the perception of space, it is a fact that the diversity of human senses, which is the most important factor in the relationship between the perceptual integrity of the space and experience, is mostly ignored. The findings of psychological studies cannot be evaluated on a spatial scale because of their limitations of research scale, contents, and participant groups (Marks, 1978; Van der Stoep et al., 2017), whereas architectural and environmental perception theories are mostly limited to the visual qualities of space (Eco, 1980; Jencks, 1980; Rapoport, 1990, Venturi & Brown, 2004; Aytem, 2005; Ertürk, 1984, Asar, 2013). Still, the increase in the number of studies investigating the role of different types of senses in the perception of spaces after 2000 shows that the deficiencies in this area have been noticed (Howes, 1991; Classen, 1993; Pink, 2009; Ingold, 2011; Pink & Howes, 2010; Henshaw, 2013; Hamlacıbaşı, 2019; Seçkin, 2010; Öktem Erkartal & Ökem, 2015; Öztürk & Durmuş Öztürk, 2020).

The main perceptual patterns emerge in childhood. During this period the ongoing physical, cognitive, and emotional development processes affect both the experience and the relationship with space and differentiate children's spatial perception from adults. This fact makes the questions of how the sensory factors work in child-space interaction and how the senses work in a child's perception process essential topics for research. However, children who are also part of an active group using space remain a partly neglected subject in former research. There are a couple of studies that have questioned the effects of different types

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of spaces (educational, play, social, etc.) on the spatial behavior, perception and learning of children (Day & Midbjer, 2007; Moore & Young, 1978; Olds, 1987), and there are some original studies that focus on spatial perception of children (Çanakçıoğlu, 2011; Baksi, 2018; Koç, 2012; Çermikli Buluklu, 2015; Köksüzer, 2013; Yılmaz, 2005), but unfortunately the studies that focus the role of senses in children's perception of space are very few (Başoğlu, 2002; Temel, 2015; Dilmaç, 2018).

Within this framework, this study aims to examine human-space interaction with a new approach and reveal the effects of sensory stimuli on children's perception and memory of space. In the first part of the study, the theories of perception, sense, and memory are discussed within the framework of spatial perception and child perception, and then the field study, findings, and general evaluations are presented.

LITERATURE REVIEW

Perceiving the World

In the actuality of living in and perceiving the world, the human body is at the center of everything (Merleau-Ponty, 1964). While man exists in the body in motion, there is a constant relationship between the entire body, its movements, and the information sources of the environment. As active information seekers, the senses constantly collect stimuli from the environment and the mind creates a cognition of the world. There is a perception-action cycle here; action is taken after perception, new stimuli are encountered while in action, and the learning process is continued by distinguishing these stimuli (Gibson, 1977). In this process, only the stimuli that exceed certain perceptual thresholds (absolute threshold and difference threshold) are perceived and then transferred to memory through "bottom-up processing". In the end, only the selected information is stored; and is repeatedly reconstructed in every reuse in the course of life (Goldstein, 2013).

Each sense has an optimal usefulness in different circumstances and its own unique subjective impressions that must not be disrupted by the integrative process (Stein and Stanford, 2008). However, if the senses operate collectively, they have the ability to increase the potentiality to detect and identify environmental data, and if they combine their individual sources of information they reveal the nature of the whole experience (Stein and Stanford, 2008). In fact, the senses always coexist and work simultaneously. The nervous system always integrates (or binds) cues from different senses to form a perception of a unitary experience (Stein and Stanford, 2008). This synthesis of the sensual information modifies our perceptions, influences our reactions, and continuously shapes our view of the world (Wallace, 2004).

Furthermore, the senses train each other by continuing to both work by themselves and by communicating their knowledge to each other (Smith, 2005). The mutually shared information is revived in future experiences that take place later; therefore, when an object is perceived

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by vision, its smell, taste, texture, and possible movements are remembered at the same time (Smith, 2005).

Just as each sense is unique, every individual's perception is unique, too. During perception, the coded information is changed in line with additional information, and it becomes subjective depending on the individual's identity, past, and the retrospective information in his memory (Goldstein, 2013; Cüceloğlu, 2006). According to Rapoport (1977) this subjective aspect of perception in which the individual makes sense with his/her feelings and values is auto-centric (self-centered), whereas the objective aspect of perception, which consists of stimuli and sources, is allocentric (others-centered).

The Beginning of Perception; Senses

In 1969, Gibson classified the senses as the visual, auditory, taste-smell, basic direction-finding, and tactile systems, whereas in 1999, Steiner asserted that there are at least twelve senses (touch, sense of life, sense of self-movement, balance, smell, taste, vision, sense of temperature, hearing, language sense, conceptual sense, ego-sense). In the last 50 years, different classifications that include from 6 to 12 components have been developed with the articulation of subcategories of touch (temperature, coldness, pain), organic senses, and muscular senses (balance, muscle) (Kahvecioğlu, 1998). Today, seven senses appear to be the basic senses included in most of the current classifications: vision, hearing, smell, touch, taste, balance, and muscle. Among these, vision, and hearing, which are named as distant or primary senses, are differentiated with their high patterning and organizational qualities, their intense use in daily life, and their ability to collect information from sources that are distant from the body (Özak, 2008, Koyuncuğlu, 2017). The sense of smell also detects stimuli at a certain distance from the body and is considered among the distant senses, still it is secondary. Taste, touch, muscle, and balance on the other hand, are secondary and close senses that sense stimuli within the limits of the body (Koyuncuğlu, 2017).

The sense of vision is the transmission of the wavelength perceived as light to the brain through the eye (Kahvecioğlu, 1998). Vision is more complex than the other senses, due to the eye's adaptability to light, color sense, and ability to perceive details (sharpness). It provides information on external features such as color, shape, size, illumination, texture, and the instant perception of a wide area at a glance. Vision allows other objects to be partially included in our perception in our peripheral vision while our attention wanders at a certain point (Ungar, 2000). Therefore, vision is critical for the perception of space, which has a three-dimensional physical existence. Changes in the temperature and lightness-darkness values of the colors used in the building elements of vision create different psychological effects or emotions on participants (Heuser, 1976, Martel, 1995), and the color preferences of children may change depending on age (Friedling, 1974).

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Hearing occurs when sound waves formed by compression and relaxation of air molecules stimulate the recipient cells in the ear (Cüceloğlu, 2006). In the subjective experience of several sounds, the very small interaural time difference between the two ears enables the individual to detect direction, distance, and movement (Marks, 1978), and every sound source is heard in its particular position (Darwin, 2007.; Besides, hearing can perceive specific changes in space that cannot be perceived by the other senses and can transfer information of events outside the field of view to the consciousness (Gellen, 2010; Blesser & Salter, 2007). These features enable the perception of the size, shape, openings, furnishings, and material of the space through sound waves reflected from the objects. Spaces themselves produce noise with equipment such as plumbing, light bulbs, curtains, air-conditioners, etc. Sounds from outside or the neighboring spaces contribute to the perception of space, and all these auditory stimuli may construct a unique acoustic character for each space.

Smell is a form of chemical perception which occurs when gas molecules in the atmosphere stimulate cells on a membrane in the nose (Kahvecioğlu, 1998). Smell's direct connection to the amygdala (limbic system) strengthens its relationship with memory and mood (Bogdashina, 2003), and causes scents to trigger some long forgotten memories. Scents increase the salience of objects and convey information that helps us to understand the essence of things, to classify them and to realize how we relate to them (Day & Midbjer, 2007; Degel et al., 2001). Throughout the experience, the elements of the space and the smells that exist there form an interface between space and human (Gezer, 2012), they provide information about the environment by adding meaning to the perception through association (Henshaw, 2013), and they affect people's (pleasant-unpleasant) judgments about the environment. Furthermore, scents have very strong effects on the remembering of spaces (Rodaway, 1994), even though they are not related to design, production and the physical-formal existence of the space.

Taste is another kind of chemical perception formed by the stimulation of receptors located at the tip, the sides and back of the tongue, partially in the cheeks, upper palate, and larynx (Bogdashina, 2003; Koyuncuoğlu, 2017). Taste works together with smell, and accompanying scents may cause losses and changes in the perception of taste (Cüceloğlu, 2006). Perceived tastes vary in every individual according to genetics, past experiences and information. The sense of taste is also recorded in the mind during some experiences and is associated with the experienced space, and it can gain a place in the memory by keeping the memory of that space alive at the level of consciousness (Gezer, 2012). Therefore, taste is regarded as a sense linked with spatial memory only in special situations.

The sense of touch emerges with the stimulation of the cells in the inner skin while an object exerts pressure on or contacts the skin

(Kahvecioğlu, 1998). In touch, five different receptors (pressure, touch, pain, heat and cold) enable the perception of different texture characteristics of an object, such as hardness, roughness, sharpness, stickiness, dryness, and the senses of hot/cold and pain/soreness (Kahvecioğlu, 1998; Bogdashina, 2003). Besides, touch plays an important role in defining the qualities of objects such as weight and shape, especially by working together with the kinesthetic senses. While visual and auditory stimuli intertwined in space are continuously imposed on individuals, the perception of tactile stimuli is always relatively limited and under the strict control of the individual (Marinetti, 2009). With the sense of touch, hands become the main means of experience due to the high density of nerve cells in the fingertips; they arouse more sensation/emotion than the eyes and make tactile experiences more important for the perception of presence. While experiencing the space, the body's contact with certain points in space or the activities of the hands in line with certain intentions are the mediators; and when a space is evaluated through touch, every kind of texture and the hard/soft, rigid/flexible, plain/rough qualities of its components become tools that define the 'tactile identity' of a place (Day & Midbjer, 2007).

The sense of balance (vestibular sense) is a type of sensation that perceives stimuli through the semicircular canals and two otolith organs in the ear. It works together with the senses of vision and kinesthetics from infancy and provides information about the body's position, posture, resistance to gravity, balance, and security feelings (Url-1). Perception processes work according to the position of the head and the movement of the body, and collect information on the direction, speed, and intensity of the body's movements (Kahvecioğlu, 1998).

The kinesthetic sense (muscle sense) perceives stimuli from cells located in the muscles, joints, skin, and tendons (Kahvecioğlu, 1998). Basic kinesthetic perceptions are the position and movement of the body, the movements of the body parts relative to each other and the muscle force and effort (Proske & Gandevia 2009; Taylor, 2013). Kinesthetic perceptions enable one to decide how much the body will move or when to stop in combination with the perception of external resistances faced by contraction, relaxation, elongation, withdrawal, and tension in the muscles and skin (Kahvecioğlu, 1998; Taylor, 2013). The combination of kinesthetic and balance senses (which is also known as the proprioception sense) enables us to perceive gravity, movement, and the body's position (Kahvecioğlu, 1998); and with the inclusion of touch, the weight, tension, stiffness, softness, and looseness of objects could be perceived. Furthermore, the combination of vision, touch and balance with kinesthetic signals may enable us to perceive ergonomic relations between humans and space or the existing potential for movement.

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Perception and Memory

The stimuli offered by an environment depend on the quality and quantity of each of the physical components, as well as the ongoing experience and its participants; each of them is a part of a whole. Still, experience is the foundation of the relationship between humans and the environment. While human memory codes and stores the information acquired through an experience, a basic understanding of that environment is formed in the mind and the experience becomes the basis that defines memory as well (Tarçın Turgay, 2018). In perception, the physical reality of the space and the individual's sense organs form a spiral structure, all parts of that reality are perceived simultaneously through the senses (Özak, 2008), and subsequently are evaluated subjectively through memory (Figure 1).

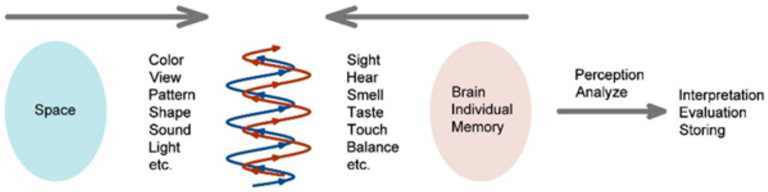

Figure 1. The sensation phase of space (Özak, 2008; s.76)

Human memory, in which the perception is actualized, is considered to have three components: sensory memory, short-term memory, and long-term memory (Figure 2). Sensory memory (SM) is the starting point of human-environment interaction. Perception begins when SM starts collecting sensory data (Kahvecioğlu, 1998) (Figure 3). In this process, a large number of sensory data that exceed the "absolute threshold", the lower limit of the creatures' sensitivity to a stimulus, are stored simultaneously; but this storage is limited to seconds and most of the data is lost rapidly. Therefore, the role of SM in perception is limited to procedures such as "collecting information to be processed", "keeping the information for a while as the previous process continues" and "filling the gaps between intermittent stimuli" (Goldstein, 2013, p.224).

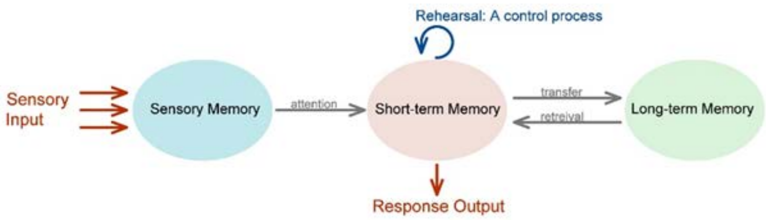

Figure 2. Flow diagram for Atkinson and Shiffrin's (1968) model of memory (Goldstein, 2013, s.217)

Short-term memory (STM), on the other hand, is a system that encodes, processes and stores information for a short time. In the Working Memory Model, Baddeley indicates that STM has four basic components (Figure 4). Among these, (1) the Phonological Loop System stores and operates verbal and auditory information, (2) the Visuospatial Sketch Pad System stores and operates visual and spatial information, (3) the Episodic Buffer, combines and stores the information from the first two components by associating them with the

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information existing in long-term memory, and (4) the Central Executive acts as a center performing complex cognitive processes (such as attention, regulating and combining information) (Goldstein, 2013; Baddeley, 2000).

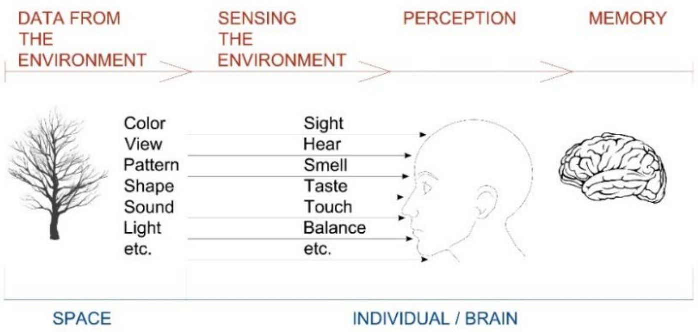

Figure 3. Interaction Process of Sensory Memory and Environment

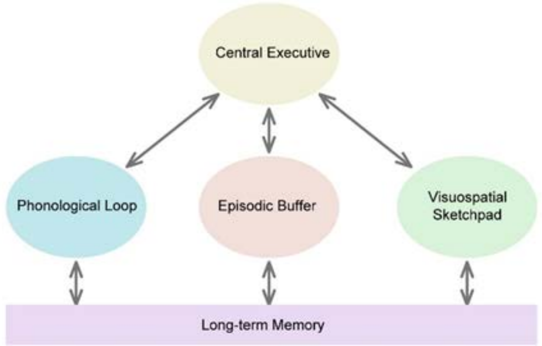

Figure 4. Baddeley's Working Memory Model (Goldstein, 2013, s.247)

The Long-Term Memory (LTM) is a system that processes and stores the information received from STM for a long time (Figure 5). The Implicit Memory (non-declarative memory) component of the LTM processes and stores information about the activities that the body continues automatically without conscious recall, time perception, or individual awareness. Explicit Memory (declarative memory), on the other hand, is a fast-working system that establishes connections between different stimuli, that stores and consciously brings together the information of close and distant memories, and that enables one to learn something at once (Nelson & Fivush, 2004). Within Episodic Memory, Explicit Memory comprises personal experiences that involve time and space information, while Semantic Memory comprises information based on facts and works as the storage of general information of the world (Goldstein, 2013). In this context, "remembering" is the conscious and successful recall from Episodic Memory, and "forgetting" is an error in the recall process. In both cases, many factors can be effected and in some unsuccessful processes, recalled information might be transformed, blocked, or replaced with misleading information (Smith & Kosslyn, 2014).

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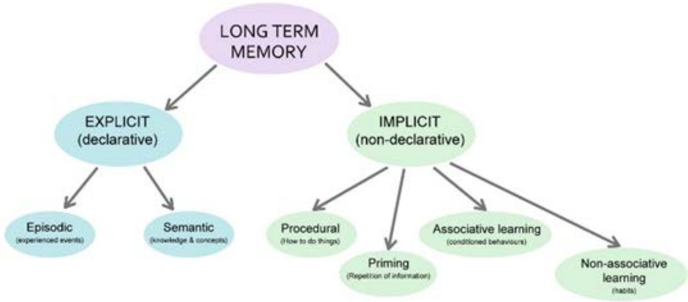

Figure 5. The Schema of Long-Term Memory (Smith & Kosslyn, 2014; p.194)

When the operation of the memory is viewed from the perspective of the senses, it is possible to say that the information is collected by the SM, transferred to the STM, and finally encoded in Episodic or Semantic Memory within the LTM, depending on whether it is personal or not. Within the framework of current memory theories (and many other related theories), this process is considered to be limited to the perception of visual and auditory stimuli, due to the critical position of STM and its accepted model that excludes the non-primary senses. However, depending on the quality of the experience, it is known that information belonging to other senses, such as scent, can be clearly recalled and has strong effects on remembering a whole experience (Koyuncuoğlu, 2017; Chu and Downes; 2000). Therefore, to reveal the effects of both separate and relative activities of the non-primary senses on perception, it is important to look at the sensory-memory relationships outside the perspective of conventional memory models.

Space as The Object of Perception

During the experience of space, all the senses actively provide data to the memory system from the beginning to the end (Özak, 2008). The conceptualization of the environmental character is a complex multi-sensory fusion of innumerable factors which are integrally grasped at once as an overall atmosphere, feeling or mood (Pallasmaa, 2014a). For instance, a museum visit exceeds the perception of mere visual stimuli and turns into an experience that comprises "the visitor's body movements, sensory experiences, associations, recollections and imaginations", and as a result of the embodied nature of this experience the exhibited works become a part of the visitors who experience them (Pallasmaa, 2014b, 241).

In the 1970's, psychologists discussed whether this multi-sensory perception of space is a "single psychological representation containing visual, proprioceptive, kinesthetic, tactile, and auditory information" or a perceptual integrity that emerged because of the coordinated work of different psychological representations of more than one modality, which resembles a single psychological representation (Marks, 1978). In the 2000's, it was accepted that the sensory data collected from a space came together at a point of perception by being coded into a common frame of reference, "a set of axes that describes the location of an object" (Van der Stoep et al., 2017; Cohen and Andersen, 2004, p.463).

According to this view, spatial information obtained from a sense is transformed into the dominant frame of reference in a particular region of the brain which is related to the eventual motor act. These reference frame transformations enable individuals to compare spatial information from different senses.

Since the 1970's, the questions of how the senses work together, how they affect each other and which one is dominant in perception have been important for psychologists (Aronson & Rosenbloom, 1971; Auerbach & Sperling, 1974; Pick et. al., 1969; Morell, 1972; O'Connor & Hermelin, 1972; Van der Stoep et al., 2017; Spence & Van der Stoep, 2020; Bedford, 2007). Nevertheless, the limitations of their research in scale, content, and participants make it difficult to evaluate their findings in the context of phenomenological integrity and upper scale of the space. Similarly, some anthropological researchers focus on the sensory perception of space (Davis, 2017; Howes, 1991; Classen, 1993, Henshaw, 2013; Hamlacıbaşı, 2019) and emphasize the multi-sensory nature of experience (Pink, 2009; Ingold, 2011). However, they mostly only deal with the sense of smell.

Also, in architectural theories, there are many studies using concepts such as sense, perception, and spatial perception of space. The architectural theories popular in the 1980s, investigated the meanings attributed by the research participants to the visual features and structural components of the buildings (Hershberger, 1980; Hershberger & Cass, 1974; Venturi & Brown, 2004); and analyzed the relations between mind and space through semiotic models (Eco, 1980; Jencks, 1980; Rapoport, 1990). These theories were elaborated partly using some particular research in the 2000's in Turkey, which argued again the effects of the visual properties (color, shape, texture, size, surface, edge, opacity) of the structural components and the effects of the visual-spatial characteristics (configuration and number of spatial units) on perception (Aytem, 2005; Ertürk, 1984, Asar, 2013; Çermikli Buluklu, 2015; Koç, 2012; Tarçın Turgay et al, 2015). Also in the same period, the multiple effects of the senses on the perception of space were investigated through studies examining the integrated effect of touch and vision on material perception (Seçkin, 2010), the effectiveness of different sensory stimuli (hearing, smelling, tasting, and touching) through experiencing (Erkan Yazıcı & Çakıcı Alp, 2017); how the sense of touch can be brought forward against the sense of vision (Öktem Erkartal & Ökem, 2015) and how the spaces' perception and comfort could be enhanced (Türk & Midilli Sarı, 2020). These studies mostly neglected multi-sensory functioning due to external reasons such as the inadequacy of measurement-evaluation methods (Öktem Erkartal & Ökem, 2015), the limitations on the spatial scale of research and the dominance of certain theories. Still, the increase in the number of studies on the senses indicates that the weight of the sense of vision or smell in related research will gradually decrease and a multi-sensory perspective will become prevalent.

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The Child-Space Relationship Through Perception

Children's perception of space is mostly evaluated within the framework of the developmental theories of Piaget, Inhalder and Szeminska (1960; 1964). The notion of phantasy act includes attention, remembering, symbolizing, planning, reasoning, problem-solving and creating (Berk, 2013); while in the context of spatial perception and spatial computing, it includes causation, judgment, and recall (Hart & Moore, 1973).

According to Piaget (2004) there are four cognitive stages during the development process of a child. Around the ages of 0-2, the child is in the sensory-motor stage and conceptualizes his environment in ways that are consistent with his senses and movements and thinks through his actions. Between the ages of 2-7, the relationship of a child with place depends on instantaneous conditions; a certain situation is perceived at a certain time, and the child has not developed a sense of integrity yet. In the concrete operational stage between the ages of 7-12 children can process information systematically and logically when confronted with concrete information, but abstract information can be processed by systematically addressing it only between the ages of 12-18 (Tunçok Sarıberberoğlu, 2018).

In this developmental process, perception of the world is always a multi-sensory event that includes the use of every sense and the whole body. Seeing something brings the desire to touch, taste, smell, shake, throw or hit that thing. This combined working causes both a difficulty in processing the simultaneous sensory stimuli (Day & Midbjer, 2007), and gives priority to senses in cognitive processes and makes them one of the main determinants of childhood. The information received from the environment is transformed into behavior by the senses and instant emotions rather than logic (Day & Midbjer, 2007). Children move on from perception to conception and from feeling to meaning by experiencing rich stimuli with their senses. This multidimensional perception also makes the conceptualization of things multidimensional and clears the way for creative thinking.

In this context, the perception of space operates by distinguishing different forms of sense rather than associating different sensory stimuli (Gibson, 1969). This dependency on the senses starts to decrease as the child strengthens his/her sense of self by separating himself/herself from the place between the ages of 3-5, and between the ages of 4-7 he/she begins to perceive places as tools that can be transformed and used for a purpose. Afterwards, development of abstract thinking skills helps the child to perceive that the environmental changes depending on his/her perspective (Tunçok Sarıberberoğlu, 2018), and he/she starts to build a sense of space which is not only perceived by the senses and the body but also conceptualized with rules and related information (Day &Midjer, 2007). Still, the holistic and systematic idea of space is formed towards puberty, after the age of 12 and the skills of imagining,

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designing, and producing spaces develop over time (Day & Midbjer, 2007).

Research on child-space interaction through the senses mostly focuses on child specific environments such as open playgrounds, educational facilities, pediatric clinics, classrooms and investigates the importance of specific environments (Moore and Young, 1978), the effects of physical qualities of spaces and visual stimuli (color and lighting) on perception (Day and Midjber, 2007; Al-Alwan and Al-Kahidi, 2009; Temel, 2015; Aral et al., 2011) and the effects of color on likes, preference and psychology (Başoğlu, 2002; Dilmaç, 2018). In this framework, there is also a group of studies instrumentalizing cognitive maps to investigate children's perception of space. Cognitive maps are defined as a psychological procedure that deciphers the processes of coding, storing, and recalling of the experienced spaces in the mind (Downs ve Stea, 1973), and transforms it to data that can be evaluated. In some significant research the effects of architectural parameters (Çakır, 1997), movement/ behavior (Hume et al., 2005) or culture (Gillespie, 2010) on perception and the effects of different socio-economic characteristics (Yılmaz, 2005), spatial experience (Tarçın Turgay et al., 2015) or spatial configuration (Köksüzer, 2013) on memory; or children's satisfaction and sense of belonging about places (Baksi, 2018) were investigated through cognitive maps.

In the scope of the above-mentioned studies, the sense of vision was still regarded as a dominant factor in the perception of space. However, the theories of child and environment interaction indicate that the whole body takes part in the child's relationship with space and none of the senses can be ignored in this context. Besides, the ongoing cognitive development of children and the long-term dependence of their thoughts on sensual information cause them to be constantly under the influence of the environment they live in, both physically and psycho-socially (Gür & Zorlu, 2002); and it is also possible that their perceptual patterns are still emerging simultaneously (Wallace, 2004). These characteristics of childhood puts them in a partly passive position toward the environmental effects and differentiates their spatial perception, experience, and spatial memory from adults (Tunçok Sarıberberoğlu, 2018). Still, children remain a neglected group of participants in current space perception research, and their different situation in human-space interaction need further discussion.

In the light of these findings, for this paper, a field study was conducted to investigate the multiple effects of the senses on the spatial experience, perception and memory processes of children.

CASE STUDY ENVIRONMENT

The field study searched for the effects of sensory stimuli in a space on children's spatial behavior and memory. A total of 33 students (10 years old), 14 boys and 19 girls, studying in the 4th grade of Çayırova-Guzeltepe Primary School participated in the study. Before the data

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collection phase, signed consent forms were obtained from the parents and the entire study was carried out with the knowledge of the school administration and under the supervision of the class teacher.

The setting of the field study was a theme park (Kidzania Istanbul) that offers the experience of different adult professions in a child scale environment. This fictional setting presents an interesting, remarkable environment that is quite different from daily life, both with its physical characteristics and the activities taking place in it (Figure 6). The theme park can be visited alone or accompanied by a parent. The total visiting time is limited to four hours and is controlled with an electronic wristband. Each participant waits in line for the profession they want to experience, if there is high demand. For this reason, the number of spaces experienced by each participant varied depending on their preferences and the demand during that day.

Figure 6. Theme Park spaces (Url-2)

Each spatial unit is furnished with specific appliances, equipment, costumes, and decors. Also, there is at least one adult who gives directions on how to experience a specific profession. The entire theme park is equipped with distinctive and intense stimuli regarding all the senses and each spatial unit predominantly presents specific stimuli to its participants through its physical qualities and activities. For example, in the Perfume House where children create and bottle their own scent mixtures, smell stimuli are dominant. On the other hand, vision, balance, and kinesthetic senses are dominant in Window Wiping and Construction Site activities in which the children walk on a scaffold with safety ropes. In the Chips Factory, Chocolate Factory and Pizza Shop, which offer activities for food production, children are exposed to smell and taste stimuli more than the others. And, in the Disco and Secret Agent Centers, besides visual and kinesthetic senses, the sense of hearing is stimulated more than the others (Figure 7).

Figure 7. Theme Park activities (Url-2)

In the Theme Park, the performed activity and its space are integrated with each other. While children perform a specific task with various kinds of bodily participation, the physical qualities of the space are perceived simultaneously. Therefore, the spatial perception process takes place through a holistic experience with more than one sense stimulated at the same time.

RESEARCH METHODOLOGY

The case study includes three different data sets that are defined by sensory stimulus types; one of which belongs to the space (spatial data), and the other two belong to the participants (behavior and memory data).

Spatial Data

The spatial data focuses on the stimuli offered by the spaces. Through a preliminary review of the park, it was observed that (1) the visual and auditory stimuli are primarily presented by the architectural components in each spatial unit, and that (2) smell, touch (fine motor activities) and kinesthetic (fine and gross motor activities) stimuli have an effect on the perception of space depending on the contents of the activities. Only in five spatial units (Window Film Application, Construction Site, Disco, Earthquake Simulation Center and Stadium), in which there is a minimum height requirement of 120cm and the sense of balance is dominant (along with kinesthetic sense). Above all, the number and type of sensory stimuli differs for each spatial unit, and six different stimuli (hearing, taste, smell, touch and kinesthetic) came to the forefront throughout the entire theme park.

In the spatial data analysis, the primary stimuli that the participants are exposed to, or obligated to experience in each spatial unit (inside the unit and during their activity) were identified. For instance, children are intensely exposed to touch, vision and auditory stimuli at the Aviation Academy in which they sit down and participate in a flight simulation. In contrast, they are exposed to hearing, vision and kinesthetic stimuli in the Secret Agent Center when performing climbing, jumping and running activities under bright lights and sound effects, whereas they are exposed to tactile, smell and taste stimuli in preparing and cooking activities (such as Chocolate Factory, Chips Factory and Pizza Shop).

In this context, the nominal values (available/non-available) of each of the six sensory stimuli are defined by determining if they are presented as the primary stimulus in a spatial unit or not. By defining

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the type, number, and distribution of the primary stimuli in each space, each spatial unit's sensory character is revealed. This characteristic data constituted the basis of the field study and was used as a tool for redefining the participant data through the senses.

The sum of the nominal values of one stimulus is the maximum number of times that stimulus can be experienced by a participant in the theme park, i.e., "the number of potential experiences". The sum of the number of potential experiences of all stimuli is the maximum number of sensory stimuli that can be experienced by a participant in the theme park, i.e., "the number of potential experiences in the theme park" (Figure 8).

Behavioral Data

The behavioral data was obtained from the forms on which participants wrote down the places they visited during the tour. The number of visits to each spatial unit was calculated by how many participants wrote it on the forms and was regarded as "the number of experiences" value of each spatial unit (Figure 8).

$$\textbf{number of stimulus experiences} = \sum_{n=43} \textit{nominal value of the stimulus x number of experiences of the spatial unit}$$

$$\textbf{total number of stimuli experiences} = \sum_{n=6} \textit{number of stimulus experiences}$$

$$\textbf{number of stimulus recalls} = \sum_{n=43} \textit{nominal value of the stimulus x number of recalls of the spatial unit}$$

$$\textbf{total number of stimuli recalls} = \sum_{n=6} \textit{number of stimulus recalls}$$

Figure 8. Data Analysis Formulas

Memory Data

The memory data was obtained from the drawings (cognitive maps) which participants drew in a classroom environment two days after the tour (Figure 9). Participants were asked to "draw what they remember about the tour" in approximately 35 minutes. At the end of the period, students were allowed to write down the names of places which could not be drawn in the session on the back of the drawing. Using these drawings, the number of representations of each space in cognitive maps was calculated and regarded as "the number of recalls" value for each spatial unit.

The number of experiences and the number of recalls of each spatial unit were considered as factors. By multiplying the nominal values of sensory stimuli in a unit with the number of experiences of that unit, the "number of stimulus experiences" for a spatial unit was obtained. Similarly, by multiplying the nominal values of sensory stimuli in a unit with the number of recalls of that unit, the "number of stimulus recalls" for a spatial unit was obtained. For each stimulus, the "total number of stimulus experiences" is calculated by adding up a stimulus's number of experiences, and the "total number of stimulus recalls" is calculated by adding up a stimulus's number of recalls.

Figure 9. Cognitive Map Drawings

For example, if six children visited a spatial unit that presented only a visual stimulus as the primary stimulus, it was accepted that the visual stimulus was experienced six times in the context of that unit, and the number of stimulus experiences was six. Accordingly, the sum of the number of visits (number of experience values) of the spatial units whose primary stimulus is vision gave the total number of visual experiences.

At the end of the study, the distributions and changes in these numerical values were compared, and participants' (1) number of experiences and number of recalls of spaces, (2) exposure to different sensory stimuli during their experience of spaces and (3) their recall of the sensory stimuli after their experience were evaluated.

DATA & FINDINGS

During the field study, 43 spatial units were available to be visited in the theme park. According to the data, only 34 of these spatial units were visited, and nine spatial units were not by any of the participants. While the most visited spatial units were Perfume House and Cargo Distribution Center; nine spatial units (ER, Hamburger Shop, Culinary School, Dentist, Ice Cream Factory, Photo Lab, Police Station and Biscuit Factory) were visited only by one participant (Figure 10).

The cognitive data shows that some units (Fashion House, Grand Bazaar and Emergency Service) were remembered and drawn rather than visited, and some units were not remembered although they were visited. These differences could be seen as demonstrating that some spaces could not be visited by children even though they wanted to and that some spaces did not satisfy the children through the experience and so were not retained in memory (Figure 10). Overall, the relationship between visiting and remembering spaces is tested through the Pearson Correlation and the result shows a positive and significant relationship (r=0.9) between experiencing a space and recalling it afterwards, in other words, the spatial experience and spatial memory.

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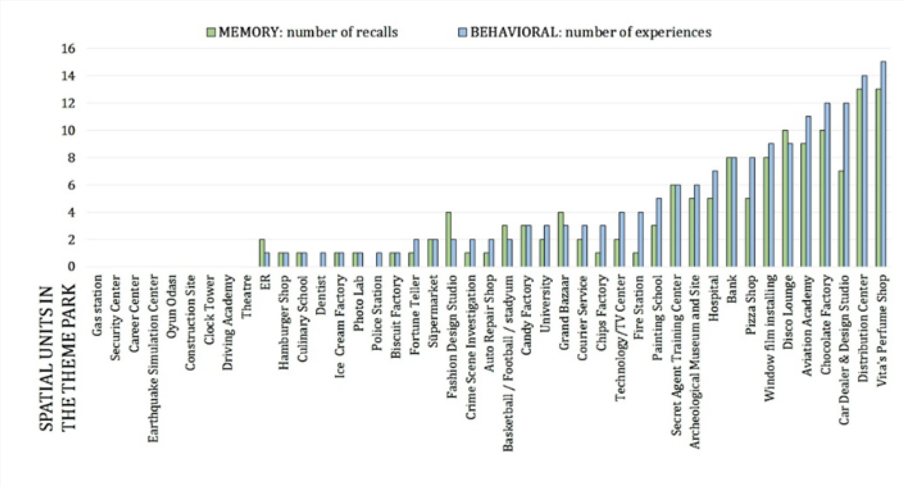

Figure 10. The participant data. The number of recalls and the number of experiences of the spatial units.

According to the spatial data that shows the number of potential experiences of sensory stimuli in the park, vision (24) and touch (23) are the most presented stimuli, while smell (9), taste (8) and hearing (7) are the least presented ones, and kinesthetic stimuli have a value (18) in the middle of these two groups (Table 1). This distribution shows that the sensory character of the theme park consists primarily of vision, touch and kinesthetic stimuli. In other words, in the process of experiencing the theme park, the participants tended to use their vision, touch and kinesthetic senses more significantly, rather than smell, taste and hearing. This finding is different from the preliminary review of the park which suggested that visual and auditory stimuli are the primary stimuli presented by the architectural components, and the others are secondary ones that depend on the contents of the activities. This difference indicates that kinesthetic activities become significant parts of perception if the participants go beyond being an observer and participate in the activities that take place in the park. Still, the other three stimuli (smell, taste, and hearing) which are encountered within the scope of the experience (general ambient, noise, etc.) or at the end of the experience (food served at the end of the activity, etc.) remain at the background of the process.

Among the 34 places visited within the scope of the study, the total number of spatial units children experienced was 165, the total number of places they recalled was 136, and the difference was 29. Accordingly, children did not remember the 29 places they had experienced and approximately one of every five places (18%) was forgotten. Similarly, the total number of stimuli experienced by the children was 359, the total number of stimuli they recalled was 278, and the difference was 81. The fact that 81 stimuli were not remembered even though they were experienced shows that one of every five stimuli (%22) was forgotten (Table 1).

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Table 1. The spatial and participant data regarding sensory stimuli

		STIMULUS TYPE						
		HEARING	VISION	SMELL	TASTE	TOUCH	KINESTHETIC	TOTAL
the number of potential experiences	number	7	24	9	8	23	18	89
	order	6	1	4	5	2	3	
number of stimulus experiences	number	32	98	45	30	96	58	359
	order	5	1	4	6	2	3	
number of stimulus recalls	number	27	81	36	3	75	56	278
	order	5	1	4	6	2	3	

Regardless of the numerical values, the ranking values of stimuli were the same as the number of stimulus experiences, the number of stimulus recalls and the potential number of experiences (Table 1). In other words, vision and tactile stimuli were the most imposed, most experienced and most recalled stimuli of the study, whereas taste stimuli were the least imposed, least experienced and least recalled. However, the changes between the numerical values show that the differences between smell, hearing and taste were variable. The number of potential experiences and the number of stimulus experiences of taste and hearing differ by only 1-2 values (7 and 8; 30 and 32). On the other hand, the difference between the number of experiences and the number of recalls for taste (30 and 3) is much bigger than the difference for hearing (32 and 27). This indicates that whereas taste stimuli were largely forgotten after the experience, this was not the case for hearing stimuli.

In order to better interpret these contrasts and reveal to what extent stimuli were forgotten, the differences between the number of experiences and the number of recalls were evaluated (Table 2, Figure 11). The findings show that;

- The values of the number of experiences and the number of recalls of kinesthetic stimuli were almost the same, all children who experienced kinesthetic stimuli remembered these activities and drew them on their cognitive map.
- The difference value of the auditory stimulus is only 5, and the difference value of the visual stimulus is 17. These difference values show that 15% of the experienced auditory stimuli and 17% of the visual stimuli were forgotten.
- The difference value of the smell stimulus is only 11, and the difference value of the tactile stimulus is 21. These difference values show that 24% of the olfactory stimuli and 21% of the tactile stimuli were forgotten.
- The difference between the number of experiences and the number of recalls of kinesthetic stimuli is 27. This difference is the biggest

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one in the study and shows that 90% of the taste experiences were forgotten.

- Finally, whether the sensory character of a space affects participants' visiting choices or their recall of spatial units could not be tested because of the incompatible data for correlation (the number of primary stimuli in the spatial units varies between 1 and 3, while the number of experiences and number of recalls varies between 0 and 15).

Table 2. The difference between the number of stimulus experiences and the number of stimulus recalls

	STIMULUS TYPE					
	HEARING	**VISION**	**SMELL**	**TASTE**	**TOUCH**	**KINESTHETIC**
number of stimulus experiences	32	98	45	30	96	58
number of stimulus recalls	27	81	36	3	75	56
difference value: number of stimulus experiences - number of stimulus recalls	5	17	11	27	21	2
difference value / number of experiences	15%	17%	24%	90%	21%	3%

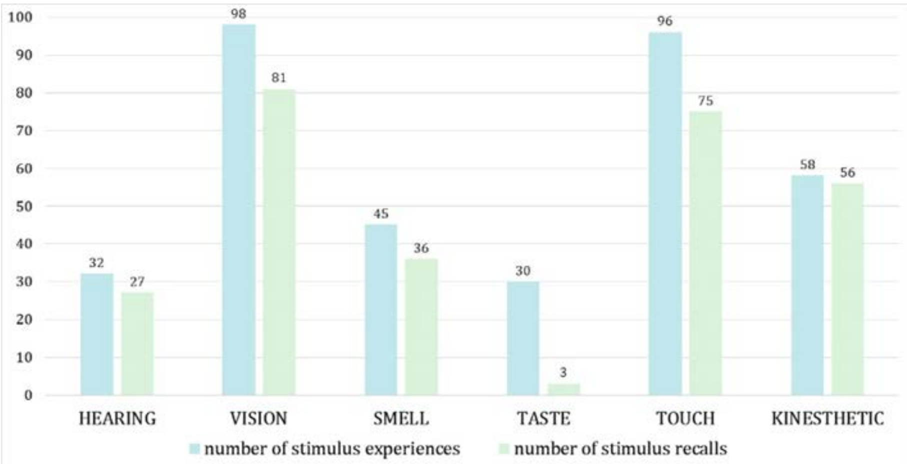

Figure 11. The change between the number of stimulus experiences and the number of stimulus recalls

EVALUATION

This study investigated spatial perception and memory in the context of the child-space relationship via environmental stimuli by examining the experience and recall processes of children who experienced a specific environment, a theme park.

Until very recently, vision and hearing were accepted as the two primary senses in both cognitive and environmental perception theories (Goldstein, 2013; Baddeley, 2000). Along with that, most of the theories reviewing space perception, especially the ones that discuss architectural spaces, agreed that visual stimuli take first place in perception (Jencks, 1980; Venturi & Brown, 2004; Asar, 2013). Today, even though much recent research in several fields reveals that perception is always a multisensory process, its multi-component mechanism is still an area that is unclear (Wallace, 2004). It is possible that this ambiguity leads many researchers to continue to work in the known, safe field of vision and touch (Öktem Erkartal & Ökem, 2015; Seçkin, 2010) or the visual-spatial characteristics of space (Aytem, 2005; Koç, 2012). This study, on the other hand, aims to go beyond these limits by proposing a new method that examines the multi-sensory perception of an architectural space by accepting the human experience as an integral part of the environment.

The findings of the study show that the most common stimuli in the field are the sense of vision, touch, kinesthetic, smell, hearing and taste in that order. This ranking is also coherent with visiting and recalling the spaces on a cognitive map. Therefore, it can be stated that the potential stimuli offered by the place were effectively and consistently transferred to the participants throughout the experience. Furthermore, those perceived sensual data were also effectively and consistently transferred to memory, and no stimulus comes to the fore as being unlikely to be recalled. First of all, this finding confirms that perception is always a multisensory process. Secondly, contrary to the general consensus, this finding shows that visual stimuli are not always prioritized in the perception of architectural space and visual and auditory stimuli cannot be considered as the main sources of perception in the functioning of memory. Most importantly, this demonstrates that the type and number of perceived stimuli are related to how much they are present in the space to be experienced; and the type and number of recalled stimuli are related to how much they are experienced. This is compatible with the fact that all parts of an environment, the space, the participants and the ongoing experience are perceived and conceptualized simultaneously (Özak, 2008). The efficiency of the senses in this context may vary depending on the qualities of the space and the participant that undergoes the experience. Still, the experience remains the main ground of perception and therefore of remembering a space.

Another finding of the study was that the changes between the numbers of experienced and recalled stimuli showed that the experiences that included kinesthetic stimuli were the most remembered with respect to hearing, seeing, touching, smelling, and taste stimuli (in that order). In the theme park, kinesthetic stimuli were experienced through gross motor activities that children participated in with their whole bodies. In contrast, tactile stimuli were experienced only within the framework of fine motor activities using the hands and taste stimuli were experienced only for a moment at the end of the activity. This difference shows that the perceived stimulus was remembered if it was experienced via the whole body for a long period, and was not remembered when the experience was shortened and the bodily interaction area became more specific. These findings indicate

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that the active participation of the body in an experience, together with the related senses, positively affects the perception and recall of the space enclosing that experience. Here, the body appears to be at the center of this perception process. There is a constant relationship between the body's actions and the information sources of the environment, as Merlau-Ponty (1964) stated, and the physiological qualities of the body and its movement in space defines both the perception and memory of that space.

Finally, the most significant change was seen between the experience and recall values of the sense of taste. Almost all the taste experiences were forgotten. Even though taste is defined as a "close sense" along with touch, muscle and balance, it is kept in the background in the perception processes in this context. This indicates that hearing and other stimuli are stored in memory more efficiently than taste in the framework of perception of space. It is known that taste sense can be included in spatial memory if it is associated with the experienced space, and support the memory of space at the level of consciousness (Gezer, 2012); but this requires some specific conditions that bring the sense of taste to the forefront during the experience, which was not shown in our case.

CONCLUSION

We live in a multisensory world in which we are constantly bombarded with information conveyed via the different sensory modalities, and our brains are continuously synthesizing this commixture of sensory information into an adaptive and coherent wholeness to reveal the nature of our experiences (Wallace, 2004; Stein and Stanford, 2008). This process sometimes resembles reasoning or problem solving (Goldstein, 2013), and the individual's experience of space is like a ball of knowledge that is constantly fragmented, reassembled, and transformed in the mind. This is much more complicated for children, as they are much more dependent on their bodies and senses during their development to learn and understand the world that they are growing up in.

Experience is both the ground and the act of interaction with the world, and it defines how a space is perceived with all the senses, how it becomes a part of us and what that space will mean for us afterwards. Therefore, the space should not be regarded as an object, but a process ((Ökem & Öktem Erkartal, 2015), that involves both its physical components, its participants and the experience that is ongoing there. In this study, the concept of space is reconsidered from this perspective, and it has been expanded to include the activities carried out by the participants during their experience of a space. In addition, the cognitive data of the research was derived from the sensory characteristics of this particular concept of space.

Our results regarding the child-space relationship show that different sensory stimuli have various roles in and effects on perception and

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recall of spaces. First, together with vision, all the senses are included in the perception of space, depending on the type and quantity of stimuli presented in the space. Second, the recall of perceived stimuli may change depending on the rate and time of the participation of the body in the experience. And third, some stimuli, taste in our case, may remain in the background in the process of transferring the perceived information to spatial memory. On the other hand, the gender and age differences were ignored and could not be discussed by necessity.

The findings of the study indicate that the perception of space has a multi-sensory structure, which is strongly defined by the characteristics of space and how much its participants, children in our case, bodily participate in the activities that take place in that space. Moreover, the study itself reveals that paying regard to the role of experience enables us to evaluate human-space interaction with a broader perspective and that multisensory research models offer the potential to analyze the perception of space more effectively.

At the present time, many challenging questions regarding the function of the senses in perception of space still remain unanswered. New innovative and holistic research methods that additionally question the human factors and subjective aspects of perception would definitely exceed the limitations of existing theories, and further cross-disciplinary research between behavioral and neuro-cognitive fields would provide a much broader perspective. And eventually, the obtained answers shall lead to alternative design methods that will guide the production of all types of architectural spaces, along with the specific children's spaces like in our case.

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