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THEORETICAL MODEL CONCEPT OF SPATIAL AWARENESS – DEFINITION AND COMPONENTS

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ABSTRACT

Motives: In the context of new spatial (rapid urbanisation and suburbanisation) and technological conditions (smart tools), studying the level of spatial awareness has become critical. It is particularly important from the perspective of enhancing cognitive skills of the current, digital generation of children, who struggle with analogue forms of navigation and orientation in multidimensional space. This highlights the need for a standardised and comprehensive tool to assess spatial awareness, grounded in a clear identification of its key components.
Aim: Therefore, the research's main aim was to develop a definition of spatial awareness as a diagnostic term comprising knowledge, skills, and affective reactions.
Results: A thorough review, selection, and classification of the literature allowed to distinguish four components in the knowledge domain, five in the skills domain, and three in the affective domain within the definition of spatial awareness.

Keywords: spatial awareness, spatial skills, spatiality of emotions, spatial orientation, education

INTRODUCTION

In the face of rapid urbanisation globally (Bodo, 2019; Zhang, 2016), but also in the way of orienting in urban spaces and their memorisation (Crinson, 2005; Jalaladdini & Oktay, 2012). Increasingly, urban space users utilise navigational tools to support orientation (Coutrot et al., 2022), especially map services, spatial information systems, geoportals, and Spatial Data Infrastructure, which are gaining increasing significance (Hall & Smith, 2014; Kulawiak et al., 2019). These services and systems, through their diverse

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databases, present space in different ways depending on the thematic layers displayed. They are created as a response to the demand for information on the location of various objects and phenomena in space. In conjunction with navigational systems (e.g., Global Positioning System), they facilitate finding objects and navigating when moving in the field. Increasingly, even primary school-aged children use these systems to reach their destinations (Hergan & Umek, 2017). Undoubtedly, the use of new Information Technologies (IT) in the process of learning about space affects its memorisation and understanding (Ishikawa, 2019). This issue is crucial for improving the cognitive skills of today's children, the digital generation, who are unfamiliar with analogue forms of navigating and orienting in multidimensional space. The Alpha generation, born in the 21st century, sees the world as a media-integrated reality, where IT and media are inseparable from daily life. Therefore, it is crucial to monitor and control the impact of new technologies on spatial awareness to minimise harmful effects and enhance desirable ones, especially for children. This is important given the rapid changes in city layouts, which complicate spaces and create vast urban jungles that are difficult to navigate even for adults (Bowie, 2004).

It is essential to examine the level of spatial awareness in both children and adults using a standardised, comprehensive scale that identifies all its components, due to the gradual development of spatial awareness throughout the lifespan. Hence, the main aim of the research was to develop a definition of spatial awareness as a diagnostic term, comprising knowledge, skills, and affective reactions.

Current literature offers general definitions of spatial awareness, such as "an awareness of the body in space, and the child's relationship to the objects in the space" (Poole et al., 2006) and others discussed in detail in the following subsections. These definitions are not sufficiently precise for diagnosing spatial awareness levels according to standard measures, focusing mainly on fragmented skills rather than comprehensive assessment. Other studies highlight the limited understanding of the relationship between neighbourhood environmental characteristics and a child's spatial awareness (Loebach & Gilliland, 2010). Moreover, these definitions lack the precision needed to diagnose spatial awareness levels in children.

Many scientific studies have been identified concerning: spatial intelligence (Chamizo et al., 2014) or spatial thinking (S. Metoyer & Bednarz, 2017; Newcombe & Shipley, 2015), spatial orientation (Sopa, 2021) or navigation in space (Y. Yang et al., 2019), spatial skills (Gómez-Tone et al., 2021; Harris et al., 2022), perception of space (Blitz, 2021; Wronkowski, 2018), valorisation of space (Groeger & Lasek, 2021), spatial visualisation (Farrell et al., 2015; Godfred et al., 2021) and mental rotation (Linn & Petersen, 1985; Vandenberg & Kuse, 1978). However, each of these issues was considered separately, rather than from a comprehensive perspective. Studies explore learning about space, e.g., through using programs to learn about object shapes or even more broadly – learning about shapes (Wright et al., 2008). Studies on the components of spatial awareness have focused either on adults (Gazova et al., 2013; Vieites et al., 2020), or on children (Brown et al., 2008; Horton et al., 2014). Many researches on children's mobility often oversimplify space concepts, focusing on static movements from one place to another (Carver et al., 2013), Elements of children's spatial orientation are also addressed in studies (Horton et al., 2014). Wronkowski (2018) suggested implementing spatial education classes already at the preschool level, drawing on initial considerations of spatial awareness. However, research on comprehensively measuring spatial awareness is still lacking, particularly in identifying interrelated elements. Considering that emotions pertaining to space significantly impact our behaviour within that space and our comprehension of it, the following thesis was formulated: emotions should be integrated as a component of the theoretical model of spatial awareness.

The proposed definition of spatial awareness aims to fill a cognitive gap in the scientific literature, providing a foundation for a contemporary diagnostic tool tailored to research at the intersection of geography and cognitive science, concerned with

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human-space relationships . After a comprehensive literature review, the elements of spatial awareness will be identified and categorised to formulate a logical theoretical model applicable not only to children.

LITERATURE REVIEW

As part of the literature review on spatial awareness, scientific publications concerning various terms related to human-space relations were analysed, each shedding light on different facets of spatial awareness. Among the identified elements in the literature are: spatial perception, spatial orientation, navigation in space, spatial thinking/spatial intelligence/spatial ability, spatial visualisation, spatial mental rotation and transformation (scaling), or valorisation. Most research focused on spatial orientation and spatial thinking.

Spatial thinking/spatial intelligence/ spatial ability

Spatial thinking, a multifaceted concept often called "spatial intelligence" or "spatial skills", includes abilities like location, dimensionality, continuity, pattern, spatial association, network, and proximity (Huynh & Sharpe, 2013; S. K. Metoyer et al., 2015). While not precisely defined, spatial thinking involves varied skills (Hegarty, 2010), and a harmonised framework is crucial (Cohen & Hegarty, 2012). In an educational context, spatial thinking can be defined as "as a constructive combination of cognitive skills comprised of knowing concepts of space, using tools of representation, and applying processes of reasoning" (National Research Council, 2006).

Spatial thinking evolves from egocentric to allocentric representation, progressing through landmark to abstract frames of reference like maps (Robson, 2012). Research approaches include psychometric approaches and classification systems (Newcombe & Shipley, 2015; Uttal, Meadow, et al., 2013a). Research approaches include psychometric approaches and classification systems (Newcombe & Shipley, 2015). Intrinsic skills involve object size and orientation, while extrinsic skills relate to object relationships (Hodgkiss et al., 2021).

In an education, spatial thinking is defined as a blend of cognitive skills involving space concepts, representation tools, and reasoning processes (National Research Council, 2006). A three-factor taxonomy includes concepts of space, mental operations, and reasoning processes, with phases of mastering these skills (Jo & Bednarz, 2009; Piróg & Świętek, 2021). Developing spatial thinking is possible, especially in early childhood, with effective training methods like practical exploration and visualization (Uttal, Miller, et al., 2013; W. Yang et al., 2020). Spatial thinking is crucial for interpreting spatial attributes and solving problems, integrating spatial concepts with reasoning (National Research Council, 2006), and is fundamental in daily life (Sinton et al., 2013).

Spatial orientation

Spatial orientation allows individuals to determine and update their location during movement (Ishikawa, 2023; Sopa, 2021), maintain orientation from different viewpoints (Pastel et al., 2022), and identify object locations in space (Azatyan, 2022; Sopa, 2021). It is a complex multisensory cognitive process relying on visual perception and memory (Coluccia & Louse, 2004; Pastel et al., 2022; Sopa, 2021), adjusting information over time and space (Pastel et al., 2022). Spatial orientation integrates various inputs to map the environment (Gerb et al., 2022), often assessed with GIS tools and geosurveys (Kulawiak et al., 2023).

Wayfinding relies on spatial orientation and spatial navigation to create mental maps from sensory input (Ishikawa, 2023; Pastel et al., 2022). Spatial orientation is crucial for navigation using environmental landmarks (Azatyan, 2022; Sopa, 2021). Collaboration between psychologists and geographers is advocated for its holistic understanding (Coluccia & Louse, 2004). Individual differences necessitate considering internal and external factors in determining spatial orientation (Sopa, 2021). Its proper understanding is vital in education, influencing cognitive and personal development, essential for personality growth (Azatyan, 2022).

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Spatial navigation

Spatial navigation is defined as the ability to find the way between places in the space (Bruder et al., 2012; Pastel et al., 2022) or find one's way around the environment (Lind et al., 2013) on the basis of information about distance, direction and place (Lövdén et al., 2012), coming either from sensory experiences or external representations in forms of maps etc. (Lind et al., 2013). This also requires the ability to maintain a sense of direction while movement in space (Lind et al., 2013) and ability to recognise objects that can be used as landmarks (Newhouse et al., 2007), as well as to simulate or change perspectives (Di Tore et al., 2015; Lind et al., 2013). Spatial navigation is strongly linked to the process of exploration of space enabling collection of spatial information (Basso, 2008), essential for independent life (Burles et al., 2020; Farran et al., 2019). This skill helps people on how to deal with changes of their surroundings and how to improvise in case of memory problems (Waismeyer & Jacobs, 2013).

Perception of space

Perception, a challenging concept to define, is shaped uniquely for each individual by their experiences and learning processes (Järvinen et al., 2022). According to Chądzyńska (2004), it involves the capacity to interpret informational stimuli present in space, thereby forming judgments about its constituents – resulting in the same space being perceived differently by various observers. Perception involves the registration of sensations, analysis, interpretation, pattern formation, their categorisation, selection, and grouping in such a way that the information obtained is useful (Rak, 2013). Benoudjit et al. (2004) describe the progression of perception as moving from the identification of objects as separate entities to the incorporation of personal significance.

Socially, perception involves how individuals distinguish themselves and others, as well as objects in their surroundings (Hegtvedt, 1988). Perceiving space causes a person to adopt a positive, negative, or even indifferent attitude towards it (affective sphere). Research into public space perception centres on its aesthetics and the enjoyment it offers (Blitz, 2021). Factors shaping this perception encompass individual traits (age, education, occupation, location, knowledge, financial status), spatial elements (quantity, variety, and change over time), and sources of spatial knowledge (personal experiences and others' opinions) (Chądzyńska, 2004).

Spatial visualisation

The term "visualisation" is understood as "imagine and describe", being one of the main elements of human intelligence (Roslan & Ahmad, 2017). Spatial visualisation is defined as a cognitive ability to: use simulated mental images (Schneider & McGrew, 2012), manipulate visual spatial information (Roslan & Ahmad, 2017), mentally handle complex forms and patterns (Gómez-Tone et al., 2021), and simulate how they might look when transformed (Alias et al., 2003; Schneider & McGrew, 2012). Moreover, it involves the ability to conceptualise and to understand how various spatial elements are (and can be) interconnected, as well as understanding three-dimensional space (Cheng & Mix, 2014; David, 2012). It is directly connected to tasks requiring complicated and multistep manipulations of spatial information (Farrell et al., 2015).

Spatial mental rotation

According to Linn & Petersen (1985) and Samsudin et al. (2011), mental rotation is the ability to rotate figures in two or three dimensions. The mental rotation test assumes the sequentiality of cognitive processes, involving stages such as creating object's a mental representation, rotating mentally until figures align for comparison, comparing, deciding on the identity of the figures, or their absence, and documenting the decision (Boyer & Levine, 2012). Parsons (2003) and Yu et al. (2020) outline five phases in completing a mental rotation task: perceiving stimuli and coding, analysing rotation direction, executing rotation, comparing, and valuation, reaction. Usually, studies on this employ two-dimensional or quasi-three-dimensional geometric shapes,

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instructing participants to rotate them by a specified angle. The Mental Rotation Test (Vandenberg & Kuse, 1978) and the Card Rotation Test (Ekstrom et al., 1976) assess this ability, with their performance levels being high and rotation speed indicating the level of mental rotation ability (Drążkowski et al., 2017).

Emotions related to space

As emotions are an integral part of human reality, "such as perception, speech/talk, gestures, practices and interpretations of the surrounding world" (Simonsen, 2007), since the 1990s, spatial aspect has been increasingly included in social research, considering the interactions of people with their physical environment and the analysis of its symbolic meanings (Tang, 2021). This approach has led to the development of affective geography, focusing on the interaction between emotions, space, and society (Sági, 2022; Thien, 2017). Space influences people's choices and capabilities (Tang, 2021) and shapes emotional connections, with memories often tied to specific places (Kensinger & Schacter, 2008; Tang, 2021). Additionally, individual stress levels and emotional sensitivity influence how people respond in these environments (Galvez-Pol et al., 2021). Urban spaces, where much of our time is spent, greatly impact mental health and well-being as we navigate and interact with architectural elements (Cooper et al., 2014), evoking various emotional responses (Hauthal & Burghardt, 2016). Furthermore, a person's emotional connection to a space can change over time, and different individuals may perceive the same space differently, attributing different emotions to it (Pernau, 2014). We can say that someone radiates joy, creates an atmosphere of anxiety or irritation. It refers to feelings and also include spatial metaphors. Therefore, feelings can have a spatial character. Emotions are pure phenomena of consciousness (Landweer, 2020).

Until now, the emotional and affective dimensions have not been incorporated into definitions of spatial awareness or into research on spatial abilities. Emotions have typically been examined independently or in relation to the perception of space, for instance in landscape studies (cf. Angiel, 2019).

Valorisation of space

Valorisation refers to classifying space for various purposes, being a subjective value that occurs between the evaluating subject and the evaluated object. It involves assigning characteristics to objects and actions, determining significance, and attributing value aiming at the classification of space in terms of different purposes. It is valuing, that is, the assessment of selected fragments of space based on the image created in people's minds. This image is created based on information collected from the environment by assigning characteristics to various objects and actions occurring in that space (Janiszek & Majorek, 2017). Valorisation is the process of creating value by possessing knowledge about the surrounding world and adapting that knowledge to the environment (Cleton, 2015). Perception and valuation of space shape preferences, often driving spatial decision-making (Chądzyńska, 2004; Senetra & Cieślak, 2004).

Preferences towards space

Preferences reflect the positive appraisal of spatial elements in meeting specific needs, embodying the interplay between cognition and behaviour (Słysz et al., 2007). Environmental stimuli shape human choices and emotions, forming the basis for preferences (Diec, 2010). Space acts as a medium eliciting comfort, emotions, and even fear (Ostrowska, 1991), profoundly influencing reactions (Byrska, 2015).

While preferences have been studied extensively, no analyses specifically target spatial awareness or spatial skills. Research on Dutch entrepreneurs indicates stable spatial preferences influenced by potency, activity, and evaluation (Meester & Pellenbarg, 2006). Rushton (1969) emphasizes studying spatial behaviour for accurate preference identification. Visual preference relates to spatial perception and creation (Csíkos & Kárpáti 2018; Rushton, 1969). Other studies explore links between preferences and loneliness prevention (Uchihira et al., 2023), business location (Habibi et al., 2024), or residential choices (Jaroszewicz & Majewska, 2021).

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MATERIALS AND METHODS

Spatial awareness was defined through qualitative research, combing through extensive literature to identify contributing factors using an inductive approach. Every factor identified in the literature was considered for analysis. Over 420 literature items were analysed based on keywords: children in urban spaces, spatial awareness, spatial thinking/intelligence, spatial skills, spatial reasoning, walk paths children, spatiality of emotions, space-related emotions, valorisation, spatial perception in the Web of Science, Scopus, and Google Scholar databases. The most frequent terms were visualised in a word cloud (Figure 1).

Figure 2 presents the names of approximately 700 authors and their interrelationships, and Figure 3 – the spatial distribution of their affiliations in the cited literature.

Scientific activity is concentrated mainly in Europe and the United States, likely due to widespread English-language research publications. Factors influencing this were categorised using a relationship matrix, reflecting Bloom's taxonomy (Bloom, 1956) with cognitive (knowledge), psychomotor (skills), and affective (emotions) spheres (Anderson & Krathwohl, 2001). The taxonomy of spatial thinking (Jo & Bednarz, 2009) and its simplified version (Scholz et al., 2014) have already been established.

Spatial awareness was defined in schematic and tabular formats, then evaluated by experts using the competent judges' method. It is usually applied to assess research material, in this case, to assess

Fig. 1. A word cloud of the most frequent terms from the literature review
Source: own elaboration.

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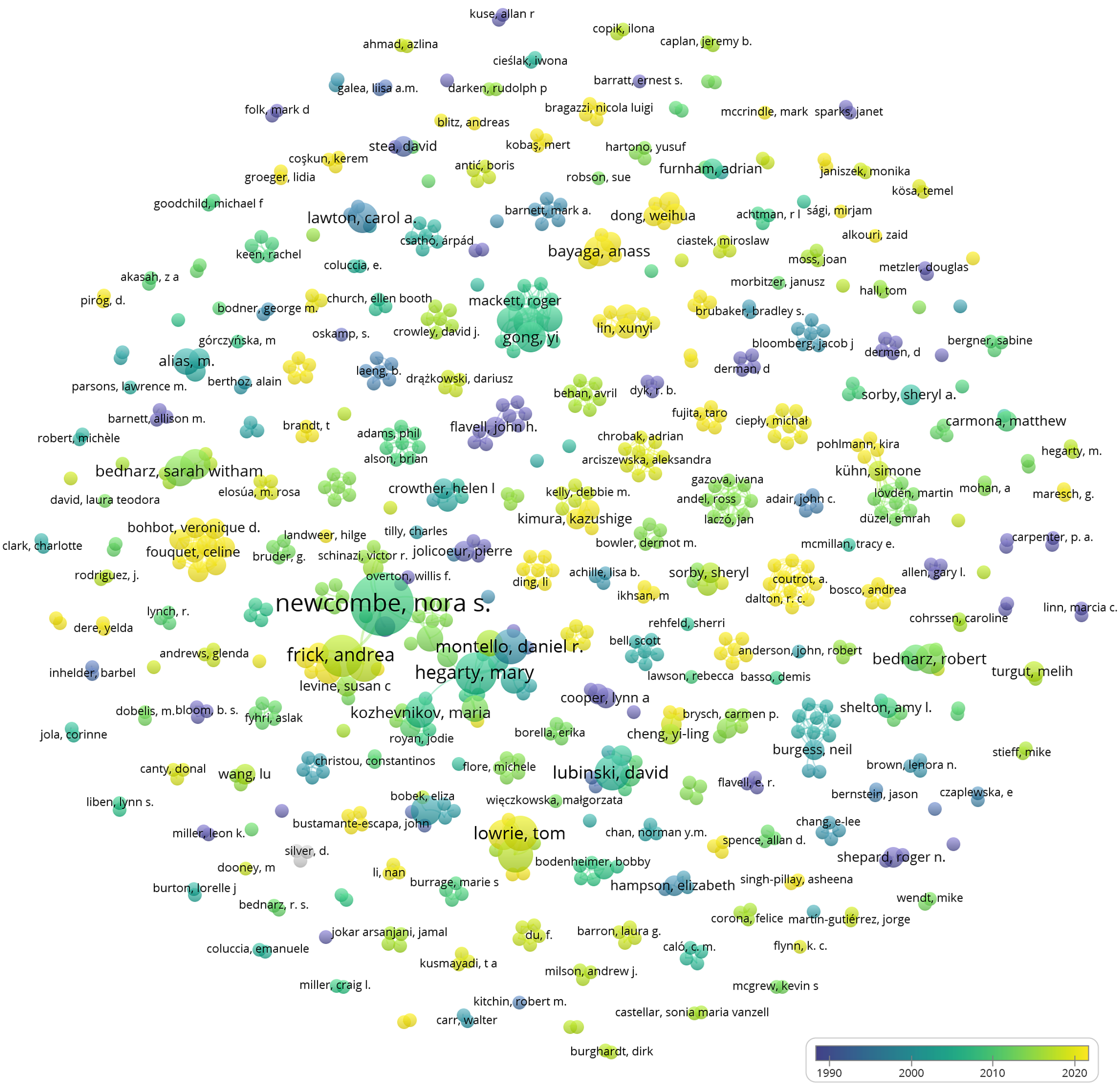

Fig. 2. Visualisation of the analysed scientific publications related to the studied issue, categorised by authors and years of publication
Source: own elaboration.

the validity of spatial awareness's component selection. Independent experts (odd number), including teachers, educator-scientists, and geographer-scientists, were interviewed to compare knowledge elements against primary school curricula to assess their relevance to the model. Each expert marked the element that appears in the current curricula and teaching materials. At least 2 out of 3 experts in each subgroup had to indicate a given factor. Then the results were discussed among all experts and considered significant or not within the constructed model.

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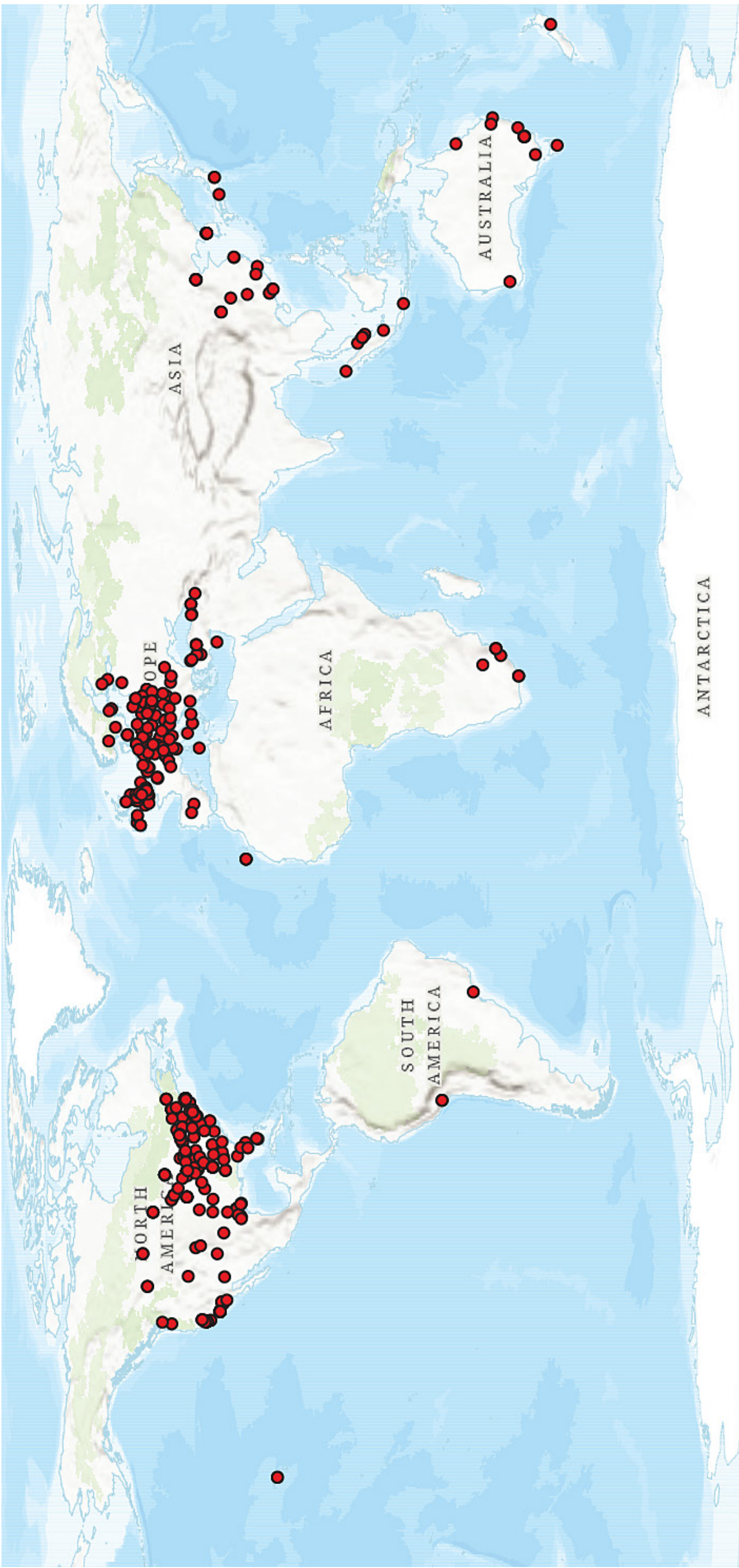

Fig. 3. Spatial distribution of authors' affiliations of the analysed literature
Source: own elaboration.

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RESULTS

Review of existing definitions of spatial awareness

In the literature, definitions of spatial awareness can be found, differing from each other depending on which element the researcher focused on. According to Dooney (2017), spatial awareness refers to comprehending one's position and the interconnections between objects in a designated area. Other definitions of spatial awareness are presented in Table 1, linking them with their corresponding elements.

Based on the results of this analysis, it was observed that previously developed definitions of spatial awareness only measure selected elements of spatial awareness found in the literature. The most frequently occurring components were spatial orientation and spatial visualisation; less frequently, they referred to spatial mental rotation or transformation, as well as the perception of space. Valorisation and navigation were not considered in existing definitions, which means such definitions cannot be considered comprehensive.

Constituent elements of spatial awareness based on the analysis of its definitions

Following the "from general to specific" approach, the literature analysis then allowed for the identification of constituent elements in 8 components of spatial awareness. The identification process is presented in Table 2.

In total, 27 different elements were identified. The most frequently occurring component of spatial awareness in research was spatial orientation; in second place was spatial thinking, followed by spatial navigation and spatial mental transformation. The frequency with which these components are studied by researchers may indicate their significant role within the structure of spatial awareness. On the other hand, it is possible that the remaining components warrant greater attention from the scientific community. Such an overview may serve as a valuable starting point for further research into spatial awareness and, above all, highlights the necessity of developing a comprehensive definition of the concept.

Table 1. Definitions of spatial awareness

Definition	spatial thinking	spatial orientation	spatial mental rotation	perception of space	valorisation of space	spatial navigation	spatial visualisation	spatial mental transformation
(…) spatial perception, spatial visualization (mental rotation and manipulation of objects in two or three dimensions), and spatial orientation (Sopa, 2021)		+	+	+			+	+
The indicators of spatial reasoning are spatial visualisation, mental rotation, and spatial orientation (Safrina et al., 2022)		+	+				+	
spatial perception, spatial visualisation, mental rotation, mental relationships, and spatial orientation (Gómez-Tone et al., 2021)		+	+	+			+	+
spatial visualisation and spatial orientation (Gómez-Tone et al., 2021; Tartre, 1990)		+					+	
Spatial awareness can be defined as the understanding of oneself and the relationships between objects within a given space (Dooney, 2017)	+							
SUM	1	4	3	2	0	0	4	2

Source: own study.

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Table 2. Constituent elements of spatial awareness

Constituent elements	spatial thinking	spatial orientation	spatial mental rotation	perception of space	valorisation of space	spatial navigation	spatial visualisation	spatial mental transformation
Active reception of sensory phenomena (Górczyńska, 2008)				+				
Analysis of sensory phenomena: location and scale of objects, phenomena, and processes; relationships, dependencies, and spatial regularities occurring between them; direction and scale of emerging changes (Ciepły et al., 2019; Górczyńska, 2008)	+			+				
Good city form (Lynch, 1984), good design, urban quality, comprehensive assessment of space's quality (Wojnarowska, 2017)					+			
Identification, modelling, forecasting, and understanding of: location, scale of objects, phenomena, processes; relationships, dependencies, spatial regularities; direction and scale of emerging changes (Ciepły et al., 2019)	+					+		
Interpretation of sensory phenomena; location, distance, direction in space (Górczyńska, 2008; Mohan & Mohan, 2013)	+			+				
Understanding the spatial dimensions and configurations of both the environment and the objects within it (Mihilewicz, 1999)		+				+		
Cognitive mapping involves acquiring, coding, storing, recalling, and decoding information about the relative locations and attributes of phenomena in everyday spatial (Ishikawa, 2023)		+						+
Making sense out of a visual representation (Tartre, 1990)		+	+			+		+
Organizing a visual representation (Tartre, 1990)		+						
Spatial perception (Azatyan, 2022)		+						
Visual perception (Sopa, 2021)		+						
Map perspective (Kozhevnikov & Hegarty, 2001)		+						+
Object perspective (Kozhevnikov & Hegarty, 2001)		+						
Distance perception (Pastel et al., 2022)		+						+
Spatial perspective taking – ability to represent viewpoints different from one's own (Brucato et al., 2022)		+				+		+
Spatial representations (Azatyan, 2022; Schneider & McGrew, 2012)		+					+	
Recognizing a visual representation (Tartre, 1990)		+	+			+		+
Reasoning with location, distance, movement, and changes in space (Mohan & Mohan, 2013)	+							
Path integration, crucial for human navigation, involves updating one's position relative to a home base using self-motion cues (Ishikawa, 2023)		+				+		+
Spatial thinking – Intrinsic skills pertain to an object's properties and relationships, while extrinsic skills involve object-reference frame relations. Dynamic skills involve movement or change, while static skills focus solely on object representation (Hodgkiss et al., 2021)			+					
Knowledge (Groeger & Lasek, 2021)					+			
Viewing a visual representation from another perspective without mentally relocating the object (Tartre, 1990)		+						
Visualisation (Mohan & Mohan, 2013)	+							
Sense of direction (Kozhevnikov & Hegarty, 2001)		+				+		
SUM	8	15	3	3	2	7	1	7

Source: own study.

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Determinants of spatial awareness elements

After analysing factors categorised by existing definitions, we verified them with the literature. Identified determinants were organised to create a list influencing spatial awareness levels, presented in Table 3.

28 determinants were identified as factors influencing the level of spatial awareness. According to the existing literature, most of them affect spatial navigation, spatial orientation, and spatial perception. As has been observed thus far, spatial orientation is the component most frequently appearing in research on spatial awareness – whether in the context of its constituent elements, factors influencing its level, or in the limited number of existing definitions of spatial awareness.

Table 3. Determinants of spatial awareness elements

Determinants	spatial thinking	spatial orientation	spatial mental rotation	perception of space	valorisation of space	spatial navigation	spatial visualisation	spatial mental transformation
1	2	3	4	5	6	7	8	9
Education (schooling, knowledge) and training (Chądzyńska, 2004; W. Yang et al., 2020)	+			+	+		+	
Locomotor functions (Azatyan, 2022)		+	+					+
Intelligence (Gómez-Tone et al., 2021)		+						
Quality of speech (W. Yang et al., 2019)		+				+		
Number and type of elements, their diversity (Chądzyńska, 2004)				+				
Family's geographical settlement (rural or urban) (Chądzyńska, 2004; Godfred et al., 2021)				+				
Analytical thinking, e.g. playing chess (W. Yang et al., 2019)		+	+			+		+
Intellectual disability (Azatyan, 2022)		+						+
Spatial orientation (Epstein, 2008; W. Yang et al., 2019)						+		
Higher cognitive processes involving the limbic and cortical areas related to spatial memory (Epstein, 2008; Lövdén et al., 2012; W. Yang et al., 2019)		+				+	+	+
Gender (Coluccia & Louse, 2004; Linn & Petersen, 1985)	+	+	+	+				+
Social economic status (Chądzyńska, 2004; Godfred et al., 2021)				+	+			
Long-term habits and preferences (Chądzyńska, 2004)					+			
Rate of change over time (Chądzyńska, 2004)				+				
Social and professional affiliation (Chądzyńska, 2004)				+				
Mental rotation (Weisberg et al., 2014)						+		
Emotional states and spatial anxiety (Ishikawa, 2023)		+						
Cues (Chen et al., 2017)						+		
Spatial learning (W. Yang et al., 2019)						+		
Spatial updating skills (W. Yang et al., 2019)		+				+		
Path integration (Chen et al., 2017; W. Yang et al., 2019)						+		

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Cont. **Table 3**

1	2	3	4	5	6	7	8	9
Valuation, assigning merits, determining significance (Chen et al., 2017; Senetra & Cieślak, 2004)					+	+		
Age (Azatyan, 2022; Epstein, 2008; Godfred et al., 2021; Lövdén et al., 2012; Y. Yang et al., 2019)		+		+		+	+	+
Mental imagination (Epstein, 2008)						+		
Source of knowledge about space (personal experience and opinions of others) (Chądzyńska, 2004)				+				
Purpose (Benoudjit et al., 2004)				+				
Sketching (Kok & Bayaga, 2019)							+	
SUM	2	11	3	10	3	14	3	6

Source: own study.

Theoretical model of spatial awareness

The expert assessment of Table 2 and Table 3 produced the theoretical model of the definition of spatial awareness, shown in Table 4. Accordingly, the following original definition was formulated: Spatial awareness is a complex ability of an individual to operate within space, comprising three equivalent components: knowledge of space and the tools for its description and analysis, intellectual and motor skills related to functioning in space, and emotional responses to objects within space. Components were categorised into three parts of the learning model, following Bloom's model (Bloom, 1956), with specific elements outlined.

The table identified 3 groups: knowledge and experience, spatial skills, and spatial affectivity, totalling 12 components. Each was detailed in the first three subsections of the results chapter. This theoretical model of spatial awareness, developed from extensive literature review, is depicted in Figure 4.

Given that various components are examined in different configurations across numerous studies (e.g., spatial orientation in conjunction with emotions and knowledge of spatial objects), the proposed model emphasises the interrelationships and mutual interpenetration of component groups, highlighting their inseparability. It is not possible to study a single element in isolation without considering the influence of other interconnected components.

Table 4. Components of spatial awareness

SPATIAL AWARENESS		
KNOWLEDGE AND EXPERIENCE	**SPATIAL SKILLS** (intellectual, motor)	**SPATIAL AFFECTIVITY**
Knowledge about objects in space and tools for their description and analysis	Application of knowledge about space – reasoning processes (mental) and practical actions	Emotional reactions to objects in space
– knowledge about spatial objects (natural and anthropogenic) and related experiences – knowledge about directions and spatial relationships, and perspective – understanding of units of measurement and scaling – cartographic knowledge and about new technologies supporting space understanding	– spatial perception – spatial orientation – spatial visualization – spatial mental rotation and transformation (scaling) – spatial navigation	– emotions – valorisation – preferences

Source: own study.

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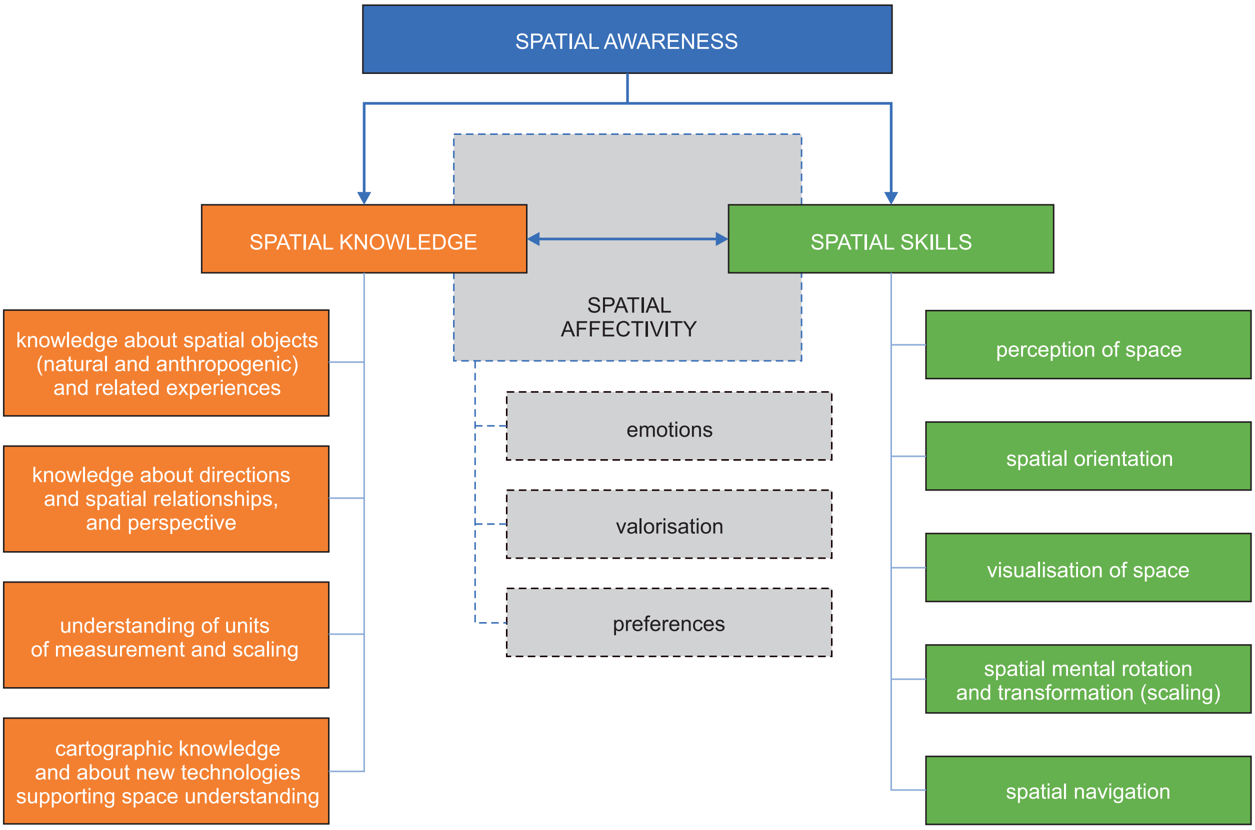

Fig. 4. A schematic representation of the components in the spatial awareness model
Source: own study.

Knowledge and experience

Childhood mental development primarily occurs through interactions with others (Witten et al., 2019), though not all interactions lead to knowledge acquisition (Krasuska-Betiuk, 2015). Throughout their lives, people experience various changes. These mainly result from the ability to move through space by different means of transport, but currently also as a result of the development of new technologies through media (Danilewicz, 2016). The way of perceiving place in space changes – in virtual reality, which a person can independently create and stay in, even just for a moment, depending on needs. Spatial knowledge, crucially derived from life experience and maps, encompasses procedural (route) and map (survey) knowledge (Depta, 2012). The scope of components from the knowledge area was determined through analysis of education programs (Mohan & Mohan, 2013; National Research Council, 2006). National curricula in various countries may address the development of spatial awareness within topics related to natural science education, geography, or mathematics.

Spatial skills

Spatial skills, a key focus in cognitive and educational psychology for over a century, are shaped by internal and external factors (Gómez-Tone et al., 2021; Sopa, 2021). They enable processing, understanding, and memorization of spatial relationships between objects, crucial across diverse human activities (Farrell et al., 2015). These abilities are essential for tasks involving graphs, figures, sketches, etc., influenced significantly by early experiences but also trainable

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into adulthood (David, 2012). Systematic training can improve these skills, particularly benefiting in STEM (science, technology, engineering, mathematics) domains (Baenninger & Newcombe, 1995; Roslan & Ahmad, 2017; Schneider & McGrew, 2012; Uttal, Miller, et al., 2013). However, current education systems often neglect spatial skills, hindering the development of essential competencies for STEM-related professions (Kok & Bayaga, 2019; Roslan & Ahmad, 2017; Uttal, Meadow, et al., 2013b).

Affectivity

Not only knowledge of its elements and skills associated with this knowledge but also the experienced affective states influence functioning in space. Affectivity influences the way people think and act in social situations (Forgas et al., 2001), as well as in interactions with space (Sági, 2022; Simonsen, 2007). Affectivity refers to the capacity to feel and express emotions. In the taxonomy (Krathwohl et al., 1973), the affective sphere describes how people emotionally react and concerns feelings, motivations, values, and attitudes. In our proposed model, this sphere includes emotions, valorisation, and preferences (Chądzyńska, 2004).

It's important to differentiate between affects (pre-cognitive, sensory experiences), emotions (more cognitive and expressible), and feelings (bodily sensations and perceptions) (Bondi, 2009; Sági, 2022). The interplay between bodily cues and spatial perception influences emotional responses (Dobricki & Pauli, 2016), highlighting the significance of emotional spatiality in spatial analysis.

Organising emotional information is necessary (Hauthal & Burghardt, 2016), with Plutchik's Wheel of Emotions (Plutchik, 1980), which categorises emotions into eight bipolar opposites (Nielek et al., 2017): surprise vs. anticipation; fear vs. anger; disgust vs. liking; sadness vs. joy. For the clarity of the spatial awareness model, the basic thesis regarding the regulatory role of distinguished emotions was used, i.e., the arousal of one emotion in the dyad prevents the arousal (at the same time) of the opposite emotion.

DISCUSSION AND CONCLUSIONS

To construct a model of spatial awareness, components of broadly understood spatial abilities identified in the literature were used. The concept of their formation was also referenced. For this purpose, critical analyses of Polish core curricula were consulted (Pokojski et al., 2021; Szkurłat & Piotrowska, 2018). To include the international context, findings commonly considered in empirical research formulated by the American National Research Council (2006), which developed an international report with basic terminological and research findings, calling for the creation of a curriculum and support system for spatial thinking in an educational context, were taken into account. Recommendations from the report by Mohan & Mohan (2013), which presents the development of spatial skills in ontogeny and on this basis proposes a synthetic program for developing spatial thinking skills at various stages of education, were also considered. Research findings on education contained in other documents and websites were also included (Jo & Bednarz, 2014; Kerski, 2013; Sinton et al., 2013).

The achieved results are consistent with the existing guidelines and further develop them towards composing a comprehensive definition of spatial awareness. Our research results revealed a different perspective on the definition of spatial awareness as a complex concept requiring comprehensive study. Until now, scientific research focused only on selected components of this awareness, not addressing this issue holistically.

Previous studies attempted to integrate individual elements, such as in the case of spatial thinking (2 literature items, where the most comprehensive approach was found), however, in this case, affectivity as a significant element of spatial awareness was not considered. In building the model of spatial awareness, international educational recommendations (Mohan & Mohan, 2013; National Research Council, 2006) and educational standards, as well as Bloom's conceptual model of learning (Bloom, 1956). The composed model combines theoretical and practical elements, resulting in a comprehensive interpretation of the

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definition of what spatial awareness is. It turns out that affectivity, comprising emotions related to space, valorisation, and preferences, are integral elements of spatial awareness because they condition decisions made in space and are the driving force for its exploration. Hence, the thesis posed at the beginning is valid. In further research diagnosing the level of spatial awareness in children and adults, all elements should be considered collectively.

Measurement results considering all elements may shed different light on the level of spatial awareness in children and thus expand the repertoire of educational actions. Besides focusing on the technical side of the cognitive sphere, attention should be focused on ways of emotionally domesticating space.

Previous diagnoses did not show all aspects of spatial awareness simultaneously. Considering the above, the next stage of research will be the construction of an intelligent tool for diagnosing spatial awareness based on the developed theoretical model. As a consequence of these findings, further research will examine the interrelations between components or groups of components. Consultations will be conducted in an international forum to confirm the validity of the developed scale for measuring spatial awareness.

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