RBECT
Revista Brasileira de Ensino de Ciência e Tecnologia

Revista Brasileira de Ensino de Ciência e Tecnologia
ISSN: 1982-873X

https://periodicos.utfpr.edu.br/rbect

Spatial perception of a blind person: interactions and experiences

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ABSTRACT

This paper presents the results of a study whose objective was to analyze the spatial perception of a blind person, as well as their understanding through their expressions. For that, this person, a Geography student, agreed to contribute, which allowed us to carry out the activities that we propose. Therefore, it was a qualitative research, characterized as a case study. In data collection, we used five physical scale models where data related to the participant's tactile perceptions were recorded in audio and further transcribed. In the analysis, the 'link' was made between the field data and the perceptual theory obtained. The results allow us to identify that the perception of knowledge related to 'relief', 'hydrography' and 'cartography' of this blind student went through the three phases of Modeling, that is, the phases of perception-apprehension; understanding-explanation; and signification-expression. The identification of how the mental process of human beings occurs, especially the collaborator of this research (due to blindness), can contribute to teachers who work in Basic Education to know how to help their students in improving their knowledge and, most of all, in finding their career interests.

KEYWORDS: Modeling; Blindness; Perception - Comprehension.

INTRODUCTION

Historically, according to Mazzotta (2005), Special Education in Brazil is divided into three phases. In the first (eighteenth century), it was understood that 'disability' was related to religious beliefs and that whoever had some kind of limitation should be punished for having committed some sin. These people would need to be purged, not included in common life. In the second phase, called medical-sanitary, it was believed that these people should be referred to sanatoriums or asylums, to be treated by doctors. During this period, the belief in hygiene and segregation of people still remained. Only in the third phase, in the middle of the 20th century, did it come to be understood that, even with limitations, these people were fully educable and that they should, therefore, have the support of teachers to learn. The landmark of Special IEducation in Brazil was the creation of the Imperial Institute of Blind Boys (Imperial Instituto para Meninos Cegos), in 1854, which aimed to assist the visually impaired. Only in the mid-1960s did the demands of this public come to be understood as State policy (ARAGÃO, 2012; MAZZOTTA, 2005).

In official documents in Brazil, Special Education is supported by the Law of Guidelines and Bases of National Education (LDB), law nº 9.394/96 (BRASIL, 2017), and by the National Policy of Special Education in the Perspective of Inclusive Education (BRAZIL, 2008). The LDB, which governs both Basic Education and Higher Education, presents, in two articles – out of a total of 92 – the specific legislation for the modality of Special Education. In them, it is explicit that the assistance to these students should occur, preferably, in the regular education network, through specialized support services, with adaptation of curricula, methods, strategies, pedagogical resources and with specialized teachers, whose training may occur in service. The document emphasizes that education should be related to the world of work, there needs to be equality for the access and permanence of all students in the school and academic environment, that it is necessary to value extracurricular experiences and that higher education should train graduates, in different areas, prepared for the exercise of the profession (BRASIL, 2008, 2017). The National Education Plan (BRASIL, 2014), in its goal 4, explains the specialized educational service for the public that needs it. In 2020, Decree 10,502 was published, establishing the National Policy on Special Education (BRASIL, 2016a).

At the international level, related to inclusion, there is the Declaration of Salamanca (BRASIL, 1994). This document originated from a meeting in Spain, in June 1994, which brought together 88 countries to discuss issues associated with inclusion. At that moment, the following are advocated: the right of all to quality Education; respect for diversity and individual needs; the preference for attending regular schools; the development of projects and the exchange of ideas between countries; the need for teaching qualification; carrying out and disseminating academic research; the adaptation of curricula; and the creation and improvement of teaching resources and strategies. It can be seen that there are several points of convergence between the LDB and the Salamanca Declaration.

Special Education, from an inclusive perspective (BRASIL, 2008), has been the subject of several studies. Rocha et al. (2020) reported the inclusion of students with intellectual disabilities in a public school in Maranhão, based on the analysis of Portuguese and Mathematics activities. The authors concluded that there is the application of methodologies to include students and that teachers have

knowledge on the subject, although much still needs to be done in this regard. The research by Fiorini and Manzini (2016) presented success and difficulties in the inclusion of students in Physical Education classes – based on the filming of 28 classes. It was concluded, in addition to the success of inclusion in the researched context, that there are some needs to be considered in the training of new teachers, so that inclusion can happen. Aragão (2012) carried out a research in which he analyzed the contributions and limitations of the use of a specific didactic material for teaching Chemistry content (atomistic) for blind students in High School. Araújo and Lima (2011) sought to identify possible barriers – in the understanding of teachers – in relation to students with cerebral palsy. Martins (2010) sought to understand the sound perception of people who are blind through the use of a calculator in learning rational numbers, concluding that the resource used – a calculator that emitted sounds depending on the type of rational number shown on the display – contributed to that participants recognized simple, compound, and irrational repeating decimals. Cardinali (2008) found out about the learning of cytology for people who are blind, through tactile models, resulting in different advantages of using this resource for Biology teaching.

By seeking to understand the context of people with some type of disability, it was possible to know more about their ability to learn, about their contributions to the context in which they live and, above all, about how much they can contribute to the improvement professional conditions of people who have visual impairments. In order to improve knowledge about visual impairments, this research sought to answer the guiding question: How does blind people perceive spatial concepts involving cartography?

To answer this question, this article presents: 1) introduction; 2) theoretical foundation on perception; 3) methodology, considering: the approach and type of research; the study collaborator and the procedures adopted for data collection; 4) the results and discussion of the relationships between the theoretical substrate and the empirical data; 5) final considerations, pointing out the main contributions to the areas of Science and Mathematics.

THEORETICAL FOUNDATION

Initially, a synthesis of perception is presented through cognitive and philosophical biases. On the philosophical side, Didier (1969) argues that perception is made up of two components: one affective and the other cognitive. For example, when listening to a song, our previous experiences bring out a good or bad emotion, possibly related to some episode experienced in which that song was part of the context. This fact highlights the affective component of perception. The cognitive component, in turn, allows us to understand and name this sound as music, and not just any noise. According to Didier: “the nature of our perceptions, when seeking to understand an affective element (a certain sensation), provokes a feeling of exteriority that allows us to name, determine the object” (DIDIER, 1969, p. 250). (DIDIER, 1969, p. 250). Although perception is preliminary to a possible acquisition or improvement of yet another piece of knowledge, it is a global process. When listening to music, we perceive the melody as a whole, not the musical notes. According to this author, “perception is the immediate apprehension of structures of reality [...], the starting point of our knowledge” (*Ibidem*).

For Russ (1991, p. 215), still in the view of Philosophy, perception is

> the function by which the spirit organizes sensations, [...] it is empirical consciousness, that is, a consciousness accompanied by sensation, [...] it is a mixture of sensible and reflective determinations [...], it is consciousness from the immediate object present to the sensory organ, [...] it is the conclusion of a representation".

It appears that, for the author, perception begins with the sensation of an object by the sense organs, going through a cognitive work of reflection, based on previous experiences, ending with a representation of the object. For him, there is a perceptive path, namely: 1) sensation through the sense organs; 2) reflection and cognitive work; 3) final representation of the object.

For Biembengut (2016), also in the philosophical conception, perception-apprehension is the first step that attracts the senses, sharpens our interests and instigates our needs, whether they want to have, or want to be, or want to contribute, help. Perception-apprehension, although not the source of knowledge, is the driving source, which begins with the identification of an object by the sense organs and, when connecting with previous experiences, produces or reproduces a certain representation of the object. It is the mind in continuous process. Anything that draws attention, immediately, takes a certain route in an attempt to know it better, understand. A fourth philosophical aspect is brought by Antunes, Estanqueiro and Vidigal (1995, p. 130). They explain perception as "the action of mentally forming representations about external objects, [...] being the awareness we have of the object as soon as it is presented to the sensorial organ". For these authors, perception is associated with a sequential process composed of phases: (1) sensation by the sense organs; (2) awareness-raising process; (3) formation of a mental representation (ANTUNES; ESTANQUEIRO; VIDIGAL, 1995).

Concluding this perspective in the philosophical aspect, on Abbagnano's conception (1998), three definitions for the term perception can be distinguished:

> (1st) very general meaning, according to which this term designates any cognitive activity in general; (2nd) more restricted meaning, which designates the act or the cognitive function, for which a real object is presented; (3rd) specific technical meaning, according to which this term designates a specific operation of man in his relations with the environment. (ABBAGNANO, 1998, p. 753).

Based on the above, Abbagnano (1998) conceptualizes levels of perception, from the simplest act to the most complex. At the first level, simple thought, perception involves any theme, representing the initial act of perceiving. At the second level, perception is more restricted, related to an object. And, at a third level, perception is a complex act, which brings together the organization and interpretation of environmental stimuli by the person.

For this author, perception has three associated characteristics: (1st) selectivity, (2nd) expectation of the future and (3rd) creation of hypotheses and judgments. As it is not possible to perceive everything in the environment, it is necessary to select a portion of reality through attention. In addition, previous experiences are taken into account, and the expectation of how they would like to perceive things also interferes with perception. These interferences can lead to other hypotheses and judgments of what was perceived or what one wants to perceive. The philosophical aspects presented so far are listed in the table below,

in the form of topics in order to be better visualized and so that the authors' proposition can be compared.

Chart 1 – Perceptual process from the point of view of Philosophy

PHASES	DIDIER (1969)	RUSS (1991)	ANTUNES; ESTANQUEIRO; VIDIGAL (1995)	ABBAGNANO (1998)
1	Contact with the object (knowledge component)	Sensation by sense organs	Sensation by sense organs	Simple act of thought, no interpretations
2	Past experiences (affective component)	Reflection and cognitive work	Awereness	More restricted cognitive act, related to the object (empirical)
3	Global perception (combination of components)	Final representation of the object	Formation of a mental representation	Complex human operation combining aspects of the environment and knowledge

Source: The authors (2020).

When analyzing the concept of perception from a philosophical point of view, considering the different authors, it is noted that the process of perceiving is composed of three stages that are refined throughout its development. First, there is the initial contact with the object. Next, there is a complex cognitive activity that considers the subject's past experiences and prior knowledge, which creates hypotheses and makes judgments about the object of knowledge with which one is in contact. Finally, there is a representation, referring to perceived knowledge. In this last step, the final representation of the object of knowledge is formed.

From the perspective of Cognitive Psychology, Davidoff (2001) points out that perception has three components, namely: (1st) the sensation by the organs of the senses: the stimuli of the environment are captured; (2nd) capturing a portion of reality through attention: selection of stimuli; and (3rd) the organization and interpretation of stimuli: complex mental activity whose purpose is to return an adequate response to the environment. The author also points out that previous experiences and the affective (emotional) component, similarly to the philosophical aspect, also influence perception.

According to Davidoff (2001), physiological issues and constructive skills are also influenced. Although, in general, people's bodies have the same anatomy (structures) and physiology (way of functioning), there are natural differences that interfere with perception. Constructive skills, in turn, refer to the ability to carry out successive hypotheses, whether to refute or accept them, in order to constitute an increasingly elaborate perceptive framework. Davidoff (ibidem) also shows that the second component of perception, which is linked to attention, is influenced by three factors: needs, interests, and values. People tend to be more

attentive and, in a way, perceive details of what meets their needs or interests and that is connected to their beliefs and values.

The variation of sensory stimuli seems to be a component to be considered in tactile perception, particularly in people who are blind. Thus, using materials with different textures, which do not harm the epithelial tissue and which promote the differentiation between the parts of the object, seems to be an indispensable factor for this public. However, it is fundamental that the same texture has the same meaning in different materials, so that the blind person acquires perceptual memory. Unlike common sense, there is no compensation for one sense (ORMELEZZI, 2000) due to the lack of another. What happens is a functional reorganization of the body, which makes certain sense organs more acute in people who are blind. Finally, Davidoff (2001) says that, unlike vision, which has a globalizing characteristic, in tact, people touch successive parts several times to form the whole, not having a holistic perception, as with vision (*ibidem*).

Still, in this psychological perspective, there is a perceptive theory that studies patterns, structures, and forms, called Gestalt. It features eight characteristics conceived from the sense of sight. It is believed that, in some blind people, four of these characteristics can be observed: continuity, symmetry, background figure, and regularity. The others – perceptive constancy, grouping, closure, and closeness – would not be observed in these people (*ibidem*).

Continuity refers to the fact that a certain representation has no interruptions. Symmetry, on the other hand, concerns identical representations, but in different positions, if different axes are considered. The figure-ground feature highlights the fact that a given structure, in a representation, can be highlighted (figure) or in the background, depending on how the individual focuses their attention. The characteristic of regularity allows human beings to perceive objects as simple as possible, inferring only the basic characteristics. Perceptual constancy explains that an object remains the same shape and size, regardless of the angle or perspective from which it is observed. The grouping occurs when a set of represented entities have characteristics in common, and they tend to be perceived as grouped, as well as the characteristic of proximity. Closure, in turn, explains the tendency to complete incomplete representations (*ibidem*).

Finally, we refer to perception through the formation of mental models. According to Borges (1998, p. 9), “a mental model is a model (representation) that exists in someone's mind”. According to the author, in order to understand something and, consequently, give explanations about it, it is necessary for human beings to form models. Souza (2013, p. 173) says that “[...] mental models are cognitive structures related to understanding [...]. Understanding something means building a mental model for it.” And, from the perspective of Moreira and Krey (2006, p. 357-358):

> people reason with mental models, which are like cognitive building blocks that can be combined and recombined as needed. The meaningful understanding of a concept, event or object implies the construction of a working mental model of this concept, event or object.

For the authors, the formation of mental models occurs when we are led to make something explicit to another person. D'amore (2007, p. 153) says that the formation of mental models “it is a dynamic process that happens as we are required to explain or know something”. In order to have mental models, our

cognition is organized in three stages: (1st) contact with the object through the organs of the senses; (2nd) formation of different mental images; (3rd) formation of the mental model after the saturation of the mental images.

In turn, the phases of Mathematical Modeling, proposed by Biembengut (2014), are highlighted. In the author's conception, Modeling is a research method used by human beings since they stopped moving using their hands and feet, that is since they started to move only with their feet. The human mind processes itself in the form of models. Our thinking, in a way, is formed through images – mental models. We think through models (BIEMBENGUT, 2014).

As the process of modeling is inherent to human beings, since the 1960s and 1970s, some countries (USA, England, Germany, and Brazil, among others) began to defend Modeling as a teaching strategy. Although the use of Modeling in teaching was defended, none of these countries presented a method to use it, in particular in Mathematics teaching. This Modeling method for teaching students was prescribed by Biembengut in 1990 and improved in 2013, for teaching Mathematics and Science in regular courses (*ibidem*).

This method follows three phases. In the first phase – perception and apprehension –, it is time to learn about the situation that is expected to be resolved or improved. In the second phase – understanding and explanation –, it is time to formulate hypotheses and outline a model or a system that represents it, explaining the data and their relationships. In the third phase – meaning and expression – it is time to interpret and evaluate the results, verifying whether the model is valid or not (*ibidem*).

METHOD

In this research, we deal with a case study from a qualitative perspective (BOGDAN; BICKLEN, 1994; FLICK, 2009; CRESWELL, 2014). The authors explain four characteristics of this approach that integrate the study: (1) research carried out in a natural environment in which the researcher is the main instrument for data collection, insofar as there was an approximation of the researched person to record the audios; (2) descriptive and interpretative study, since the objective is to understand the blind person's perception process in a global way, presenting their description of the perceptive process; (3) concern with the research process, not just the final product; (4) the research “gives meaning to the lives of the people involved”, that is, it had a close connection with the way of life of the study collaborator.

The study had the collaboration of a geographer (born in 1992) who, due to congenital glaucoma, became blind at the age of 9. Until then, he could see texts adapted with larger letters or with the use of glasses. His Basic Education took place in a private school that, initially, was designed for the visually impaired and blind, but since 1998, it has been serving students with all characteristics. At first, this collaborator's literacy training took place through conventional writing and, at a second moment, in Braille. At the age of 17, he started his studies in College, getting a Bachelor's degree and a Teaching License in Geography. Afterward, he enrolled in the master's degree in Tactile Cartography at the Federal University of Santa Catarina (UFSC). He performs most daily tasks alone, such as example, preparing meals that require a few steps of preparation, playing ball and playing

the guitar, and needing help with activities that require visual fluency, such as crossing the street and watching television.

According to Coutinho (2008, p. 12) "[...] the sample has to be appropriate, composed of participants who best represent or know the topic on which the research focuses [...]". It is understood, therefore, that the intentional choice of a single person who is blind" [...] ensures efficiency and an effective saturation with an optimal quality of the informative power of the data and a minimum of losses" (ibidem), this being sufficient option to respond to the objective of the presented research.

In this study, five materials originating from the Laboratory of Tactile and School Cartography (LabTate) of the Federal University of Santa Catarina (UFSC) were used. Created in 2006, LabTate aims to provide a space for the development of tactile teaching materials to help students with visual impairments or blindness. In addition, it promotes the gathering of researchers to investigate the teaching of Geography, through extension actions or academic research, serving as a reference, in the state of Santa Catarina, for companies, schools and government agencies that need assistance in making decisions related to the inclusion of people who are blind.

Five physical scale models were used. According to Biembengut (2014, p. 21):

> Physical-Mathematical Modeling constitutes a process involved in the expression, reproduction and/or description of a set of data or image or a physical entity. The model resulting from this way of modeling can be scaled (drawing and/or replica) or analogy (graphical and/or algebraic representation).

The models used were: 1) map with the UFSC campus: the representation contains the location of the main buildings, bus stops and routes inside the campus; 2) styrofoam contour lines: representation of two hills, with their contour lines and a river, made of styrofoam; 3) styrofoam contour lines and finish: this is the same representation as before, but with a clay finish to represent the terrain of the hills, with each level curve contoured with string to enhance tactile perception; 4) terrestrial globe in styrofoam: representation of the terrestrial globe in styrofoam, with the mantle (with ethylene-vinyl acetate - EVA) and the core (with cellophane) represented on the inside; 5) terrestrial projections: flattening of the terrestrial globe, in the shape of a hand fan, made with balloon and glue, to allow identification by touch.

Each model was handed over to the collaborator so that he could express his perception of each representation. The speeches were recorded in audio, totaling about 4 hours of recording, and were later transcribed. In addition to the transcription, an adapted interview and a synthesis were produced. The researcher performed the same procedures as the collaborator, explaining what he perceived in each material, so that there was a parameter for comparison. Due to the reduced space, the analysis of the perception referring to only one model will be exposed in the following section. The material chosen was the map of the UFSCatarina campus (Model 1), as it presents more details and, consequently, a more in-depth analysis.

Regarding the ethical issues of research, data collection was prior to Resolution 510, which deals with "the rules applicable to research in Human and

Social Sciences, whose methodological procedures involve the use of data directly obtained from participants or identifiable information or that may entail greater risks than those existing in everyday life" (BRASIL, 2016b). Therefore, only the participant's signature of the free and informed consent form was collected so that the didactic procedures could be carried out, recorded and used in the investigation

RESULTS AND DISCUSSION

To better organize the analysis and discussion of the results, this section will present a table (Chart 2) with excerpts from the collaborator's impressions, which were taken from an adapted interview, organized in speech shifts (SASSERON; DUSCHL, 2016). Language defects were removed from the original transcription in order to make the text fluid. The table shows: classification of the collaborator's statements in the phases of Mathematical Modeling (MM); brief discussion about the application (or not) of the Gestalt characteristics in the perception of the blind person, analysis of the perception of the person who is blind associated with the perception in the view of Philosophy; perception of the blind linked to perception in the field of Cognitive Psychology; perception of the person who is blind and association with the formation of mental models.

It should be noted that this procedure was performed with all materials. But, due to the limited space, it was decided to present the impressions related to only one of the models, in this case Model 1.

Chart 2 - Cutting and organization of the research collaborators speeches.

EXPLORED PART OF THE MATERIAL	SPEECH TURN	SPEECH CUTTING	CLASSIFICATION ON MATHEMATICAL MODELING PHASES
Library	1	Here it has this shape, it looks like an hourglass. It appears to be a butterfly. I don't know.	PHASE 1
	2	It's the library. Let's see if I can find the library here. I don't know if I'll find it. I know that the library is in the middle of the University. On this map I'm in the middle, so I'm looking for the library around the middle, to make sense of my search. I already went to the library. And I also know that it is close to the RU (University Restaurant). I also know it's close to the Rectory.	PHASE 2
	3	I found it! Here is the library!	PHASE 3
University Hospital	4	Then there is this symbol here that is an H, for me this is an H.	PHASE 1
	5	It's the University Hospital, and I can't imagine where it is. I know it's outside the University. It is not	PHASE 2

		exactly in the middle of the University. I don't know if it's on campus, but it's not really on campus.	
	6	Yes, here! The Universitary Hospital! I knew it was out.	PHASE 3
Representations of lines on the map	7	I believe it's the street types here.	PHASE 1
	8	There's the triple line up here which are access avenues, those that go around the entire University. There are three lines together. Then there is the double line, which are the inner streets. And there is a finer one which is a path, probably the paths that are done on foot, which are the thinnest ones. There's one that looks dotted, which is the streams.	PHASE 2
	9	This here is a stream! Here's a loop. It's a dotted line, really. Comparing with the line that represents the internal path, it looks like a dotted line.	PHASE 3

Source: The authors (2020).

When exploring the part of the map that corresponds to the library, the research collaborator makes the initial recognition of the situation and a first data collection (shift 1), configuring the perception and apprehension – first phase of the MM. Then (turn 2), he elaborates hypotheses when he says that the library is "more in the middle of the campus" and "closer to the cantine", moving, therefore, to the second phase of the MM, called understanding and explanation. Finally, in the third phase of the MM, called meaning and expression, the collaborator evaluates and interprets, expressing the final meaning regarding the location of the library (turn 3).

It is noticed that, when exploring the part of the map where the University Hospital is located, the research collaborator goes through the three phases of the MM again. In speech turn 4, he makes an initial recognition of the letter H, configuring the first phase of the MM (perception and apprehension). Then, in speech turn 5, he makes some conjectures about the location of the University Hospital ("I know it is further away from the University"), reaching the second phase of the MM (understanding and explanation). Finally, in speech turn 6, there is a confirmation of the location of the University Hospital, as if it were a validation, configuring the third phase of the MM (meaning and expression).

When exploring the styles of lines that make up the map, it is clear that the collaborator brought out the three phases of the MM. In speech turn 7, he initially recognizes the situation – phase 1 of the MM. In turn 8, the participant risks some hypotheses regarding the meaning of each line and weaves initial explanations, configuring phase 2 of the MM. And, in speech turn 9, there is the validation of the model, characterizing the phase 3 of the MM.

Thus, when considering the expressions of the collaborator who is blind, it can be inferred that they are closely associated with the MM phases proposed by

Biembengut (2014). In phase 1, perception and apprehension, there is an initial contact with each model, in order to obtain recognition of each representation of entities related to Geography, through touch. Moving on to the second phase, understanding and explanation, there is formulation followed by acceptance or rejection of hypotheses, with the formation of a representative mental model of the situation, considering the tactile experience of the blind collaborator. Finally, there is the validation and confirmation of the model, demonstrated by the participant's statements, configuring phase 3 of the MM, *meaning* and *expression*.

The second part of the analysis refers to the application of Gestalt characteristics in the explored models, from the perspective of Cognitive Psychology. Continuity refers to the material having no interruptions in representation. When seeking to know about people who are blind, it is perceived that this is a fundamental characteristic, since an interruption, for them, denotes the end of a representation. With regard to symmetry, it seems that it contributes to the future expectation of perception (ABBAGNANO, 1998), insofar as there are the same representations, considering different axes.

The *figure-ground* refers to the fact that the same representation is sometimes configured as a figure, sometimes as a background. Through touch, the blind person can give greater focus to some aspect. In this case, that portion of the representation is characterized as figure, and the rest as background. Concluding the Gestalt characteristics that, as understood in this study, apply to blind people, there is regularity. It refers to the fact that people perceive forms as simple as possible. The simpler a representation, the more easily it is analyzed by touch and the less chance of mistakes (DAVIDOFF, 2001).

The characteristics of this perceptual theory that, according to this research, do not apply to a person who is blind, are: perceptual constancy, grouping, closure and proximity. Perceptual constancy explains that, regardless of the position or angle from which something is observed, the representation does not change. In the case of theblind person, this cannot be applied, as the object needs to be positioned in a specific way for perception to occur correctly. In the case of models, they present the representation of north, which must always be positioned in the upper left corner. One of the models (Model 2 – Styrofoam Contour Curves) did not have this element, and the employee got confused.

The grouping explains that the individual tends to perceive similar representations as grouped. For the person who is blind, grouping can be harmful, as it can cause juxtaposition of representations. Closure concerns the tendency of human beings to complete incomplete representations, based on previous knowledge. It happens that, in people who are blind, an interruption means the end of the transmitted information. Finally, in proximity, as the name suggests, close visual elements are perceived as a whole. In the absence of the sight sense, this can be harmful.

Considering the philosophical current of Abbagnano (1998) and contemplating the third item of the analysis, three distinct definitions for the term perception are evident: 1) free thought, without any complex operation (sensation); 2) empirical experience related to contact with the object, becoming a more restricted perceptive activity; and 3) complex act of organization and interpretation of sensations. The author seems to deal with levels of perception, being possible to associate each one with the MM phases: 1) perception and apprehension: initial

contact with the situation and recognition of the situation; 2) understanding and explanation: formulating perceptive hypotheses and obtaining a model; 3) meaning and expression: interpretation of solutions and validation of perceptions. The elaboration of perception following these phases can be observed in speech turns 7, 8, and 9, respectively.

When comparing the perceptions of the research collaborator (who is blind) with those of the researcher (sighted), it was verified that they are similar in almost all the represented elements, considering the five explored models. It can be said that, qualitatively, the perceptual stages are similar for both. Therefore, it was decided to explore the divergent points of the perceptions of both, as follows.

In Model 1, two differences are shown: the blind person did not measure the distances or mention that one of the types of lines formed a closed polygon inside the campus. According to Russ (1991, p. 215), perception is "[...] empirical consciousness, that is, consciousness accompanied by sensation, that is, it is a representation accompanied by consciousness". In fact, even if there is an idea, on the part of the blind, of the scale of the map, the empirical awareness of distance seems to be facilitated by sight. The same divergence occurred in model 2 (styrofoam curves).

In Model 3, which corresponds to the same representation as before, except for the finishing details, no significant differences were observed regarding the perception of both. With regard to Model 4 (terrestrial globe), the differences resided in the fact that the researcher numerically estimated the diameter of the material and perceived the longitudinal and transverse lines that represent the tropics and time zones. Again, it seems that the conjecture of a numerical measure is inappropriate for the blind. Painted lines, like those represented on the globe, without any differentiation for the sense of touch, caused difficulties for the employee. The importance of the ground-figure characteristic, advocated by Gestalt (DAVIDOFF, 2001), is verified so that elements can be distinguished by those who do not have the vision. Model 5 (planes of the terrestrial globe), finally, provoked divergences in relation to the representation of the tropics and the Equator, a representation that was perceived in a confusing way by the person who is blind. Thus, it was understood that the characteristics of grouping and proximity (*ibidem*) caused mistakes in the collaborator, which is in line with the theoretical foundation presented.

Considerando um viés da Filosofia, o colaborador parece sempre agregar às suas concepções um componente afetivo, remetendo-se a experiências positivas, e um componente cognitivo, que permite nomear aquilo que sente pelo tato. Ao explicar a unidade de medida utilizada na escala do mapa, ele diz: "Eu sei que eles fazem isso lá no LabTate para facilitar a compreensão", demonstrando satisfação (componente afetivo positivo) ao se referir ao modo como as unidades e escalas são elaboradas (DIDIER, 1969). Além do componente afetivo, pode-se afirmar que existe conhecimento agregado que permite nomear as coisas. Parece que, ao tocar cada parte dos materiais, o cego consegue formar uma visão globalizante de cada modelo, o que permite, em última instância, explicar o que sente (*ibidem*).

In the same way that excerpts from the researcher's statements (Chart 2) were associated with the phases of MM (BIEMBENGUT, 2014) and with the levels of perception from a Philosophy perspective (ABBAGNANO, 1998), one can also relate them to the stages of perception in Cognitive Psychology exposed by

Davidoff (2001): 1) sensation by the organs of the senses; 2) capturing a portion of reality through attention; 3) organization and interpretation of stimuli. This comparison is configured as the fourth point of the analysis.

Observing, for example, speech shifts 1, 2 and 3 shown in Chart 2, one sees such an association. Initially, the collaborator, through touch, has the initial sensation of the material, starting the process of perceiving, trying to imagine if the representation looks like “an hourglass” or “a butterfly”. He then focuses on a small portion of the model, turning his attention to the part where the cantine and rectory are. Finally, when interpreting the stimuli, he is able to name, in fact, the library, making a location relative to other points.

The fifth point of the analysis refers to perception in the light of mental models. Souza (2013, p. 173) explains that “understanding something means building a mental model for this something”. The research contributor appears to have formed many mental models by explaining the representations contained in each model. D'amore (2007) highlights three stages in the formation of mental models: (1st) initial contact with the object to be known; (2nd) formation of numerous mental images, so that the characteristics of the object are inferred, until saturation; (3rd) formation of the mental model.

Initially, through touch, there was the first contact with the object, configuring step 1. Afterward, he created hypotheses, in an attempt to explain the characteristics that make up the model, taking place in step 2. Finally, after the saturation of the image's formation, the expression of the mental model occurs – step 3. The occurrence of these steps is evident in speech shifts 4, 5, and 6 shown in Chart 2.

During the analysis, associations were observed between the phases of MM (BIEMBENGUT, 2014), the levels of perception in the view of Philosophy (ABBAGNANO, 1998), the definition of perception in Cognitive Psychology (DAVIDOFF, 2001), and the stages of formation of mental models (D´AMORE, 2007), which allows the presentation of the following chart (Chart 3), which is the main result of the research. It is noted that the perception of the person who is blind permeates the phases of MM and maintains a close relationship with perception in other areas, such as Psychology and Philosophy.

Chart 3 – Perception and its relations with the Modeling phases.

PHASES	MATHEMATICAL MODELING (Biembengut, 2014)	PHILOSOFY (Abbagnano, 1998)	MENTAL MODELS (D´Amore, 2007)	COGNITIVE PSICOLOGY (Davidoff, 2001)
PHASE 1	Perception and apprehension. Initial reconnaissance of the situation and data collection.	Simple act of thought, no interpretations.	Contact with the object/concept to be known.	Environmental sensation
PHASE 2	Understanding and explanation. Formulation of hypotheses and model.	More restricted cognitive act, related to the object (empirical).	Formation of several mental images for the accommodation and	Perception of small portion, from attention.

			understanding of what one wants to know.	
PHASE 3	Meaning and expression. Interpretation and evaluation of solutions. Expression of situational awareness.	Complex human operation, combining aspects of the environment and knowledge.	Formation of mental models.	Organization and interpretation of sensations.

Source: The authors (2020).

FINAL CONSIDERATIONS

This study aimed to analyze the spatial perception of a person who are blind through the MM (Mental Modeling), that is, following the steps of the process of modeling. It was a case study. In the theoretical contribution, the cognitive theory was used – from Neuroscience and also from the philosophical and psychological areas. The theory of Mental Models, in line with the MM phases, was prescribed by Biembengut, in 1990, and improved by the author in 2014 (Biembengut, 2014). This research was presented as a case study, within a qualitative perspective, with a geographer who is blind as a collaborator. Using audio recordings and the researcher's field diary, tactile impressions about the five physical models used were recorded, transcribed, and analyzed.

Based on data analysis and Chart 3, it can be seen that, as the main result, the perception of the blind person permeates the three phases of the MM: (1) perception and apprehension; (2) understanding and explanation; (3) signification and expression. When in contact with the models, the collaborator performs the initial reconnaissance and a first survey of the characteristics of the models, and deduces the elements related to the geographic aspects of each one, configuring the first phase of the MM. Then, configuring the second phase of the MM, the collaborator creates hypotheses about each representation and formulates a mental model. Finally, he demonstrates the interpretation of the hypotheses of the previous phase, stabilizing them and expressing, in fact, the knowledge of the elements present in each representation. All elements recognized by the person who is blind are what was expected to be represented with each physical scale model.

Besides, correspondence was observed between the perception of the blind person and the steps proposed in the definitions of philosophical aspects (ABBAGNANO, 1998; ANTUNES, ESTANQUEIRO, VIDIGAL, 1995; RUSS, 1991; DIDIER, 1969). These authors proposed that the perceptive process goes through three stages: (1st) initial sensation, from contact with the object through the sense organs; (2nd) reflection and cognitive effort, in an attempt to create hypotheses about each representation, taking into account emotional/affective aspects and previous experiences; (3rd) formation of a mental representation and oral explanation of what was perceived by touch. Analogously, this correspondence occurred when considering the formation of mental models in three stages, proposed by D'amore (2007): (1st) initial contact with the object; (2nd) formation of mental images until saturation; (3rd) formation of the mental model. According

to Chart 3, the perception of the blind permeates the three phases of MM proposed by Biembengut (2014) and is in line with perception from a philosophical perspective (ABBAGNANO, 1998), from the perspective of Cognitive Psychology (DAVIDOFF, 2001) and, also, with the stages of formation of mental models (D´AMORE, 2007). This is the main result of this study and can be configured as an innovative element.

It is believed that this study can bring contributions to the area of Science and Mathematics Education since it offers theoretical and practical subsidies for the perception of people who are blind. By understanding the way in which a blind person apprehends concepts – theoretical contribution –, possibilities are open up for teachers to think about characteristics for tactile didactic resources and teaching strategies for blind students, from the perspective of inclusive education – practical contribution. Thus, it suggests this study for the design or improvement of existing teaching materials, considering both the characteristics of Gestalt and the stages of perception and formation of mental models pointed out in different aspects of this study. Coutinho (2008, p. 9), when discussing the fidelity, validity, and rigor of qualitative research, explains that through transferability "[...] the results obtained in a given context, in a qualitative research, can be applied in another context", as long as the adaptations are made.

As with any research process, this study has limitations. Although the amount of data collected and analyzed was sufficient to answer the research question, time was a limiting factor, as the recordings could have lasted longer. In addition, other materials could have been explored. The Tactile School Cartography Laboratory at UFSC has other models which explore other areas of Geography, but, due to the scope of the study, it was necessary to make choices. There is also the limitation of the qualitative approach and of the researcher, who could have interpreted the data with other nuances. It is hoped that this study can contribute to the education of people who are blind, offering subsidies to researchers and teachers who are interested in understanding perception in its different dimensions.

PERCEPÇÃO ESPACIAL DE UMA PESSOA COM CEGUEIRA: DAS INTERAÇÕES E DAS VIVÊNCIAS

RESUMO

Neste estudo, são apresentados resultados de uma pesquisa cujo objetivo foi analisar a percepção espacial de uma pessoa com cegueira, bem como sua compreensão por meio de suas expressões. Para tanto, essa pessoa, estudante de um curso de Geografia, aceitou contribuir para tal, o que permitiu acompanhar as atividades que lhe foram propostas. Portanto, tratou-se de uma pesquisa de abordagem qualitativa, caracterizando-se como um estudo de caso. Na coleta de dados, foram utilizados cinco modelos físicos de escala, em que dados referentes às percepções táteis do participante foram gravados em áudio e transcritos na sequência. Na análise, fez-se o 'enlace' entre os dados de campo e a teoria perceptiva obtida. Como resultado foi possível identificar que a percepção dos conhecimentos relacionados a 'relevo', 'hidrografia' e 'cartografia', desse estudante com cegueira, perpassava as três fases da Modelagem, isto é, as fases da percepção-apreensão; compreensão-explicação; e significação-expressão. A identificação sobre como se dá o processo mental dos seres humanos, em especial o do colaborador desta pesquisa (devido à cegueira), pode contribuir para que os professores que atuam na Educação Básica saibam como auxiliar seus estudantes no aprimoramento de seus conhecimentos e, mais que tudo, na busca de seus interesses profissionais.

PALAVRAS-CHAVE: Modelagem; Cegueira; Percepção-Compreensão.

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Received: Mar. 15th, 2021.
Approved: Jan. 12th, 2023.
DOI: 10.3895/rbect.v16n1.13944
How to cite: COSTA, J. F. S.; LIMA, V. M. R.; BIEMBENGUT, M. S. Spatial perception of a blind person: interactions and experiences. **Brazilian Journal of Science Teaching and Technology**, Ponta Grossa, v.16, p. 1-20, 2023. Available at: <https://periodicos.utfpr.edu.br/rbect/article/view/13944>. Access on: XXX.
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