

## STRUCTURE OF PHENOMENAL STATES DURING MENTAL ROTATION ACTIVITY IN BLIND INDIVIDUALS<sup>1</sup>

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**ABSTRACT.** This study aimed to map the structure of emerging phenomenal states during mental rotation activities using touch as a sensory source in visually impaired individuals. The sample included congenitally blind individuals (7 participants) and individuals with acquired blindness (10 participants), who were subjected to mental rotation activity as a self-focusing task, in which geometric stimuli were presented for tactile exploration and mental image construction. Subsequently, the Phenomenological-Cognitive Interview of Self-Conscious States (EFEA) was administered. Our findings confirmed that visually impaired individuals, when using touch as a sensory source, can, through this stimulation, create and experience complex phenomenal states that mediate access to ongoing inner experience. These results contribute significantly to the beginning of the systematization of knowledge regarding this important issue, which is still a gap in current cognitive theory, especially in visually impaired individuals. The findings highlight the need to consider new methodological procedures that can reliably access the phenomenal states experienced by individuals with visual impairments, broadening the current understanding of cognitive research on the phenomenal mind in this population.

**Keywords:** Visually disabled; mental representation; mental rotation.

## ESTRUTURA DOS ESTADOS FENOMENAIS DURANTE ATIVIDADE DE ROTAÇÃO MENTAL EM CEGOS

**RESUMO.** O estudo objetivou mapear a estrutura dos estados fenomenais emergentes durante atividade de rotação mental tendo-se o tato como fonte sensorial, em pessoas com deficiência visual. Foi composta uma amostra dividida em grupos de cegos congênitos (7 participantes), e indivíduos com cegueira adquirida (10 participantes), os quais foram submetidos à atividade de rotação mental como tarefa de autofocalização, em que foram apresentados estímulos geométricos para tato e construção de imagem mental dos mesmos. Em seguida aplicou-se a 'Entrevista Fenomenológico-Cognitiva dos Estados Autoconscientes' (EFEA). Os resultados do estudo confirmaram que pessoas com deficiência visual, ao utilizar o tato como fonte sensorial, podem, através dessa estimulação, criar e vivenciar estados fenomenais complexos, que mediam o acesso à experiência interna em curso. Os resultados encontrados no estudo contribuem significativamente para o início da sistematização do conhecimento referente a esta importante questão que ainda configura uma lacuna na teoria cognitiva atual, principalmente em pessoas com deficiência visual. Os achados põem a necessidade de se pensar novos procedimentos metodológicos que acessem com fidedignidade os estados fenomenais vivenciados por deficientes visuais, alargando a compreensão atual da pesquisa cognitiva sobre a mente fenomenal, em pessoas com deficiência visual.

**Palavras-chave:** Deficiente visual; representação mental; rotação mental.

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## ESTRUCTURAS DE LOS ESTADOS FENOMENALES DURANTE ACTIVIDAD DE ROTACIÓN MENTAL EN LOS CIEGOS

**RESUMEN.** El estudio objetivó mapear las estructuras de los estados fenomenales emergentes mientras actividades de rotación mental teniendo el tacto como fuente sensorial, en las personas con deficiencia visual. Se compuso una muestra dividida en grupos de ciegos congénitos (7 participantes) y personas con ceguera adquirida (10 participantes), que fueron sometidas a actividades de rotación mental como tarea de autofocalización, dónde fueron presentados estímulos geométricos para palpar y la construcción de imagen mental de los mismos. A continuación fue aplicada la Encuesta Fenomenológico-cognitiva de los Estados Autoconcientes (EFEA). Los resultados del estudio han confirmado que las personas con deficiencia visual al utilizar el tacto como fuente sensorial, pueden, por medio de esa estimulación, crear y vivenciar estados fenomenales complejos que median el acceso a la experiencia interna en curso. Los resultados encontrados en el estudio contribuyen significativamente para el principio de la sistematización del conocimiento referente a esta importante cuestión que aún configura un vacío en la teoría cognitiva actual, principalmente en las personas con deficiencia visual. El hallado trae la necesidad de pensarse nuevos procedimientos metodológicos que accedan con fidedignidad los estados fenomenales vivenciados por deficientes visuales, desarrollando la comprensión actual de la pesquisa cognitiva bajo la mente fenomenal, en las personas con deficiencia visual.

**Palabras clave:** Discapacidad visual; representación mental; rotación mental.

### Introduction

Studies in the area of mental representations, more particularly mental rotation, place a strong emphasis on visuospatial skills (Martolini et al., 2021; Tivadar et al., 2020; De Borste & De Gelder, 2019), while research on inner experience considers the phenomenality of these images (McKelvie, 2021; Heavey et al., 2019; Lapping-Carr & Heavey, 2017), focusing on visual imagery. Recently, some researchers in the field have revisited this theme, presenting it in terms of *inner experience* as the apprehension of contents such as thoughts, feelings, and perceptions as if one were looking inside oneself (Nascimento, 2022; Heavey et al., 2019).

Researchers such as Heavey and Hurlburt (2008) have presented the elements that constitute and mediate inner experience. These elements are: *unsymbolized thinking*, thoughts without images or verbal discourse; *inner speech*, or inner discourse; *inner seeing*, the subject's ability to create and describe mental images; *feelings*, the ability to describe feelings and emotional experiences; and *sensory awareness*, which is the experience of paying attention to particular aspects related to sensory experience, both internal (e.g., characteristics of pain) and external (e.g., intensity of the color red). Therefore, these characteristics are related to each other, to behavior, and to other aspects of cognition.

These findings were made possible by using the DES (Descriptive Experience Sampling) method, where each participant was instructed to pay attention to what occurred in their inner experience immediately after hearing a beep and to note anything that could help them remember the details of their inner experience. After the beeping, participants were interviewed in depth to describe their inner experiences at each recorded moment (McKelvie, 2021; Heavey et al., 2019; Lapping-Carr & Heavey, 2017).

Chalmers (2014) provides an extensive list of elements of experience, including visual and auditory experiences, the elements described by Velmans (2009), such as the three-dimensionality of the world beyond the skin, the sense of self of Shanon (2003, 2010), and the *phenomenal self-awareness* of Nascimento (2022). This author describes the mediation of self-awareness by inner speech and mental imagery in distinct registers of consciousness (wakefulness and uncommon states), and how this representational processing gives rise to the complex phenomenology of self-experience.

Using the EFEA (Phenomenological-Cognitive Interview of Self-Conscious States), Nascimento (2008) thoroughly described the iconic and verbal phenomenology in self-conscious states in common

(wakefulness) and uncommon (altered) states of consciousness. This study provides evidence of a heuristic pathway for the ideographic description of inner experiences through an experimental procedure in the form of a first-person interview script supported by a *phenomenal self-awareness* task. First-person methodologies like the EFEA and DES have provided innovative methodological contributions to the study of conscious experience in contemporary phenomenological research.

From a cognitive processing perspective based on two codes (verbal and imagistic), as described by Paivio (2014), Nascimento (2022) emphasizes the significance of the imagistic code in mediating self-awareness and inner experience. Access to inner speech and inner experience is provided through visually constructed mental images. However, it is necessary to consider the possibility that mental images can be formed through stimulation of the other senses, such as hearing, smell, taste, and touch, in both sighted individuals and visually impaired people, the latter being the focus of this research.

According to Oliveira et al. (2021), visual impairment can be defined in different ways, by total loss (blindness) or partial loss (low vision or subnormal vision) and measured by visual acuity with the best correction (use of glasses), which means that the ability to see, taking into account the best eye, is less than 0.3 m and greater than or equal to 0.05 m, with a visual field of less than 20°. Total blindness is considered total when the visual acuity value is less than 0.05 m and/or the visual field is less than 10° or when there is *no light perception*, which is the absence of visual perception or the inability to recognize intense light when it is exposed directly to the eye.

Blindness remains poorly understood in terms of cognitive processes and the phenomenal states experienced by this population. Research focuses more on including visually impaired people in mainstream education and the challenges of this process (Santos et al., 2021; Marcatto et al., 2019). These studies use tactile stimulation but do not examine the content evoked by it. Images produced by tactile stimulation are known as haptic images and are mental images constructed through tactile stimulation. Visually impaired individuals use this sensory input to create and manipulate mental images of surrounding objects (Martolini et al., 2021; Tivadar et al., 2020).

The study by Occelli et al. (2016) investigated whether visual experience influences the performance of congenitally blind and sighted people on mental rotation tasks involving 3-D objects. The researchers hypothesized that people with visual impairments are more susceptible to changes in object orientation. The study used a sample of 12 visually impaired participants, six of whom were women, and 11 sighted participants, seven of whom were women. Ten of the visually impaired participants were congenitally blind, while the remaining two lost their sight at the age of four.

The results showed that differences in the angle of stimulus presentation provided longer response times, corroborating the findings of Shepard and Metzler (1971). It was also found that sighted individuals are vision-dependent, while those who are visually impaired are vision-independent. The aim of the study was not to show that the visually impaired have better tactile perception than the sighted, but rather to emphasize that, due to their greater tactile experience, they can better cope with changes in object orientation (Occelli et al., 2016).

De Borste and De Gelder (2019) focused their research on understanding brain structures and their relationship to mental imagery. The researchers investigated whether primary sensory cortices, including the visual cortex, could distinguish between tactile and auditory perception in congenitally blind and sighted participants. They also examined whether congenitally blind individuals exhibit enhanced representations in the auditory and somatosensory cortices. The sample consisted of two groups: 1) congenitally blind individuals and 2) sighted participants.

The findings showed that, compared to sighted individuals, congenitally blind individuals exhibited intermodal discriminative patterns in auditory versus tactile perception. This suggests that, after vision deprivation, cortical plasticity does not influence auditory and tactile perception as measured in this study. The results suggest cross-modal activation of higher visual areas in individuals with vision impairment, including auditory imaginative representations related to visual area V4 (De Borste & De Gelder, 2019).

Based on literature findings that sighted individuals automatically generate allocentric spatial structures, and since these findings point to an equivalence in visually impaired individuals in the processing of allocentric images, another study (Eardley et al., 2016) was conducted to identify a spatial deficit in people with retinopathy of prematurity (RoP). Based on this data, researchers sought to understand if

groups with congenital blindness would perform equivalently in allocentric tasks and if the RoP group would perform worse in allocentric inference and map generation tasks.

By analyzing the accuracy of the participants' mental representations and the data from the textual descriptions of spatial location, Eardley et al. (2016) observed that RoP participants obtained lower scores than those with congenital blindness or who lost their vision in early childhood or adulthood. The latter two groups performed similarly. Therefore, visual impairment itself, as well as visual impairment associated with RoP, resulted in impairment in spatial allocentric performance (Eardley et al., 2016).

As described above, research with visually impaired individuals has focused on instructional oral dimensions aimed at learning or cognitive development or on pure cognitive-representational processing (De Borste & De Gelder, 2019; Occelli et al., 2016; Eardley et al., 2016). This research has neglected the possible phenomenal architectures that stem from cognitive image processing in the form of *inner visualizations* and other elements of inner experience that should comprise such phenomenal states (Nascimento, 2022; McKelvie, 2021; Heavey & Hurlburt, 2008; Fazekas et al., 2020).

The research aimed to investigate the elements and structure of emerging phenomenal states during the mental rotation task in people with congenital or acquired blindness. This data is expected to shed light on the phenomenal architecture of individuals with visual impairments and how these elements arise in consciousness. The hypothesis of the study is that individuals with visual impairments also possess a rich and complex phenomenal gradient.

## Methodology

### Design

This study is qualitative research that starts from a phenomenological perspective. The analysis is descriptive and focuses on the description of conscious experience. It uses a first-person instrument based on phenomenological studies in cognitive psychology of consciousness and inner experience (Heavey et al., 2019; Nascimento, 2008), as well as on the work of researchers in phenomenological consciousness and self-consciousness (Nascimento, 2022).

### Participants

This research study included a total of 17 participants, who were divided into two groups: (1) seven people with congenital blindness (one man and six women) with an average age of 43 years, and (2) ten people with acquired blindness (five men and five women) with an average age of 40.3 years; all were adults. Participants were selected from an institution that provides services to people with visual impairments in the city of Recife, state of Pernambuco. All participants in the study were completely blind.

### Instruments and material

Two instruments were used in the study: the Haptic Imagery Task (Damasceno, 2015) and the Phenomenological-Cognitive Interview of Self-Conscious States – EFEA (Nascimento, 2008). These instruments are described in general terms below.

*Haptic Imagery Task (HIT)* (Damasceno, 2015): This task was used for the mental rotation activity, which aimed to stimulate the production of mental images through touch by manipulating geometric figures (squares, circles, triangles, stars, and crosses) at different rotation angles ( $0^\circ$  {A},  $90^\circ$  {B},  $180^\circ$  {C}, and  $270^\circ$  {D}). All participants performed this activity. Before starting, participants were instructed on how the activity would be conducted. They were also informed that the stimuli would be randomly presented in different positions, labeled A, B, C, and D. All participants began the activity in the same way, with the stimulus presented in the initial position (position A{ $0^\circ$ }). This ensured that all participants were in the same condition. The HIT was constructed based on classic experiments, such as those of Shepard and Metzler (1971). Eight adult participants with normal vision took part in this study. Each participant was presented with a total of 1,600 pairs of 3D figures at ten different angles, ranging from  $20^\circ$  to  $180^\circ$ . Each object consisted of ten cubes joined face-to-face to form a rigid structure. Eighteen corresponding projections of each set of ten objects were made from different perspectives, rotating on their own axis. These figures were projected onto computers. Participants were asked to pull a lever on the right to indicate whether the

figure was a mirror image of the original and a lever on the left to indicate whether it was not. Their response times and the number of correct and incorrect answers were recorded.

*Phenomenological-Cognitive Interview of Self-Conscious States – EFEA* (Nascimento, 2008) is a structured, qualitative interview consisting of an investigation script of self-conscious phenomenology and cognitive mediations (e.g., mental images and self-talk). This research was adapted to a situation involving the execution of a cognitive routine of imaginative skill, namely mental rotation, through the aforementioned haptic imagery task. The guiding question was: “While paying attention to yourself during the mental rotation task, did any images come to mind? Could you describe in detail what these images are like, if they appeared in your experience?”

### **Procedures**

The research was only carried out after the project was approved by the Research Ethics Committee of the Federal University of Pernambuco (UFPE), Health Sciences Center (opinion no. 607.563; approval on April 14, 2014), and the entire research process observed the terms of resolutions 196/96 and 251/97 of the National Health Council, which regulate research involving human subjects in Brazil. The activity was divided into two parts, which were carried out on the same day. Before administering the instrument, a 2-minute training session was conducted to help the participants understand the activity and construct a mental image of the geometric stimuli (trapezoid, rhombus, and rectangle). These stimuli were only used to demonstrate how the activity would be performed.

After the explanation, the Haptic Imagery Task was administered to all participants in both groups, one at a time, in an isolated room to maximize control of external stimuli. The execution table was marked with adhesive tape where the base with the stimuli was placed to ensure all participants were in the same position during the experiment. Participants had one minute to feel the instrument and form a mental image of it in different positions. Their response time was timed after the presentation of the stimuli. The application took place at the institution where the participants were recruited.

In the second phase, the Phenomenological-Cognitive Interview of Self-Conscious States (EFEA) was conducted. After the first activity, an in-depth interview was conducted to question the participants about the nature of the mental images evoked during the task. The *in-depth interview* aimed to explore and describe the phenomenology of the self-conscious experience triggered by the tactile stimulation task. Participants had 1h30min to complete the task. Note that all interviews were audio-recorded and transcribed in full.

### **Data analysis**

The model of Cott and Rock (2008) was used for data analysis, following a thematic analysis based on the principles of standard phenomenological methodology. Interview protocols were thoroughly reviewed to identify phrases or statements related to the phenomenal gradient that emerged during the mental rotation task. These phrases and statements were then extracted from each protocol. Statements with the same meanings were organized and translated to create constituent themes for each protocol. Those examined and judged as belonging to the same theme were then organized into overarching themes, which were evaluated for overlap to determine which constituent themes could be selected. Finally, the constituent themes were integrated into a paragraph to form a fundamental structural definition that captured the essential aspects of the phenomenal consciousness of the visually impaired participants during the mental rotation task.

### **Results and discussion**

#### **Thematic analysis of phenomenal data**

Thematic phenomenological analysis revealed the complexity of the phenomenal states related to the mental images produced by the participants in the two groups (PCB: Participants with Congenital Blindness and PAB: Participants with Acquired Blindness) during the mental rotation activity. These findings align with studies on inner experience, with Chalmers (2014) as a precursor, followed by research conducted by Heavey and Hurlburt (2008) and Nascimento (2022). The elements of inner experience

identified were: (C1) haptic image, (C2) inner seeing, (C3) inner speech, (C4) sensory awareness, and (C5) feelings.

Since the sensory source was touch, the element of inner experience that occurred most frequently was haptic images. According to the phenomenological analysis, participants with visual impairments, especially those with congenital blindness, constructed mental images of objects through tactile stimulation and mentally manipulated them. This demonstrates the complexity of the experienced images, which possess considerable detail in their resulting phenomenology, including shapes, spatial relationships, and other characteristics. Therefore, the flow of inner experience in people with congenital blindness occurs primarily through haptic images. The content of the phenomenal gradient, in terms of its objects and characteristics, is detailed by the emerging categories of thematic analysis below.

### **(C1) Haptic image**

#### Objects

According to their phenomenal accounts, the objects that mediated the participants' inner experience were the following: triangle, cross, star, square, Our Lady, house, picture, disc, parallelepiped, car tire, bicycle tire, rectangle, circle, sky, ball, trapezoid, starfish, hat, hula hoop, balloon, matchbox, dominoes, board game, cyclone, table, and classroom. A total of 61 objects were recorded, of which 27 were produced by the PCB and 34 by the PAB.

These objects emerged from the flow of the participants' inner experience in both groups. Some objects were experienced by only one or a few participants, while others were experienced by both groups. These objects, which emerged in the participants' phenomenal consciousness as they explored the stimuli presented in the task, are intentional objects of consciousness and are part of a complex cognitive architecture experienced by the participants (Nascimento, 2022; Nascimento & Roazzi, 2013).

These objects point to complex mental activities. Participants reported that, while manipulating the geometric stimuli, they could construct mental images of them and subsequently describe them in rich detail. These objects were not merely mental representations of the stimuli presented in the task. They were accompanied by details related to their shapes, spatial relationships, and types of material. Others were immersed in a rich and complex scenario. Thus, the flow of inner experience was constructed through the interplay of these objects and characteristics that mediated the ongoing inner experience. The following excerpt illustrates this: Example: Triangle Object: PAB12: "I can perfectly remember the triangle. It's [...] that drawing. We can really keep it in our minds, but without color or anything!" (Female, 19 years old).

Similar to people with congenital blindness, participants with acquired blindness experienced haptic images (Chalmers, 2014). Since these participants had previously experienced visuality, their visual experience may have influenced the construction of mental images, causing them to perceive the objects that emerged in their consciousness differently. However, these objects were also complex, demonstrating that the flow of inner experience of participants with acquired blindness is also constructed through haptic images and with mental images from other modalities.

Research exploring touch as a sensory source for constructing and exploring mental images highlights haptic imagery used by the visually impaired to move through and relate to the world. This research is based on the psychological mind, exploring psychophysical aspects (Martolini et al., 2021; Tivadar et al., 2020; Fazekas et al., 2020; De Borste & De Gelder, 2019). However, these studies point to the complexity of developing methods for exploring mental images in visually impaired individuals and fail to consider phenomenal architecture (McKelvie, 2021; Nascimento, 2022; Chalmers, 2018) when exploring mental images, leaving this field with little understanding of the topic.

### **(C2) Inner seeing**

#### Object

The objects that mediated the participants' inner experience were: star, doll, English hat, hat, ULBRA (an educational institution), cross, window, church, triangle, square, rectangle, matchbox, and person. Although the activity involved tactile stimulation, the stimulation of touch evoked visual mental images that were part of the ongoing inner experience. In order to identify the stimuli they were touching, the participants with acquired blindness evoked images from when they could see; these objects emerging

in the participants' consciousness are part of the phenomenal architecture in flux during the mental rotation task. A total of 18 objects were recorded.

These emerging objects suggest that, in addition to performing the task, a complex phenomenal life assisted in executing the task. These objects mediated the participants' inner experience process. Therefore, the images contain intertwined objects and complex scenarios, indicating the vividness of these images, as described in the following example: Star Object: PAB17: "The star isn't really like a star, like most people draw this type of star in books, I've seen it before!" (Female, 33 years old).

These results indicate that participants with acquired blindness experienced complex phenomenal states, in which the objects that emerged into consciousness mediated access to their inner experiences, as reported in the interviews. These results are consistent with the literature (Heavey & Hurlburt, 2008; McKelvie, 2021; Heavey et al., 2019) that mapped the rubrics of inner experience and investigated how participants experienced them. Nevertheless, the results of these studies were obtained with sighted participants and visual stimulation.

Studies with sighted individuals that incorporate mental imagery, such as the inner seeing processes examined by Nascimento and Roazzi (2013), support the hypothesis of cognitive mediation of self-consciousness by mental images, showing that there is a relationship with the level of development of imaginative skills. Nascimento (2022) demonstrates the cognitive mediation of self-consciousness by mental images and that iconic mediation is related to the level of development of imaginative skills. Shanon (2003) shows that specific content elements are prevalent in ayahuasca visions and can be found in different cultures. McKelvie (2021) found that 32% of his participants experienced inner seeing, highlighting the importance of mental images in inner experiences.

Few studies have examined both mental images (inner seeing) and inner experiences in visually impaired individuals, but Ring and Cooper (2008) investigated near-death and out-of-body experiences in this population. Their results indicated that most participants reported seeing during near-death and out-of-body experiences. Kastrup (2013) sought to identify characteristics and dynamics of mental images in individuals who lost their sight early in life, analyzing non-visual imagery components in dreams and memories. For this study, four adults who lost their sight prematurely were sampled, and a first-person methodology was employed to access internal content.

### **(C3) Inner speech**

#### Object

The objects that mediated the participants' inner experience were: square, talking to oneself, task resolution, and teacher. These objects are part of the architecture that constitutes the participants' inner speech. It is evident how participants with congenital and acquired blindness experienced these objects. A total of five objects were recorded, one by PCB and four by PAB. The inner dialogues produced relate to executing the task, that is, internal questions about recognizing the stimuli, recognizing changes, and questioning whether responses were correct. Thus, these objects emerging in the participants' consciousness acted as mediators of their inner experience. This demonstrates the importance of these objects for consciousness and shows that they are part of the flow of inner experience, as described below.

Example: Object Square

PAB15: [...] Then I said 'square', which caught my attention. That's what I was supposed to say [...] I was going to tell you, 'this isn't square, there's no square here,' but then I realized, and I stopped and said, 'no, but it can't be like that' (Male, 53 years old, emphasis added).

Regarding inner speech, all participants experienced this element by referring to internal dialogues experienced during the task (Nascimento, 2022; Lapping-Carr & Heavey, 2017; Heavey & Hurlburt, 2008). The dialogues that emerged in the stream of consciousness of the participants in both groups were related to questions about identifying the stimuli, responding correctly, identifying the stimulus, and understanding the activity.

Throughout the analysis, we realized that inner speech is an internal product originating from the subject, meaning it is produced internally and does not originate from an outside source (Kelsey, 2016). Inner speech appears to play a significant role in human cognition by reflecting the development and

sharing of other cognitive resources (Lapping-Carr & Heavey, 2017). Self-talk is also used for behavior regulation and shows that anxiety and impulsivity are related to executive affective functions (Ren et al., 2016), as seen in the interviews.

#### **(C4) Sensory consciousness**

##### Object

The objects that mediated the participants' inner experience were: triangle, cross, star, and square. A total of eight objects were recorded, two by the PCB and six by the PAB. The objects that emerged in the participants' consciousness during the task clearly demonstrate their level of attention to their ongoing experience. These objects allowed the participants to focus on their details and how they mediated access to inner experience. These objects are part of the participants' rich and complex mental lives, in which they could create or evoke mental images from memory through touch and pay attention to and describe their details.

##### Example: Object Triangle

PCB2: A square-shaped house with a triangular roof on top, but like a little slope, and at the top there's a point, then the slope goes down, and the roof fits into the [...] correct in the house, right!? It would be a straight part, a point on each side (Female, 33 years old).

PAB14: The images that passed through my mind were the same ones I was feeling, feeling in the [...] touching, like a triangle, then the same thing came to mind, a triangle itself [...] Then, in the same way as a triangle, in the same way, sometimes it was what, upside down in the same way I was touching, in the same way, a triangle, a square, then always [...] (Male, 30 years old).

Participants from both groups experienced the element of sensory consciousness. The objects that emerged in their consciousness provided information about their experiences with these elements (Lapping-Carr & Heavey, 2017; Ren et al., 2016; Heavey & Hurlburt, 2008). This highlights that, through tactile stimulation, participants can create mental images and experience the sensory details of those images. The phenomenal characteristics of the objects of consciousness were created and experienced through touch.

When participants reported how these objects emerged in their consciousness, it became clear how intense and vivid these images and objects were, especially when analyzing the interviews. The interviews also revealed that these objects mediated inner experiences in flux. For example, one participant reported that when touching the cross stimulus, they experienced the object as being made of different materials. This emphasizes that the cross that appeared in their consciousness was not metal but wood. These details demonstrate the sophistication and complexity of these images, which are similar for both groups.

Our findings are consistent with those of other researchers, except that their studies used sighted participants. In the interviews, participants were asked to focus on a specific sensory quality of the object. Because of this focus, participants could describe these qualities in great detail (McKelvie, 2021; Lapping-Carr & Heavey, 2017; Heavey & Hurlburt, 2008). Chalmers (2014, 2018) also reinforces these findings, emphasizing how individuals experience objects in their entirety and particularities, forming a complex network of objects and particular characteristics.

#### **(C5) Feeling**

##### Object

The objects that mediated the participants' inner experience were: expectation, tension, curiosity, and liking. A total of six objects were recorded; two by the PCB and four by the PAB. These objects signal how the participants were experiencing the activity, emerging in the participants' stream of consciousness and mediating access to their inner experience. These objects are related to the emotional state in which the participants found themselves during the activity. Some participants were expectant, waiting to see what the next stimulus would be.

##### Example: Object Expectation

**PCB6:** The expectation and curiosity to know what the next figure will be [...] No, just that, the expectation of what the next one will be, and where it will be positioned, always, is [...] that concern about what it will be like in [...] not even a concern, it's the expectation of what the next ones will be like (Female, 45 years old).

The feelings that emerged in the participants' consciousness during the activity were related to the activity itself, as reported by the participants. Since the activity required attention, and the participants provided responses regarding the stimuli they touched, this may have influenced the emergence of these feelings. However, one participant attributed these feelings to personal issues being experienced alongside other objects of consciousness.

Heavey and Hurlburt (2008) describe the category of feeling as the ability to both describe and report experiences. In their studies, they used the DES and found that this category accounted for an average of a quarter of the data. Chalmers (2014, 2018) points out that frequently experiencing distinct emotions can affect one's conscious experience. In this case, the effect depends on the emotion experienced, as reported by the participants. The feeling of anxiety can hinder the flow experience process and task execution.

The structural synthesis of inner experience during mental rotation, the essential aspects of the experience, with touch as the sensory source, were: (C1) haptic image, (C2) inner seeing, (C3) inner speech, (C4) sensory awareness, and (C5) feelings. These results show that visually impaired people can create and experience mental images, highlighting the phenomenal complexity of the images that emerge in consciousness. These findings corroborate existing literature on phenomenality (Nascimento, 2022; McKelvie, 2021; Chalmers, 2014, 2018; Nascimento & Roazzi, 2013; Heavey & Hurlburt, 2008) and the mental representation process (Martolini et al., 2021; Tivadar et al., 2020; De Borste & De Gelder, 2019). This shows that phenomenality is complex during mental rotation for visually impaired individuals.

## Discussion

This research aimed to investigate the elements and structure of emergent phenomenal states during the mental rotation task in people with congenital or acquired blindness, hypothesizing that visually impaired individuals also possess a rich and complex phenomenal gradient. The findings confirm the study's hypothesis that visually impaired individuals produce a rich and complex phenomenal gradient of mental images during the mental rotation task with tactile stimulation. These results support previous research indicating that individuals with visual impairments can construct and manipulate mental images through touch (Martolini et al., 2021; Tivadar et al., 2020; De Borste & De Gelder, 2019), as well as they can describe the experience of these objects in detail within the flow of inner experience (Nascimento, 2022; McKelvie, 2021; Chalmers, 2018).

A complexity was also found in the phenomenal architecture produced by the participants, with phenomenal objects and characters rich in details such as shape, color, texture, and spatial orientation. Notably, in terms of the quantity of objects produced, participants with acquired blindness produced more objects in the flow of inner experience than participants with congenital blindness, except in the inner seeing, which corroborates the findings for inner seeing, in which participants with congenital blindness never had access to visuality and were therefore unable to form visual images. Regarding haptic images, participants with acquired blindness produced more images than participants with congenital blindness. One hypothesis that could explain this data is that access to visuality may have somehow influenced the production of haptic images, suggesting a relationship between the processes of constructing visual and tactile images. However, further studies are necessary to better understand the relationship, if any, between these two cognitive processes.

## Final considerations

The results corroborated the research objective by identifying the elements and phenomenal states experienced by this population. The study also found that visually impaired individuals, by using touch as a sensory source, can create and experience complex phenomenal states that mediate access to ongoing inner experience through this stimulation. This study contributes to the beginning of the systematization of knowledge regarding this important issue, which remains a gap in current cognitive theory. Therefore, new

methodologies are necessary to gain a more detailed understanding of mental images and their role in constructing the inner experience of both visually impaired and sighted individuals.

However, the study has some limitations. For example, the sample size does not allow for more complex comparisons, such as the quality of images produced by the two groups. Additionally, there is an intragroup discrepancy regarding gender, which prevents coherent comparisons regarding whether gender influences the process of producing objects and experiencing them in the stream of consciousness. Another limitation is the age of the participants. It would be helpful to create age-based groups with different levels of visual ability, such as congenitally blind, acquired blindness, low vision, and sighted individuals. This would help us better understand how these objects are produced and experienced in the stream of consciousness.

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