Comparing creative imagination between blind and sighted individuals across sensory modalities

An introduction to an instrument that measures and compares creative imagination between blind and sighted people across sensory modalities.

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Abstract

Imagination plays a role in many cognitive processes, helping us to understand the world around us, giving us the ability to create new concepts and anticipate future events. Despite the importance of imagination in our daily lives, little research has been conducted on the imagination of blind people and how it differs from the imagination of sighted people. The aim of this study was to explore the possibility of developing a measurement instrument with which the creative imagination of blind and sighted people can be compared. A modality-independent instrument was developed and exploratively investigated in an experimental study. Forty-four participants in three conditions (sighted/visual, blind/tactile, sighted/tactile) perceived a simple tactile or visual graphic. This simple graphic generated mental representations. The most original of the mental representations was selected and elaborated on, creating a creative mental representation. The qualitative analysis suggests that the sighted participants in both conditions generate more visual mental representations while the blind have more tactile mental representations. The quantitative results suggest that the creative imagery abilities of blind individuals are less than those of sighted individuals, as the blind participants scored lower on the constructs of vividness and transformativeness. Visual acuity seems to influence both creative imagery abilities and the sensory modality of a mental representation. The instrument seems to be able to compare the creative imagination of blind and sighted people, although it should be further validated to make valid assumptions. Further research seems essential to better understand the differences in creative imagination and cognitive abilities between blind and sighted people.

Keywords: Creative Imagination, Visual Impairment, Visual Acuity, Multisensory, Tactile Graphics, Creative Imagery Abilities, Vividness, Originality, Transformativeness,

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1. Introduction

Imagination is the act of forming a mental representation of something which is not present to the senses or has never before been wholly perceived in reality (Merriam-Webster, n.d.). A distinction has been made between reproductive and productive (or creative) imagination. Reproductive imagination is about reproducing experiences, while creative imagination is about creating novel images or concepts (James, 1890; Scott & von Stumm, 2017). This study focuses on creative imagination. Creative imagination helps us to understand the world around us (Vygotsky, 2004), to envision our future (Wilson & Gilbert, 2005), to experience empathy (Gaesser & Schacter, 2014) and it plays an essential role in the effective use of creative potential (Runco, Nemiro, and Walberg, 1998; Ren et al. 2012). Ribot (as cited in Vygotsky, 2004) says that "every invention, whether large or small, before being implemented, embodied in reality, was held together by the imagination alone. It was a structure erected in the mind through the agency of new combinations and relationships…" (p.10). Creative imagination is thus an important aspect in our daily lives that helps us to understand the world and gives us the ability to create new concepts.

Researchers from different disciplines who have investigated creative imagination mainly used visual measurement instruments. These instruments make use of visual stimuli (e.g. Ren et al., 2012; Schaefer, 1970) to elicit mental representations, because imagination was traditionally thought to be inherently linked to visual perception (Renzi et al., 2013). Visual measurement instruments, however, are unsuitable to measure the creative imagination of blind people as blind people are unable to perceive visual stimuli. Alternative instruments to do so are scarce. Research investigating the imagination of blind people mainly focuses on the modality of the

mental representations (e.g. Röder et al., 1997; Struiksma et al., 2009) and the reproductive imagination (e.g. Campos, 2004; Cornoldi et al., 1979) rather than the creative imagination.

However, if creative imagination plays a meaningful role in our daily lives, it is important to gain a better understanding of the creative imagination of blind people. This study explores the possibility of developing a new instrument to measure the creative imagination of blind people using tactile stimuli, while the imagination of sighted people is measured using visual stimuli. The development of this instrument can not only scientifically contribute to research into the creative imagination of blind people, but also to practical solutions that help improve cognitive processes of blind people. This study could be a start for further research into the differences between blind and sighted people in creative imagination and their cognitive processes, which can ultimately lead to improvements in, for example, learning processes (e.g. educational curricula) or creative processes of the blind. The research question of this study is as follows:

Is it possible to measure the creative imagination of blind and sighted people with the same instrument and therefore enable the comparison of both groups?

In an explorative experiment in which the newly developed instrument is used, blind participants will be compared to sighted participants. The experiment contains three conditions. The first condition are sighted individuals perceiving a visual graphic. The second condition are blind individuals who perceive a tactile graphic. The third condition consists of blindfolded sighted individuals who perceive a tactile graphic. Blind people are defined as people with a visual acuity worse than 3/60, which means that a person is able to see a detail from 3 metres away while a person with "normal" eyesight would see the same detail from 60 metres away (Holladay, 2004; WHO, 2020).

2. Theoretical Framework

In order to develop an instrument that can measure creative imagination through both touch and sight, this study first looked at what a modality-independent instrument of creative imagination should look like. Historical and recent theories of creative imagination give an idea about the constructs of creative imagination and how those constructs can be used to measure creative imagination. An overview of existing measures of creative imagination is presented from which one instrument is chosen as the basis of the instrument developed for this study. The new instrument is used in an experiment to gain a first insight in the differences in creative imagination between blind and sighted people. The relations between visual acuity, the sensory modality of the stimulus, and creative imagination are discussed, which results in formulated hypotheses.

2.1. History of Creative Imagination Research

Over the years, various theories on creative imagination have emerged, of which Ribot (1906) was the first. He presented a theoretical concept of creative imagination within psychology. According to Ribot (1906), imagination depends on two mechanisms, dissociation, and association. Dissociation selects the mental representations which are necessary for a certain task without connecting them to other mental representations. It is the breakup of a complex whole into a set of individual parts. Without dissociation, one would retrieve an entire experience instead of just one event or object that is needed for a certain task. Dissociation allows us to break up an experience into smaller parts. Those individual parts, which are collected by previous perceptions, become incomplete figures, because we cannot remember a certain experience with all its details. Those incomplete figures then form the basis of new, original mental representations. Ribot calls this association. Association follows after dissociation and

enables combinations of elements of various mental representations. Previous experiences are thus transformed and combined to create new and original mental representations.

Vygotsky (2004) presented his theory of creative imagination, called combinatorial behavior, in the 1930's. He defines newness, an important trait of creativity, as a result of combining and transforming fragments of remembered reality. Vygotsky says that development is a combination of internalisation and externalisation. Internalisation includes experiences and needs, combinatorial or creative abilities, and technical abilities. Externalisation is about the environment and time a person lives in, which gives the person possibilities to express and embody his creative imagination. An invention, something that is expressed through creative imagination, arises from experiences and needs that were created before in the mind. Creative imagination and its function of transforming and reorganising mental representations makes the transfer from external perception to internal perception not a simple transfer, but gives room for creativity. This can result in the construction of a complex mental representation (Vygotsky, 2004). The last part of imagination, according to Vygotsky (2004) is the embodiment of those complex mental representations in external images, objects, or events.

A more recent theory was presented by Ward (1994) which he called structured imagination. He explains the role of categorical structure when generating new ideas. Ward (1994) says that "*imagination is structured or directed by knowledge of the category or categories most related to the individual's goals."* (p.31). This was shown in experiments in which he asked the participants to come up with animals that live on another planet. In most cases the imagined animals had typical properties of animals on earth. Creative imagination thus comes down, according to Ward (1994), to generating new fragments of knowledge and adding it to existing domains.

Table 1

Overview of Creative Imagination Theories and its Constructs

Author	**Mechanism**	**Creative imagination constructs**
Ribot (1906)	Dissociation Association	Originality Transformativeness
Vygotsky (2004)	Internalisation Externalisation	Complex imagery Novelty Transformativeness
Ward (1994)	Categorical structure	Complex imagery Novelty Transformativeness

These theories all mention the creative character of imagination but describe its operation with different mechanisms (see Table 1). Both the ability to generate complex mental representations and to transform mental representations are mentioned. Transforming prior experiences into mental representations that are unfamiliar or completely new refers to the originality and novelty of the generated representations. The complexity, transformativeness and novelty or originality can be seen as the main constructs of creative imagination.

2.2. Existing measurement instruments of creative imagination

Instruments that measure the constructs complexity, transformativeness, and novelty and/or originality of creative imagination occur within the research domains of both creativity and imagination (see Table 2). The overlap of both domains can be explained by the shift from imagination research towards the research of creativity. Although imagination measurement (Galton, 1880) has a longer tradition than research on creativity (Guilford, 1950), creativity research has had more influence on the testing of imagination than the other way around.

Table 2

Overview Measurement instruments of Creativity and Imagination

Name of test	**Domain**	**Constructs**	**Performance based/ Self reported**	**Sensory modalities**
Galton (1880)	Imagination	Vividness - Illumination - Definition - Colouring	Self reported	Visual
Test for Creative Imagination (Simpson, 1922)	Imagination	Creative changes in - decorative drawings - objects in representative drawings	Performance based	Visual
Franck Drawing Completion Test (Schaefer, 1970)	Creativity	- Flexibility - Elaboration - Originality - Asymmetry - Abstraction	Performance based	Visual
Vividness of Visual Imagery Questionnaire (Marks, 1973)	Imagination	Vividness of recalled pictures	Self reported	Visual
Torrance Tests of Creative Thinking (Torrance, 1974)	Creativity	- Fluency - Flexibility - Originality - Elaboration	Performance based	Visual and verbal
Survey of Mental Imagery (Switras, 1978; 1979)	Imagination	- Vividness - Controllability	Self-reported	Visual; Auditory; Olfactory; Gustatory; Tactile; Somesthetic; Kinesthetic
Creative Experiences Questionnaire (Merckelbach et al., 2001)	Imagination	Proneness to fantasy	Self reported	Not specifically targeting a sense

Name of test	**Domain**	**Constructs**	**Performance based/ Self reported**	**Sensory modalities**
Schifferstein (2009)	Imagination	Vividness	Self reported	Olfactory, Gustatory, Tactile; Auditory; Visual
Test of Creative Imagination (Ren et al. 2012)	Creative imagination	- Richness - Flexibility - Profundity - Originality	Performance based	Visual
Test of Creative Imagery Abilities (Jankowska & Karwowski, 2015a)	Creative imagination	- Vividness - Originality - Transformativeness	Performance based	Visual
Self-Descriptive Imagination Questionnaire (Feng et al., 2017)	Imagination	- Expressive imagination - Openness to variations - Instrumental imagination - Past/future mindedness - Conventionality	Self-reported	Not specifically targeting a sense

Fantasy Questionnaire (Weibel et al., 2018)	Creative imagination	- Imaginative fantasy
		  - Vivid imagination
		  - Absorption
		- Creative fantasy
			Self-reported	Not specifically targeting a sense

The instruments measuring creativity and imagination were mainly focused on the visual aspects of imagination because imagination was traditionally thought to be inherently linked to visual perception (Renzi, Cattaneo, Vecchi, & Cornoldi, 2013). Although attention has been mainly focused on visual imagery, mental representations are also possible in other sensory modalities (i.e., auditory, haptic, olfactory) as shown by several studies (e.g. Schifferstein, 2009; Switras, 1978). Nevertheless, measurement instruments of creative imagination focusing on other sensory modalities than sight are rare (see Table 2). In the case of this study, this is

important considering the blind participants whose mental representations are based on non-visual sensory information.

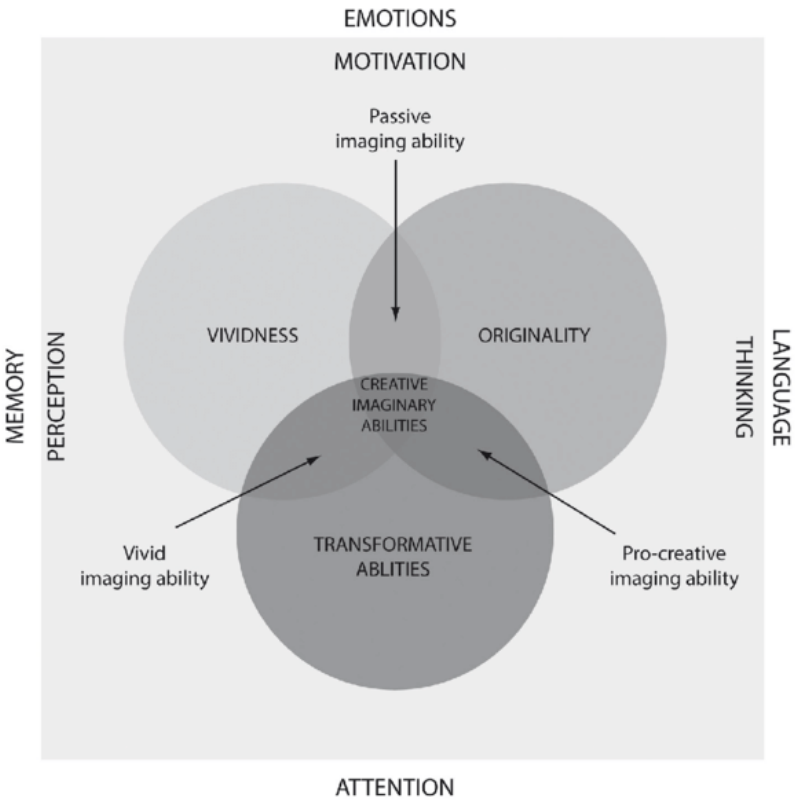
There seem to be no instruments that specifically focus on measuring creativity or imagination of blind people. The Survey of Mental Imagery (Switras, 1978; 1979) and a similar instrument used by Schifferstein (2009) are the few ones that measure mental representations across the sensory modalities. However their self-reported measures are limited to the investigation of the vividness (often defined as the ability to create complex, detailed mental representations) of reproductive mental representations. For example, they investigate how lively someone can reimagine a certain scent.

No existing instrument seemed to be able to measure the creative imagination of blind people. It was therefore decided to take one of the instruments that measures the constructs of complexity, transformativeness, and originality or novelty of mental representations and adjust it in order to be able to measure the creative imagination of blind people. It was decided to make a distinction between performance based and self-reported measures because self-reports tend to show only low or moderate correlations with several cognitive performance measures, suggesting a bias of the participants. Evidence also demonstrates that subjective measures do not tap into the same cognitive processes involved in objective tests that require imagery manipulation (Lequerica et al., 2002). Three tests which can possibly be developed into an instrument to measure creative imagination of blind individuals are the Franck Drawing Completion Test (FDCT) (Schaefer, 1970), the Test of Creative Imagination (TCI) (Ren et al. 2012), and the Test of Creative Imagery Abilities (TCIA) (Jankowska & Karwowski, 2015a). These three tests measure creative imagination on constructs that can be related to one of the three constructs (i.e. complex imagery, transformativeness, and novelty or originality).

Jankowska and Karwowski (2015a) use the conjunctional model of creative imaging ability of Dziedziewicz and Karwowski (2015) for their measurement instrument (see Figure 1). They define creative imagination "... as the ability to create and transform representations that are based on the material of past observations but significantly transcending them – the socalled creative representations." (p. 4). The model shows three constructs: (1) vividness, which is the ability to create expressive images characterized by high complexity, like metaphorical and symbolic content, and a high level of detail. (2) Originality, which is the ability to

Figure 1

Conjunctional Model of Creative Imaging Ability



Note. Derived from "Development of children's creative visual imagination: a theoretical model and enhancement programmes" by Dziedziewicz, D., & Karwowski, M. 2015 *Education 3-12, 43*(4), 382-392.

produce new and unique images which show new objects, activities, processes and events that are considerably different from existing ones. (3) Transformativeness, which is the ability to transform the perceived initial image to something creative using cognitive operations such as multiplication, distortion or amplification. Combining these three constructs results in the ability of creating creative imagery.

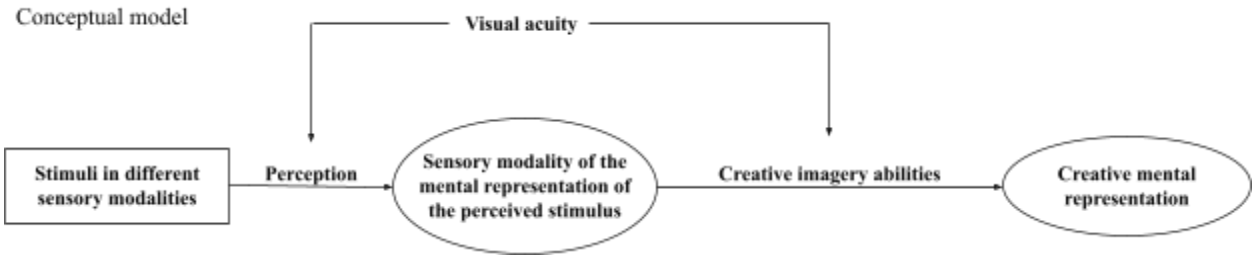
It is noteworthy that the TCIA was developed because Jankowska and Karwowski (2015a) saw problems associated with the measurement of creative imagery abilities in the FDCT and the TCI. According to Jankowska and Karwowski (2015a), the assessment criteria of the FDCT are nearly identical with those of typical divergent thinking tests while the tasks of the TCI are a "rather mechanical imitation of the specificity and scoring." (p.3). This last comment relates to a task in which the participant has to come up with as many complex figures as possible out of incomplete drawings. Jankowska and Karwowski (2015a) emphasise that it is not about the number of drawings, but being able to present a generated mental image. Another problem that the authors are concerned about, is associated with transformativeness of the mental imagery. Both the FDCT and the TCI are figural tests in which the drawings are assessed on imagery transformation. However they often focus on the elaboration of the drawing (which actually concerns the vividness of the mental image), instead of the transformations of the initial figure (for more details, see Jankowska & Karwowski, 2015). Because the TCIA was proposed with these concerns in mind, and has a performance based approach and shares a definition of creative imagination similar to the discussed theories, it was chosen as a basis to develop the measurement instrument used in this study. The development of the new instrument is discussed below in a separate section.

2.3. Expectations

The newly developed instrument is used to compare the creative imagination of blind and sighted people. Figure 2 shows a conceptual model of relations between visual acuity, the sensory modality of the stimulus, the sensory modality of the mental representation and creative imagery abilities. It is expected that sensory modality of the stimulus (whether it is perceivable visually or by touch) influences the sensory modality of the mental representation that is created from the perceived stimulus. This expectation is explained below. Visual acuity may have an effect on the sensory modality of the mental representation when perceiving a stimulus in different sensory modalities. Visual acuity may also influence the creative imagery abilities of people when transforming a reproductive mental representation into a creative mental representation. In order to be able to hypothesise the differences between blind and sighted people in creative imagination, the relations shown in Figure 2 are discussed.

Figure 2

Conceptual model of the relations between sensory modality of the stimulus and the mental representation, visual acuity, and creative imagery abilities



2.3.1. Influence of Visual Acuity on the Sensory Modality of the Mental Representation.

Cattaneo and Vecchi (2011) give an extensive overview of the neuroscience of visual impairment in their book Blind Vision. They show that the mental world of blind people is mainly formed by

their dominant senses, namely hearing and touch, while the mental representations of sighted people are formed by their dominant sense of sight. It is emphasised that spatial features of objects can be perceived through touch and hearing (for distant sources) by blind people and that their mental representations may even be of an analogical spatial format (i.e. representations which are more direct models or pictures of the things represented, very schematic and containing spatial information with almost no details). This is supported by imagery tasks in which blind people succeed to draw spatial inferences and manipulate, integrate, and combine different pieces of spatial information (Aleman et al., 2001; Eardley & Pring, 2006; Kerr, 1983; Thinus-Blanc & Gaunet, 1997; Vanlierde & Wanet-Defalque, 2004).

Accordingly, when a sighted person feels an object, it is likely that a visual mental representation is formed of the object. This has been shown by neuroscientific experiments which suggests that a visual mental representation and a tactile mental representation can be activated as much by tactile input of an object as by a visual presentation of the object and vice versa (Easton et al., 1997a; Easton et al., 1997b; Reales & Ballesteros, 1999). Evidence even showed that when sighted people explore an object tactically, they will often spontaneously report generating visual mental representations (e.g. Santhian & Zangaladze, 2001; Zhang et al. 2004), which has been supported by neuroimaging evidence (e.g. Lacey et al., 2010; Lacey & Santhian, 2012).

Due to the difference in available senses, the spatial behaviour of mental representations of a blind and a sighted person differ. Blind people tend to use their body as a reference frame and to focus on the space around them that is directly reachable with their arm or cane while the reference frame of sighted people is much larger (Cattaneo & Vecchi, 2011). That may be reason why high-imagery words referring to objects that are difficult to experience by touch (e.g. palm

tree) were rated higher on vividness by sighted people while low-imagery or abstract words (e.g. damage) were rated higher by blind people (Cornoldi et al., 1979). High-imagery words that referred to objects that could also be experienced in absence of visual experience (e.g. cat) were equally rated on vividness by blind and sighted participants.

Mental representations of blind people are expected to consist of more auditory and tactile details and may contain more low-imagery entities or objects that can be easily experienced by touch than those of sighted people. A mental representation of a blind person of a cat, for example, would thus probably contain details like the softness of the fur and the sound of the cat. Sighted people, on the other hand, form a mental representation of their dominant sense of sight and are thus expected to contain more visual traces and may contain more high-imagery objects that are more difficult to experience. Even when tactile stimuli is perceived, it is likely for sighted people to generate a visual mental representation of it. Their mental representation of a cat would contain details like the colour of the fur, the place where the cat is located, and the movements that the cat makes.

Hypothesis 1: *Mental representations of blind people will contain more tactile and auditory details and may contain more low-imagery entities while mental representations of sighted people will contain more visual details and more high-imagery objects, no matter how the stimulus is perceived (i.e. visually or by touch).*

2.3.2. Influence of the Sensory Modality of a Mental Representation on Creative Imagination

It is expected that the sensory modality of a mental representation is different for blind and sighted people. The question that follows is whether the sensory modality of a mental representation does influence the creative imagery abilities. There seem to be no prior studies that have investigated the relationship between the sensory modality of the mental representation

and creative imagination. It was therefore decided to look into the relationships between the modality of the mental representation and each of the three constructs (i.e. vividness, originality and transformativeness) of creative imagination, and into the relationships of visual acuity and each of the three constructs of creative imagination.

2.3.2.1. Influence of the sensory modality of a mental representation on vividness. It has been shown that visual mental representations are experienced as more vivid for sighted people and thus higher than tactile mental representations when participants were asked to imagine a product with a conspicuous or characteristic sensory characteristic (Schifferstein, 2008). Similar results were found in different studies in which the participants received a cue word that was related to one of the senses (White et al., 1977; Switras, 1978; 1979; Grebot & Paty, 2005). Campos (2004) showed that a person who had been blind for three years had more vivid tactile mental representations than for visual mental representations when receiving a cue word. Those results do not demonstrate that either blind or sighted participants have more vivid mental representations as they would normally create a mental representation in their dominant senses. However it can be expected that when visual mental representations are elicited from the graphics, they will be more vivid for sighted participants and tactile mental representations elicited from the graphics will be more vivid for blind participants.

All these studies only looked into the vividness of the imagery and cue words and not into the other constructs of creative imagination or other sensory modalities as input. As mentioned earlier in this study, it is expected that a blind person forms a tactile mental representation of the graphic while a sighted person forms a visual mental representation of the graphic. As studies on the vividness of the mental representations across sensory modalities showed that tactile mental representations are most vivid for blind people and visual mental

representations are most vivid for sighted people, in this study no difference is expected on the vividness of the mental representations between blind and sighted people.

Hypothesis 2a: *There is no difference in vividness between the mental representations of blind and sighted people.*

2.3.2.2. Influence of visual acuity on transformativeness. Research into the transformativeness of imagery of blind people is mainly focused on spatial processing. Imagery tasks were performed in which the participant had to manipulate shapes and generate new forms using imagery alone. Eardley and Pring (2006) showed that blind people were less successful in generating representations in two dimensions than in three dimensions. However in three dimensions, there was no difference in the number of generated representations between blind and sighted participants. In a tactile mental rotation task, congenitally blind and sighted participants were asked to judge whether two stimuli were different or the same. Blind participants showed longer reaction times, higher error rates and slower mental rotation times which can indicate a higher cognitive load for blind participants in transforming mental representations (Marmor & Zaback, 1976; Millar, 1976; Röder et al., 1997). As it takes more effort for blind people to transform their mental representations compared to sighted people, the following hypothesis has been formulated:

Hypothesis 2b: *Blind people score lower on the transformativeness of their mental representations than sighted people.*

2.3.2.3. Influence of the sensory modality of a mental representation on originality. No empirical studies were found which looked into the originality of mental imagery and how it differs across visual and tactile imagination. In addition, Palmiero et al. (2011) found no

relationship between the vividness of visual imagery and originality which makes it difficult to form well-founded expectations on the question whether the modality of the mental representation influences the creative imagination on the constructs of transformativeness and originality.

One study was found that compared blind and sighted children on their creative thinking abilities (Halpin et al., 1973) regarding verbal fluency, verbal flexibility, and verbal originality. It has been shown that imagery abilities had significant effects on fluency, originality and elaboration (Gonzalez et al., 1997). Shaw and DeMers (1986) showed similar results, when looking at the relationship of imagery to originality, flexibility and fluency in creative thinking. They found that imagery has an important place in both verbal and nonverbal dimensions of the creative process. The study of Halpin et al. (1973) showed that the blind children were more verbally fluent, flexible, and original than the sighted children. The following explanation for a higher score of originality for blind children was given: "*It is necessary for the blind child to rely upon imagination and practice its use for his survival. Things that one can see one does not have to imagine, while things that one imagines may be more unusual, unique, and original. Thus, the blind child, who is more dependent upon his imagination than the sighted child, may be more original on creative thinking tasks."* (p.273). This result suggests that the imagery abilities on the construct of originality of blind people are better than those of sighted people. However, another similar study showed that blind children were equal to sighted children in divergent thinking, except for blind children being more fluent (Tisdall et al., 1971). These results should be interpreted cautiously as imagery is not the only factor that may influence verbal originality in creative thinking. Next, according to Vygotsky (2004), imagery abilities improve at the time of puberty. As the age of the children in the study of Halpin et al. (1973) ranged from 6-12 years, it

could be argued that the results of the study may no longer apply to adults. It should however be noted that after puberty, when the developments of imagination and reason come together, the development of imagination falls rapidly and reason takes over (Vygotsky, 2004). Overall, this makes it difficult to form a concrete hypothesis on the difference in originality of the mental representations between blind and sighted people. As no other studies were found investigating the originality of mental representations and how it differs between blind and sighted people, the following hypothesis has been proposed:

Hypothesis 2c: *There is no difference in originality between the mental representations of blind and sighted people.*

To summarize, the above mentioned studies give an indication of differences between blind and sighted participants in creativity and imagination. No previous studies have been found that investigated the relationship between the modality of the mental representations and creative imagination or the relationship between visual acuity and creative imagination. The three constructs of creative imagination are equally important (Jankowska & Karwowski, 2015a), and it might therefore be thought that sighted people will have a higher overall score on creative imagination than blind people as it is expected that they score better on the construct of transformativeness. However, the little research that is done on creative imagination of both blind and sighted people, makes it difficult to give a concrete hypothesis on the comparison of blind and sighted people in creative imagination. Nevertheless, taking in account the previous formulated hypotheses, it is expected that sighted people have better creative imagery abilities.

Hypothesis 2d: *Sighted people have better creative imagery abilities than blind people.*

This exploratory study, with the use of a newly developed instrument, hopes to give a first insight into the differences between blind and sighted people on their creative imagery abilities. These differences may help us to better understand differences in other cognitive processes, as creative imagination has shown to play an important role in those processes (e.g. Amabile, 1988; Beghetto & Kaufman, 2010; Egan & Judson, 2009; Hassabis et al., 2007; Lieberman, 2014; Mills, 2000). Better understanding of these processes may lead to practical solutions that can improve the quality of life of either blind or sighted people.

3. Development of the instrument

The newly developed instrument is based on the Test of Creative Imagery Abilities (TCIA) (Jankowska & Karwowski, 2015a) and adapted so blind people can do the test. First a short explanation of the original TCIA will be given, followed by an explanation of the two modifications that are made to be able to compare blind and sighted people on their creative imagination with variations of the same instrument.

The original TCIA is a performance-based instrument of people's creative imagery abilities. It was developed because existing tests did not take into account the complexity of creative imagination and to bridge creativity and imagination constructs (Jankowska & Karwowski, 2015a). The TCIA consists of three constructs: (1) vividness, the ability to create highly detailed and complex imagery, (2) originality, the ability to produce unique imagery, and (3) transformativeness, the ability to control and transform imagery.

The original TCIA consists of seven tasks with three consecutive phases. (1) The participant generates ideas in an oral or written form based on an incomplete figure (see Figure 3, which will be discussed below). (2) The participant selects the, in his or her opinion, most original of the generated ideas and makes a complete drawing, accompanied by a brief

Table 3

Assessment Criteria for the Original TCIA.

Scoring	Vividness	Originality	Transformativeness
0	The original figure has not been supplemented, but was interpreted, i.e., it was given the title	Presentation of common objects (things, plants, animals, people, places). Their shapes, functions, and properties are real, and their activities, processes, states, and events are typical.	Multiplication of the original figure
1	Simple, frequently schematic completion of the original figure	Individual, simple modifications of shape, functions, and properties of widely known objects (things, plants, animals, people, places) as well as typical activities, processes, states, and events;	Recreation, simple completion of the original figure, and adding to it a relatively independent object(s)
2	Complex, rich in detail completion of the original figure	Complex, significantly altered with respect to reality, modification of shape, functions, and properties of widely known objects (things, plants, animals, people, places) as well as typical activities, processes, states, and events	Complex modification of the original figure - its multi-aspect elaboration

Note. Derived from "Measuring creative imagery abilities" by Jankowska, D. M., & Karwowski, M. (2015a). Frontiers in psychology, 6, 1591.

description in the form of a title. (3) Finally, the drawing is assessed using the assessment criteria on each scale (see Table 3). Those stages are repeated six times as there are seven figures. In total, the TCIA requires no more than 20 minutes to complete.

For blind people to be able to participate in the TCIA, two modifications need to be made (see Table 4). In the first stage the visual stimuli must be modified for a blind person to be able to perceive it. In the second stage, in which the participant expresses his or her creative mental representations by completing the graphic with a drawing, a modification should be made to give a blind person a way to express their creative mental image.

Table 4

Overview of Modification made to the Original TCIA.

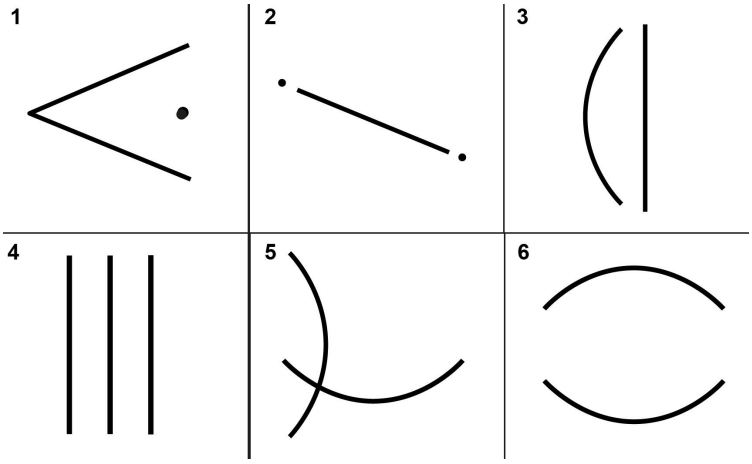
	Input	**Output**
Original version	Visual	Drawing + short description
Adapted version	Visual and tactile	Detailed description

The adapted version of the TCIA (TCIA-2) should be able to measure creative imagery abilities with input available in different sensory modalities. It is therefore chosen to add tactile stimuli to the original TCIA, because the tactile sense is, besides the auditory sense, the most dominant sense for blind people (Cattaneo & Vecchi, 2011). As we want to keep the TCIA-2 as close to the original TCIA as possible, the figures will stay the same. It was chosen to replicate the graphics into a tactile graphic instead of describing them in words. Because the graphics are rather simple and abstract, they should be easy to understand for blind participants when feeling the stimuli (Figure 3), while, for a spoken description, the abstractness of the graphic can make it harder to explain them verbally to blind participants, without giving any clues or ideas to the participant. The first six stimuli (see Figure 3) out of the seven original stimuli were replicated on swell paper, because swell paper and the swelling process is expensive and labor-intensive. These six figures would fit on one page of swell paper without sizing down the figures too much, which was better for the financial feasibility of this study.

In the second stage, instead of drawing, both sighted and blind people give a spoken detailed description of their idea on how they would complete the felt or seen stimuli. It is more reliable to compare both groups by using two spoken descriptions instead of comparing a drawing to a spoken description, because of the same output format. The assessment criteria do not have to be altered to be able to judge the descriptions (see Table 3).

Figure 3

Stimuli of the TCIA-2, both as Tactile or Visual Graphics.



Note. Derived from "Measuring creative imagery abilities" by Jankowska, D. M., & Karwowski, M. (2015a). Frontiers in psychology, 6, 1591.

3.1. Validity

It is expected that the measurement remains valid despite the fact that another sensory modality as input is added to the instrument. As mentioned earlier, results of neuroscientific experiments suggest that a visual mental representation and a tactile mental representation can be activated as much by tactile input of an object as by a visual presentation of the object and vice versa (Easton et al., 1997a; Easton et al., 1997b; Reales & Ballesteros, 1999). As there are no modifications made on the stimuli themselves, apart from the modality in which it is perceived, it is thus expected that this does not influence the internal validity of the measure.

As the output is adjusted for all three conditions, it is expected that this does not harm the internal validity of the measurement. The assessment criteria (see Table 3) of the original TCIA does not include specific criteria related to drawings, which suggests that they can be applied to spoken descriptions as well.

4. Method

To explore the possibility of measuring creative imagination of blind and sighted people with the same instrument, a partly qualitative and partly quantitative experimental study has been conducted in which the creative imagery abilities of blind and sighted people are compared. A mixed-method approach has been chosen, because the qualitative data reveals the content of the mental representations of the participants and thereby enriches the quantitative data.

4.1. Design

The dependent variable has been investigated using the developed instrument with a between-subjects design. The experiment consisted of three conditions which can be found in Table 5. The participants received six different stimuli. These stimuli were exactly the same as the ones used in the original TCIA and were presented visually to condition 1 and tactically to condition 2 and 3. The sighted participants in the third condition were blindfolded during the experiment to prevent them from visually perceiving the graphic. The order in which the graphics were shown were identical for all participants to prevent the order of the graphics to influence the results of the test.

Table 5

Overview of the Different Conditions

	Condition 1	**Condition 2**	**Condition 3**
Visual acuity	Sighted	Blind	Sighted (blindfolded)
Stimuli	Visual graphics	Tactile graphics	Tactile graphics

4.2. Participants

Blind participants were approached by the researcher through social media groups (Koninklijk Visio, Dedicon, Blinden en slechtzienden, Blinde en slechtziende jongeren, which are all Facebook groups) (purposive sampling). In addition, the participants were approached through Dedicon, a Dutch publisher of educational teaching materials for people with a visual impairment and through the social circles of the participants (snowball sampling). The blind people who were recruited, should not be able to distinguish the different tactile stimuli by sight, therefore only fully blind individuals were recruited.

Sighted people for the blindfolded condition performed the experiment in a lab condition as they were not allowed to see the tactile stimuli before the experiment, which cannot be controlled when the stimuli would be sent to the participants. Due to COVID-19 circumstances and the risk of contamination, people within the researcher's surroundings were preferred. The sighted people were recruited via personal channels of the researcher. Sighted people for the group with the visual stimuli were recruited either through convenience sampling via personal or social media channels of the researcher. There were no restrictions on residence, educational level or gender.

In total, 44 (mean age 33.4) participants were recruited. 17 sighted persons participated in the sighted/visual condition who had a mean age of 29 years and ranged from 18 to 60 years. 9 fully blind persons participated in the blind/tactile condition who had a mean age of 56.9 years and ranged from 37 to 75 years. The sighted/tactile condition consisted of 18 participants with a mean age of 25.9 years and ranged from 19 to 52 years. The ages differed considerably between the different conditions, therefore the age was included in the analysis as a covariate, because previous studies have shown that age may have an influence on imagery abilities (Kosslyn et al.,

1990; White et al., 1977). The group with blind people lost their sight at the average age of 20.8 years and ranged from 0 to 51 years. The blind participants had an average of 43.8 years of experience reading Braille, and an average of 30.6 years of experience reading tactile graphics.

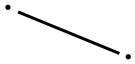
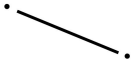
4.3. Materials

The TCIA-2 is a performance-based measure and was used to compare creative imagery abilities between blind and sighted individuals while perceiving stimuli in different modalities. Creative imagery abilities were measured on three constructs: vividness, originality, and transformativeness. The TCIA-2 consisted of three stages (see Table 6 for two examples), wherein participants were first instructed to generate ideas from an incomplete graphic. As can be seen in Table 6, the participant who generated the poor description had more difficulties in generating ideas than the participant who generated the rich description. Successively, participants selected their most original idea and gave a detailed description about how they would complete the graphic (see description phase in Table 6). Afterwards, the descriptions of the creative mental representations were assessed by the researcher on the three components of creative imagination. It was possible to score 0 to 2 points on each construct for a single drawing. The poor description scored low on vividness as few details are given and no elements are added to the initial figure. The rich description scored high on vividness as a lot of details and elements were given or added to the initial figure. The rich description scored one on originality as a simple change of state of the car was given in comparison to its normal state. Both descriptions scored one on transformativeness as simple transformations were given (see Table 6).

Furthermore, the descriptions given were selectively coded and thematically analysed to explore any differences in the expressed creative mental representations between participants in

Table 6

Example TCIA-2

	Poor description	Rich description
Initial figure		
Phase 1: Idea generation	yes indeed yes found it, here is actually a dot with a line and another dot and that's it okay ehm (pause) it is actually a bit like a slash sign as in computer science but there are two dots with a dot on each side and my fantasy says ehm there is a man on either side of the river there is a man at the top left and bottom right and in between is a river and the unbroken line yes it is uninterrupted that is a bridge that must lead to connect both men yes	oh this is a car the front of the car that center stripe is a grill and those two circles are the headlights and it's driving really fast so it is a bit tilting ... our 1.5 meter society two figures so keeping distance ehm (pause) it is also the front of a walrus a whale but a cartoon of it ehm (pause) it is the top of a fence seen from above or of a parkour thing where horses jump over (pause) ehm (pause) it's also a kind of face but that was that whale I think
Phase 2: Description	my fantasy says ehm there are men on both sides of the river each there is a man at the top left and bottom right and in between is a river and the unbroken line yes it is uninterrupted that is a bridge that must lead both men into contact with each other yes	yes ehm i'm going for the car ehm there is a car that drives really fast in a kind of eh eighties Michael Knight style (laughter) such a car it has very clean lines and so it drives really fast and on the road there is a stone that it just drove over so it is half in the air because because it drives way too fast over it and ehm it is really an 80's setting so half dark, the sky is purple and ehm really such a country road over a mountain wall let’s say and ehm the car has those square headlights and they shine very bright in the eh into the evening and there is a man behind the wheel and that is Michael Knight and the road is a dual lane but not very wide per se and probably somewhere in the US ehm I think that was it

	Poor description	Rich description
Phase 3: Assessment (Quantitative)	- Score vividness: 0 - Score originality: 0 - Score transformativeness: 1	- Score vividness: 2 - Score originality: 1 - Score transformativeness: 1
Thematic Analysis (Qualitative)	Main codes and subcodes idea generation phase: - Briefly explain ideas immediately (main) Main codes and subcodes description phase: - Simple description (main) - simple	Main codes and subcodes idea generation phase: - Originality (main) - ordinary (sub) - Briefly explain ideas immediately (main) Main codes and subcodes description phase:- Detailed description (main) - background (sub) - colour (sub)

the three conditions. Thematic analysis is a method for analysing a dataset in a systematic way, by identifying, organizing and offering insight into patterns across the qualitative data (Braun & Clarke, 2016). Thematic analysis was used to explore differences in the mental representations between participants in the three conditions guided by the broad questions “What characterizes (a group of) ideas generated during the idea generation phases?”, and “What characterizes the descriptions given during the description phases?”. On the basis of these questions, codes were assigned to fragments of the transcriptions. Afterwards, the assigned codes were compared to each other, and associated codes were grouped under an overarching code. Codes that shared a similar meaning were combined into one code. For example, during the idea generation phase, the codes ‘fills in what is missing’ and ‘explains how to finish drawing’ were combined into ‘Immediately explains ideas briefly’. In the end, 10 main codes and 20 subcodes were created (which were reduced to 9 main codes and 18 subcodes after the second rater analysed the data for the first time) (see Appendix A). Table 6 shows the codes that were assigned to the idea generation phase and the description phase of both the poor and rich description.

To control for individual differences in creative imagination between the conditions, the Fantasy Questionnaire was used. The Fantasy Questionnaire is a self-reported measure for proneness to fantasy on the dimensions of Imaginative Fantasy and Creative Fantasy (Weibel et al., 2018). Imaginative Fantasy refers to the vividness of the imagination, while Creative Fantasy refers to the creation of new ideas using imagination. The original Fantasy Questionnaire has a total of 27 statements which are rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The dimension of Imaginative Fantasy consists of 16 statements while the dimension of Creative Fantasy consists of 11 statements. All the participants were Dutch and were not all fluent in English therefore the questionnaire was translated to Dutch by a native Dutch speaker. Each participant could choose whether they preferred the English or Dutch version of the questionnaire. All items can be found in Appendix B in both languages.

4.4. Procedure

People interested in participating in the study were digitally approached with a letter of information and an informed consent form. The latter included the agreement of the participant to the recording of the phone call during the experiment, the consent for the processing of personal data, a description of how participants could revoke their consent and the participants' rights. After the participants had given their informed consent, the researcher sent them the graphics. The participants were asked to contact the researcher when they had received the graphics so they could make an appointment to conduct the experiment. Due to the COVID-19 circumstances the experiments took place remotely as much as possible through phone calls. The participants were asked to conduct the experiment in a quiet environment and to keep the envelope with the graphics closed until the researcher told them to open it to prevent them from exploring the graphics beforehand. Sighted participants who participated in the blindfolded

condition, were met in person, also to prevent them from exploring the tactile graphic before the experiment. The phone calls were recorded during the TCIA-2 and were then selectively transcribed (i.e. from the idea generation phase of the first graphic up to and including the description phase of the sixth graphic, leaving out any (in)direct personal information of the participant).

Before the call, sighted participants were sent an online questionnaire including demographic questions and the statements of the Fantasy Questionnaire. Blind people answered those questions during the call, before the TCIA-2 was conducted. The demographic information consisted of the age of the participant, their visual acuity (blind or sighted), at which age the participant lost sight, and their years of experience with braille and/or tactile graphics.

At the start of the experiment, the researcher made some small talk to the participants to let them feel at ease. Then the researcher asked the demographic questions and gave the statements of the Fantasy Questionnaire or made sure that the sighted participants had completed the questionnaire. Next, the researcher communicated the instructions to the participant and room was given to the participant to ask questions.

Before the stimuli were shown, the sighted people who received a tactile graphic were asked to blindfold themselves, whereafter the participants were given the tactile graphic by the researcher. People in the sighted/visual and blind/tactile condition were given the permission to open the envelope with the stimuli and to take the specific graphic mentioned by the researcher. The tactile stimuli were all placed on one sheet of paper on which the top left corner of the paper was made recognisable for the participant and the stimuli were numbered, to prevent the wrong graphic being felt. During the first stage of the TCIA-2, participants were free to feel the tactile graphic or look at the visual graphic to get ideas. They were asked: *"What does the drawing*

remind you of?". Their answers were noted by the researcher. When the participant did not get any new ideas, the researcher repeated the generated ideas. The participants chose the, in their opinion, most original idea which they would complete. The exact instruction given by the researcher was *"You can complete the graphic with unrestricted elements, change and develop it so you create something even more unusual."*. During the description phase, the participants had permission to still feel the tactile or look at the visual graphic and were encouraged to elaborate and transform their ideas. The same procedure was repeated five times after which the audio-recording was stopped. Lastly, participants were given time to ask questions or give comments. After the call, the descriptions were assessed on the three components of creative imagery abilities using the assessment criteria by reading the transcriptions that were made of the audio recordings.

4.5. Analysis

4.5.1. Fantasy Questionnaire

A one-way between groups analysis of variances (ANOVA) was conducted. The result of this test was used to control whether the proneness to fantasy had influence on the results of the TCIA-2. The original Fantasy Questionnaire had a total of 27 statements which are rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). However two statements were removed as they referred to movies, which a blind person may never have experienced. Crohnbach's alpha for the adapted Fantasy Questionnaire with 25 items was .88 as well. In addition, the item "*I am good at blocking out external distractors when I am involved in something"* was removed as it was probably ambiguous for a portion of the sample, because blind people would have a different definition of distractors than sighted people. The adapted Fantasy Questionnaire thus had a total of 24 statements, of which 13 statements measured

Imaginative Fantasy and 11 statements measured Creative Fantasy (see Appendix B). Example statements of both dimensions were respectively "*When I think of something cold, I actually get cold.*" and "*Sometimes I think about new inventions.*". Crohnbach's alpha for the adapted Fantasy Questionnaire with 24 items raised to .90.

4.5.2. Test of Creative Imagery Abilities 2

4.5.2.1. Assessment of the descriptions. The descriptions of the creative mental representation that were given by the participants during the experiment were assessed using the assessment criteria (see Appendix C). As there were 44 participants who each received six figures, a total of 264 descriptions were assessed. On each of the three constructs 0-2 points could be scored. The total score is the sum of points obtained by the three constructs indicating the creative imagery abilities (Jankowska and Karwowski, 2015a). These scores were quantitatively analysed.

4.5.2.2. Quantitative analysis. A one-way analysis of covariance (ANCOVA) was used to compare the creative imagery abilities of participants in the three conditions (sighted/visual, blind/tactile, and sighted/tactile). Two covariates were included to partial out the effects of proneness to fantasy and the age of the participants from the analysis. It should be noted that an ANCOVA is not the most suitable test to analyse the data because it normally measures the dependent variable on an interval scale. The dependent variable 'creative imagery abilities' however, consists of three constructs on which 0-2 points can be scored. This is rather limited for a scale. Quade's test was considered as an alternative test. However, the use of a Quade's test is not a very common procedure and is suspected to be less powerful (especially for the small sample size used in this experiment) than an ANCOVA.

Three other ANCOVAs were conducted with each of the three constructs of creative imagery abilities separately as dependent variable. These ANCOVAs were conducted to get a better insight into the differences between the three conditions on each construct.

4.5.2.2.1. Inter-rater reliability. Ten percent of the quantitative data was analysed by a second, independent rater to check for inter-rater reliability as this should be sufficient to check for agreement between the raters (Lombard et al., 2002). The quantitative data that was analysed consisted of only description phases, each of a different participant across all three conditions to represent the whole dataset. The assessment criteria were used to inform the second rater how to rate the descriptions of the graphics accompanied with a real example of each score of the three components for the quantitative data (see Appendix C)[1]. The whole description of an idea was given to the second rater.

The researcher and the second rater were in agreement regarding the scores in 64.2% of the total of 81 scores given. Percentage agreement has been chosen as a method to compute the agreement between the raters as it is easy to interpret and calculate. Cohen's Kappa was considered, but the unfamiliarity of the researcher with the test in combination with the different rating levels present in the data, made the researcher decide to choose percentage agreement as method. An absolute agreement level between 75% and 90% is considered an acceptable level of agreement (Chaturvedi & Shweta, 2015). This means that the analysis of the quantitative data seemed unreliable. The main difference in agreement between the raters was found in the construct of transformativeness (52% of agreement), which was less than the agreement on vividness (67%) and originality (74%). It was therefore decided that a second round of rating was needed to reach a higher agreement between the two raters. It was decided to only include

[1] The appendix does not include sample quotes and its motivation, because it would then be a very large scheme, but an anonymous overview of the example quotes, per score, can be provided on request.

the construct of transformativeness in the second analysis because the developed instrument is used for the first time and therefore a lower agreement may be appropriate to draw tentative conclusions. Before the second analysis, differences in the interpretations of transformativeness between the raters were discussed. The second rater mentioned that it was hard to discriminate between the construct of vividness and transformativeness. Another, different, 10% of description phases were assessed after re-explaining the construct of transformativeness which showed a slightly better agreement between the two raters (59%) on the construct of transformativeness. This brought the overall agreement to a percentage of 66.7%. It should be noted that a percentage agreement needs to be interpreted carefully as no account has been taken with the level of chance which is often integrated in a coefficient of tests used to compare ratings of two raters.

4.5.2.3. Qualitative analysis. A qualitative analysis has been conducted in the form of a thematic analysis. The experiments were audio-recorded and then transcribed orthographically, reproducing all words and sounds. The transcriptions were selectively coded and thematically analysed to explore any differences in the descriptions of the creative mental representations between the participants in the three conditions. An inductive approach has been chosen to analyse the data as the mental representations of the participants are explored and are not critically analysed as a deductive approach would do. The broad questions that were posed to guide the analysis were “What characterizes the ideas generated during the idea generation phases?” and “What characterizes the descriptions given during the description phases?”.

Codes were assigned to the idea generation phase and description phase of each participant as a whole. This approach was taken, as this study is not interested in individual ideas or descriptions but in the general characteristics of the idea generation phases and the description

phases and how they differ between the conditions. By assigning codes to whole phases, the phases between participants in different conditions could be compared. The number of a particular code in each condition was counted and expressed as a percentage of the total number of possible codes present. The quantified data has been statistically tested when they were used to explain the results of the quantitative analysis of the TCIA-2.

4.5.2.3.1. Inter-rater reliability. Ten percent of the qualitative data was analysed by a second, independent rater to check for inter-rater reliability. For the qualitative analysis a coding scheme was provided to the second coder (see Appendix A[2]). The second coder was asked to code both the idea phase and description phase using the provided coding scheme.

To assess inter-rater reliability, the transcriptions of 27 idea generation phases and related description phases (each of a different participant and across conditions) were coded using the coding scheme (Appendix A) by both the researcher and the second rater. First the main codes were assessed and when both coders agreed on the main codes, the subcodes were assessed on agreement. The amount of main codes and subcodes assigned depended on the things they mentioned. Based on the analysis of the researcher, a fixed amount of blank codes was provided to the second rater which had to be filled in, to be able to compare the agreement. For example, when the researcher assigned two main codes to an idea generation phase, two blank cells corresponding to the two main codes were provided to the second rater. The raters were in agreement regarding the maincodes in 59,43% of the total of 107 main codes given. As mentioned before, an absolute agreement level between 75% and 90% is considered an acceptable level of agreement (Chaturvedi & Shweta, 2015), which means that the analysis of the qualitative data seemed unreliable as well. Analysing the differences in agreement, it was noticed

[2] This appendix does also not include sample quotes to spare space, but an anonymous overview of the example quotes, per subcategory, can be provided on request.

that most disagreement was found in assigning the main codes of the idea generation phase (47% of the main codes corresponded). This was probably caused by the rather large amount of main codes which could be assigned to both phases. It was therefore decided to discriminate between main codes that could be assigned to either the idea generation phase or the description phase and main codes that could be assigned to both phases. Analysing the differences in agreement of the two raters also showed that the main codes ‘originality’ and ‘associations’ were often reversed. In addition, the main codes ‘immediately explains the idea briefly’ and ‘rotate / tilt figure’ were more often assigned by the first rater than the second rater. Those four codes were once more explained to ensure that both raters had a similar definition of these main codes. After discussing the differences, it was decided that the second rater would analyse another, different, 10% of idea generation phases to see whether a higher agreement would be achieved.

This time the two raters were in agreement regarding the main codes in 62,80% of the total of main codes given. The two raters were in agreement regarding the subcodes in 72,58% of the total of 112 subcodes given. Once again, it was noticed that the main codes ‘originality’ and ‘associations’ were often reversed when comparing the analysis of both raters, which suggests that those two codes should be better defined and distinguished from each other. As the agreement between the two raters did not reach a percentage of 75 or higher, considered appropriate for reliability (Chaturvedi & Shweta, 2015), the analysis of the qualitative data seems unreliable and the results of the qualitative data should be handled with caution.

5. Results

In this study, the development of a modality independent measurement instrument which enables the comparison of blind and sighted people on creative imagery abilities was the main goal. An explorative experiment was conducted in which the creative imagery abilities of blind and

sighted were measured to test the instrument. First, it was qualitatively analysed whether the sensory modality of the stimuli influenced the sensory modality of the creative mental representations. Then, the Fantasy Questionnaire was quantitatively analysed to see whether the proneness to fantasy differed between the three conditions (i.e. sighted/visual, blind/tactile, and sighted/tactile) and the outcome was included in the analysis of the TCIA-2 as covariate. The difference between sighted and blind people on creative imagery abilities was exploratively examined, by quantitatively analysing the TCIA-2 which was supported with results of the thematic analysis of the descriptions of the creative mental representations of the participants. The thematic analysis helped to better understand the results found between blind and sighted people on their creative imagery abilities.

5.1. Sensory Modalities of the Mental Representations

A thematic analysis has been performed to gain an indication whether the sensory modality of the stimuli (visual or tactile) influences the sensory modality of the creative mental representations. According to hypothesis 1, blind people would probably give more tactile and auditory details in their descriptions of their creative mental imagery, while it is expected that sighted people will probably give more visual details. In addition, it was expected that blind people use their body as reference and would therefore mention more objects or events that can be explored by touch while sighted people would mention more things that can be explored by sight, like sceneries and landscapes.

5.1.1. Qualitative Analysis

The transcripted statements of the participants in the description phase of the TCIA-2 have been analysed using the coding scheme which can be found in appendix A. To compare the three conditions, the results of the thematic analysis were partly quantified. In addition, it should be

noted that the inter-rater reliability of the thematic analysis was rather low. This means that the results discussed in this section should be interpreted carefully.

5.1.1.1. Descriptions of objects and/or surroundings. Table 7 shows how often a code was assigned to a description of a creative mental representation by a number of different participants across the three conditions. 'Total' stands for the total amount of creative mental representations that were described by a condition and how many participants were assigned to a particular condition. The codes mentioned in Table 7 are explained in the corresponding sections below.

The results of the analysis, displayed in Table 7, shows that in 36.3% of the creative mental representations of 11 different participants in the sighted/visual condition (17 participants in total), a description of a background or a description of the surroundings was given. The code 'background' was defined as a description in which not only the object in which the initial figure is incorporated, but also other objects or surroundings are described in which the original graphic is not incorporated. An example, given by a participant which contained a description of a background/surroundings, was as follows: *"Okay, well, I see a kind of tent camp with all those native Americans who are around a circle of fire and then they are somewhere in Canada with those mountains and uh maybe a lake in the distance and that dot is kind of ehh… entrance to the tent but it might have to be a bit bigger actually and then ehh... there is a mother with those braids and eh yes then eh they have a bit of a life there for it uh- it really is a typical wigwam tent."*. In the blind/tactile condition, only one creative mental representation (1.9%) contained a description of a background/surroundings. Twelve different participants in the sighted/tactile condition gave a description of a background/surroundings in 23.2% of the creative mental

Table 7

Quantified Results of the Quantitative Thematic Analysis of the Idea Generation Phases and Description Phases

	Sighted/visual		Blind/tactile		Sighted/visual	
	Assignment of the code (in %)	Amount of different participants	Assignment of the code (in %)	Amount of different participants	Assignment of the code (in %)	Amount of different participants
Total	102	17	54	9	108	18
Background/surroundings*	36.3%	11	1.9%	1	23.2%	12
Object	18.6%	9	31.5%	6	15.7%	9
Metaphorical/symbolic**	2.9%	2	18.5%	3	0%	0
Colour	19.6%	10	3.7%	1	13.9%	9

Note. * Statistically significant difference between blind/tactile and sighted/tactile (p = 0,028) ** Statistically significant difference between both blind/tactile and sighted/visual (p = 0,022), and blind/tactile and sighted/tactile (p = 0,005)

representations. It turned out that there was a statistically significant difference between the blind/tactile condition and the sighted/tactile condition.

An ‘object’ was defined as a creative mental representation in which only one object, in which the original graphic was incorporated, is described. A description of a single object in the creative mental representations like the following *“I would make the field much bigger and move the tip more to the left so that it connects a bit more to a bird's beak eh then I go to the left eh then I do such a crazy eh peacock eh peacock head, but it has a long neck this bird eh let's have a look (pause) eh yes the colors are eh a little magenta and then yellow (int: laughter) eh it kind of has a swan body eh (pause) yes the tail is eh is more like a peacock”,* occurred equally often

in each condition. There seemed not to be a significant difference between the three conditions (see Table 7).

Another notable difference was seen in the amount of metaphorical and/or symbolic ideas generated by the different conditions. Metaphorical or symbolic ideas were defined as ideas that did not really represent a tangible idea, so did participants generate the idea of *"security"* for graphic 6 (see Figure 3) or *"[...] cutting the week in half [...]"* for graphic 5. The analysis showed that participants in the blind/tactile condition generated more metaphorical/symbolic ideas than participants in the sighted conditions.

5.1.1.2. Visual details versus tactile details. It was expected that blind people would probably give more tactile and auditory details in their descriptions of their creative mental representations as they would be formed by their dominant senses of touch and hearing. One participant in the blind/tactile condition mentioned the following during the experiment: *"If I just see something, then I think: what can you do with this? I am going to fill this whole box [...]."* and *"I do not visualize this, I think it. My visualization is in my fingers actually, I notice as I go along. [...]"*. Those statements suggest that the participant did not create any visual mental representation but that their mental representations were formed in another sensory modality. Later, the same participant showed some tactile details in their descriptions of their creative mental representations: *"[...] the top line is circular and in the middle it borders on the mark that is already there, the small drawings and I will also fill them with the same sandpaper and then I place it all the way to the right."* This participant was the only one who explicitly mentioned that the figures were not visually imagined. A second blind participant also mentioned tactile details in the descriptions of the creative mental representations, like *"I somehow feel a heat and I have the feeling that it warps because of the heat, that it expands [...]"*. Those two participants were

the only two mentioning tactile details which makes it difficult to say that the mental representations of blind participants contain more tactile details than those of sighted participants. However it should be noted that none of the sighted participants in the two other conditions mentioned any tactile details in their creative mental representations.

It was expected that sighted people would give more visual details in their descriptions of their creative mental representations than blind people as their mental representations would be formed by their dominant sense of sight. Colour can be seen as one of those visual details. An example of a description of a creative mental representation of one the participants containing colour was as follows: *"I think I will go for the cake that is rising in the oven. What I see before me is that it is in one of those metal tins in the oven and that you have a little red light from the oven lights [...]".* The results showed that there was no statistically significant difference in the amount colour in the descriptions of the creative mental representations between the three conditions.

The results of the qualitative analysis seem to be in line with hypothesis 1. The creative mental representations of blind participants seem to contain more tactile details and more low-imagery entities than those of sighted participants. The creative mental representations of sighted participants seem to contain more high-imagery entities, like a description of the background around the main object. However there seems to be no difference in the amount of visual details between the blind and sighted participants.

5.2. Proneness to Fantasy

To investigate whether participants in one condition were more prone to fantasy than the participants in the other conditions the Fantasy Questionnaire was conducted. A one-way between groups analysis of variances (ANOVA) was conducted to analyse the responses.

Inspection of the skewness, kurtosis and normality statistics indicated that the assumption of normality was supported for each of the three conditions. Levene's statistic was non-significant, $F(2,41) = .66$, $p = .522$, and thus the assumption of homogeneity of variance was not violated. As the assumptions were all met, a one-way between groups ANOVA was conducted. The ANOVA indicated that there were statistically significant differences between the three conditions in proneness to fantasy, $F(2, 41) = 3.93$, $p = .028$, $\eta^2 = .16$. Post-hoc tests were conducted to identify which condition differed from the others.

As a post-hoc test, Gabriel's procedure was used because it has greater statistical power when group sizes are unequal. Post-hoc analyses with Gabriel's procedure revealed that the sighted/visual condition ($M = 3.43$, $SD = .52$) was significantly more prone to fantasy than the sighted/tactile condition ($M = 2.93$, $SD = .62$). However there was no significant difference between the sighted/visual condition and the blind/tactile ($M = 3.33$, $SD = .47$), nor between the sighted/tactile condition and the blind/tactile condition. Effect sizes for these three comparisons were $d = .84$, .15 and .55 respectively.

The only difference was found between the sighted conditions, where the sighted/visual condition was more prone to fantasy than the sighted/tactile condition. The results of the Fantasy Questionnaire were used as covariate in the TCIA-2 to see whether the proneness of fantasy had influence on the creative imagery abilities.

5.3. Effect of Visual Acuity on Creative Imagery Abilities

5.3.1. Quantitative Analysis

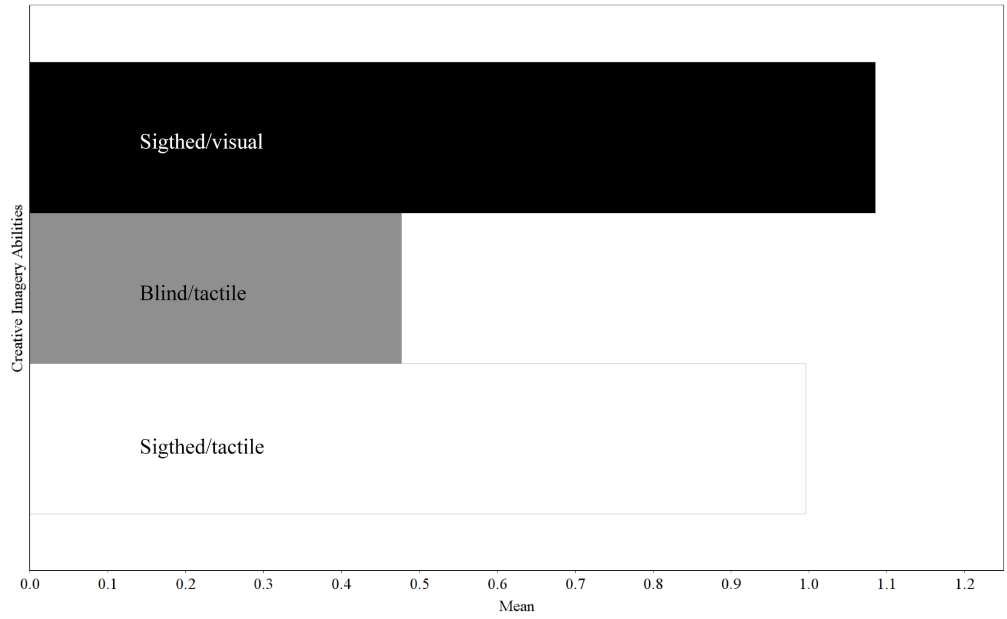
A one-way analysis of covariance (ANCOVA) was used to compare the creative imagery abilities of participants in the three conditions. A covariate was included to partial out the effects of proneness to fantasy and age from the analysis. Examination of the normality of each

condition indicated that the ANCOVA assumption of normality was supported. Scatterplots indicated that the relationship between the covariates and the dependent variable (creative imagery abilities) were linear. Finally, the assumptions of homogeneity of regression slopes and homogeneity of variances were supported as well.

The ANCOVA indicated that, after accounting for the proneness to fantasy and age, there was a statistically significant effect of visual acuity on creative imagery abilities, F (2, 39) = 9.53, $p < .001$, partial $\eta^2 = .331$. Both the proneness to fantasy ($p = .110$) and the age of the participant ($p = .848$) seemed not to be significantly related to creative imagery abilities. Post-hoc testing revealed that the blind/tactile condition reported lower creative imagery abilities than the sighted conditions. There were no significant differences between the sighted/visual and sighted/tactile conditions (see Figure 4).

Figure 4

Means of Creative Imagery Abilities of the Three Conditions after Controlling for the Proneness to Fantasy and Age.



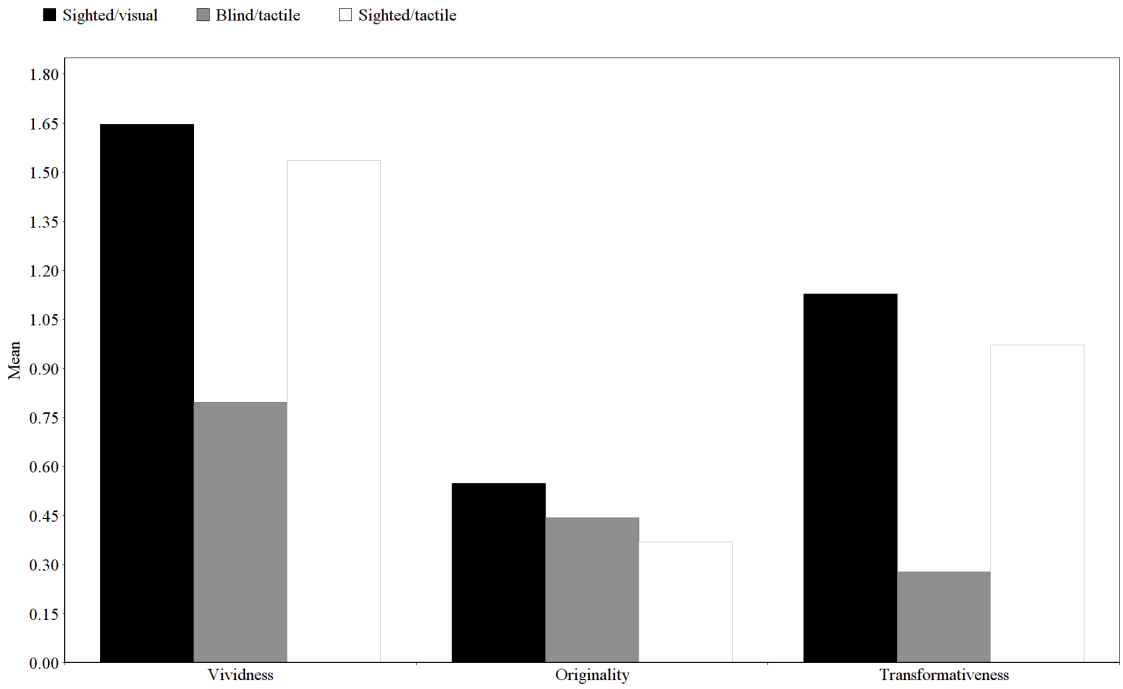
As the creative imagery abilities were measured through the three different constructs of vividness, originality, and transformativeness, it was decided to analyse each construct separately between the three conditions. Taking a closer look into the constructs of creative imagery abilities enabled us to identify where the difference between the blind and sighted conditions lie and to support the findings of the quantitative analysis with the results of the qualitative thematic analysis. Note that the analyses of the constructs are explorative analyses and the results should be interpreted carefully.

5.3.2. Effect of Visual Acuity on the Vividness of the Creative Mental Representation

5.3.2.1. Quantitative analysis. Three other ANCOVAs were conducted with each of the three constructs of creative imagery abilities separately as dependent variables. The first ANCOVA analysed the differences between the three conditions on the construct of vividness. Vividness was defined as the ability to create expressive images characterized by high complexity, like metaphorical and symbolic content, and a high level of detail. It was expected that when visual mental representations are elicited from the graphics, they will be more vivid for sighted participants and that tactile mental representations elicited from the graphics are more vivid for blind participants. As it was also expected that the mental representations of both blind and sighted people are formed by their dominant senses (auditory and tactile for blind people and visual for sighted people), no difference in the vividness of the mental representations was foreseen. The ANCOVA indicated however, after accounting for the proneness to fantasy and age, that there was a statistically significant effect of visual acuity on the vividness of the creative mental representations, $F(2, 39) = 4.81$, $p = .014$, partial $\eta^2 = .198$ (see Figure 5). Post-hoc testing revealed that the blind/tactile condition reported lower vividness than the sighted conditions. There was no significant difference between the two sighted conditions.

Figure 5

Means of the Three Construct of Creative Imagery Abilities of the Three Conditions after Controlling for the Proneness to Fantasy and Age.



5.3.2.2. Qualitative analysis. Table 8 is similar to Table 7 and shows how often a code was assigned to a description of a creative mental representation by a number of different participants across the three conditions. 'Total' stands for the total amount of creative mental representations that were described by a condition and how many participants were assigned to a particular condition. The codes mentioned in Table 8 are explained in the corresponding sections.

As mentioned, a high level of vividness was characterised by the ability to create expressive images characterized by high complexity, like metaphorical and symbolic content, and a high level of detail (see Appendix C) (Jankowska & Karwowski, 2015a). An example of a vivid creative mental representation that was described by one of the participants was as follows:

Table 8

Quantified Results of the Quantitative Thematic Analysis of the Idea Generation Phases and Description Phases

	Sighted/visual		Blind/tactile		Sighted/visual	
	Assignment of the code (in %)	Amount of different participants	Assignment of the code (in %)	Amount of different participants	Assignment of the code (in %)	Amount of different participants
Total	102 (100%)	17	54 (100%)	9	108 (100%)	18
Detail	32.4%	11	9.3%	3	18.5%	9
Metaphorical/symbolic*	2.9%	2	19%	3	0%	0
Originality - ordinary	14.7%	8	16.7%	6	15.7%	12
Originality - fantastical	14.7%	11	1.9%	1	8.3%	6
Rotate/tilt figure**	43.1%	16	9.3%	2	18.5%	9

Note. * Statistically significant difference between both blind/tactile and sighted/visual (p = .022), and blind/tactile and sighted/tactile (p = .005)

** Statistically significant difference between both sighted/visual and blind/tactile (p = .003), and sighted/visual and sighted/tactile (p = .011)

"I choose the planetarium because I always liked it very much in the past. So I would turn it a quarter turn to the right and I would place seats that are a bit in a reclining position so that you can really look at the ceiling. Yes and on that dome, while you are lying in that chair, so I think I would also draw all people in the chairs, but maybe make a bit of perspective in it, making it into the whole, so that you I also see what is projected on that dome. And a nice film is then projected over a starry sky again, so I would draw stars on it".

Quantifying the results of the thematic analysis shows that there was no difference in the amount of details in the creative mental representations of blind and sighted participants. Next, it was already mentioned that a difference was noticed in the amount of metaphorical and/or symbolic ideas generated by the different conditions. The analysis shows that participants in the blind/tactile condition generated more metaphorical/symbolic ideas than the sighted condition. The result of the qualitative analysis therefore does not seem to support the results found in the quantitative analysis, that the creative mental representations of sighted participants are more vivid than the creative mental representations of the blind participants.

5.3.3. Effect of Visual Acuity on the Originality of the Creative Mental Representation

5.3.3.1. Quantitative analysis. The second ANCOVA analysed the construct of originality. It was hypothesised that there is no difference in originality between the mental representations of blind and sighted people (hypothesis 2c). The ANCOVA indicated, after accounting for the proneness to fantasy and age, that there was no statistically significant difference on the construct of originality between the three conditions, F (2, 39) = .63, p = .538, partial η^2 = .031 (see Figure 5) and is thus in line with the hypothesis

5.3.3.2. Qualitative analysis. Originality was defined as the ability to produce new and unique images showing new objects and activities. This was reflected in the coding scheme (see Appendix A) which divided originality into three categories: ordinary, metaphorical/symbolical, and fantastical. Metaphorical and symbolic ideas were already mentioned earlier. 'Ordinary' was defined as ideas or objects that can be encountered daily. An example of ordinary ideas that were given by a participant were *"a ski slope ... ehm a whale ... hmm ... a car ... hmm ... I see those two dots as eyes now and can't see anything else [laughter] ... hmm kind of eh seesaw".* 'Fantastical' was defined as ideas or objects that are rarely encountered. A description of a

fantastical scene given by one of the participants contained *"a war path, barbed wire on the side eh you have to go under barbed wire through the mud path ehm there are false dogs on the side eh... you have to cross a river also but there is a crazy goat man you have to pay a toll before you can pass it but you are 10 seconds faster than if you would take the normal path."*.

The qualitative analysis showed no difference between the three conditions on the occurrence of both the 'ordinary' and 'fantastical' code (see Table 8). These results are in line with the results of the quantitative analysis.

5.3.4. Effect of Visual Acuity on the Transformativeness of the Creative Mental Representation

5.3.4.1. Quantitative analysis. The third ANCOVA analysed the construct of transformativeness which was defined as the ability to transform the perceived initial image to something creative using cognitive operations such as multiplication, distortion or amplification. It was expected that it takes more effort for blind people to transform mental representations than sighted people. The ANCOVA indicated, after accounting for the proneness to fantasy and age, that there was a statistically significant effect of visual acuity on the transformativeness of the creative mental representations, $F\,(2, 39) = 28.54$, $p < .001$, partial $\eta^2 = .594$ (see Figure 5). Post-hoc testing revealed that the blind/tactile condition reported lower transformativeness than the sighted conditions, even after controlling for proneness to fantasy and age. There was no significant difference between the two sighted conditions.

5.3.4.2. Qualitative analysis. A way of transforming the initial graphic is to rotate or tilt it which was one of the codes in the coding scheme of the qualitative thematic analysis. The quantified results of the qualitative analysis revealed that there was a statistical significant difference in rotating the initial figure between the three conditions. Post-hoc testing showed that

participants in the sighted/visual conditions significantly more often rotated the initial figure in their creative mental representations than participants in the tactile condition. As the sighted/tactile condition did not differ significantly from the blind/tactile condition, it seems that the sensory modality of the stimuli may influence the ability to mentally rotate the initial figure (see Table 8).

6. Conclusion and Discussion

6.1. Conclusion

Imagination plays a role in many cognitive processes (e.g. MacInnis & Price, 1987; Martin et al., 1999; LeBoutillier & Marks, 2003) and is therefore an important aspect in our daily lives. Despite this importance, little research has been conducted on the imagination of blind people. The aim of this study was to explore the possibility of developing an instrument that is able to compare the creative imagination of blind and sighted people.

A modality-independent instrument was developed after looking at theories of creative imagination and investigating existing instruments. The developed instrument was used to measure the creative imagery abilities of blind and sighted people in an experimental study. Participants perceived a simple graphic from which they had to generate as many ideas as possible. From those ideas they chose one idea that they were allowed to develop in a creative way. Those creative mental representations were expressed through a spoken description which were then assessed on three constructs, namely vividness, originality and transformativeness. Three groups were compared in the experiment to gain a first insight into the differences in creative imagination between blind and sighted people. Sighted individuals who perceive a visual graphic, blind individuals who perceive a tactile graphic and blindfolded sighted individuals perceiving a tactile graphic.

It was expected that the sensory modality of the stimuli would not influence the mental representation of the graphic because mental representations are mainly formed by the dominant senses of the person (auditory and tactile for the blind, visually for the sighted) (Cattaneo & Vecchi, 2011). The results of the qualitative analysis were partly in line with hypothesis 1 as the mental representations of blind participants contained more tactile details than those of sighted participants and an equal amount of visual details. It thus seems that visual acuity affects the modality of the mental representation. It should, however, be noticed that the inter-rater reliability of the qualitative analysis was rather low so the results should be interpreted carefully.

Next, it has been investigated whether the modality of the mental representation influences creative imagination with the use of the developed instrument. The results of the quantitative analysis showed that the blind participants had lower creative imagery abilities than the sighted participants. The creative imagery abilities did not differ significantly between the sighted participants perceiving either a visual or tactile graphic. This was in line with hypothesis 2d. The quantitative analysis is exploratory, as it was the first time that the newly developed instrument was used to measure creative imagination. The results should therefore be interpreted carefully. To better understand the difference between blind and sighted participants on their creative imagery abilities, the three constructs of creative imagery abilities were further explored.

The results showed that the vividness of the descriptions of the creative mental representations of the blind people were significantly lower than that of the sighted people while no difference was expected (hypothesis 2a). The results of the qualitative analysis showed different results as the blind/tactile condition generated more metaphorical/symbolic ideas than the sighted condition. In addition, an equal amount of details was found in the descriptions of both blind and sighted participants.

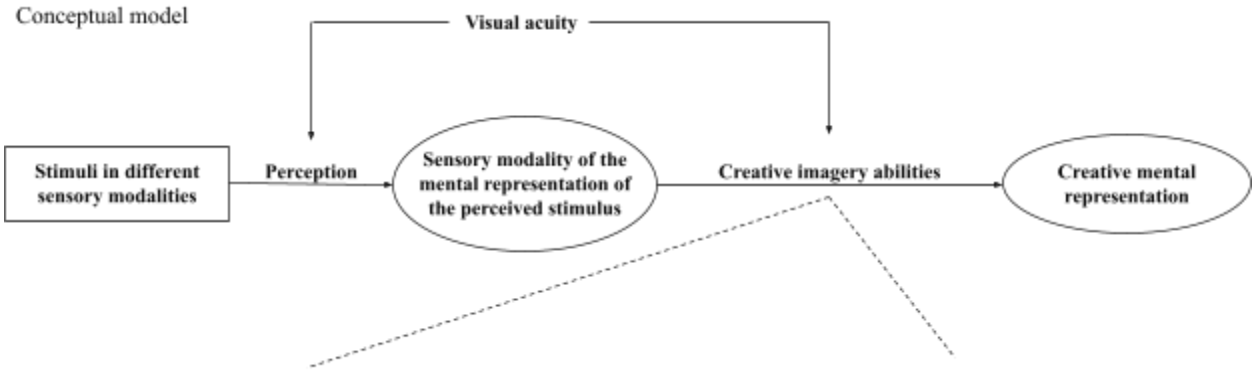
It was hypothesised (hypothesis 2b) that blind people would score less on the transformativeness of their mental representations than sighted people as it takes more effort for blind people to transform their mental representations compared to sighted people (Marmor & Zaback, 1976; Millar, 1976; Röder, Rösler, & Hennighausen, 1997). The results of the quantitative analysis showed that the transformativeness of the creative mental representations of the blind people was significantly lower than that of the sighted people. Those results suggest that visual acuity influences the transformativeness of a creative mental representation. This was partly supported by the quantified results of the qualitative analysis which showed that the sighted/visual condition significantly more often rotated the initial figure in their mental representations than the tactile conditions.

It was hypothesised that there would be no difference in originality between the mental representations of blind and sighted people (hypothesis 2c). The results of the quantitative analysis were in line with hypothesis 2c, and showed that there was no difference in the originality of the descriptions between the three conditions. The result of quantitative analysis was supported by the findings of the qualitative analysis which showed a similar amount of ordinary ideas as well as fantastic ideas across the three conditions.

The mental representations of the perceived stimulus is influenced by the visual acuity of the participant as the mental representation of a blind person would have more tactile details while those of a sighted person would be more picture-like. Visual acuity seems to influence the creative imagery abilities of a person directly and indirectly, through the sensory modality of the mental representation. These relations are shown in the conceptual model (Figure 6). The results of the quantitative analysis are shown in the figure as well and should be interpreted carefully as it was the first time that the developed measurement instrument was used to compare creative

Figure 6

Conceptual Model Including the Means on Creative Imagery Abilities and its Constructs



	Sighted/visual	Blind/tactile	Sighted/tactile
Creative imagery abilities	1.085	0.477*	0.996
Vividness	1.647	0.796*	1.537
Originality	0.549	0.444*	0.370
Transformativeness	1.128	0.278*	0.972

imagery abilities of blind and sighted participants. The significant differences are indicated with a *.

It should be noted that the relationship between visual acuity and the sensory modality of the mental representation has not been confirmed statistically, however qualitative analysis suggests that there is a relationship between the two which was also mentioned by Cattaneo and Vecchi (2011). If it is assumed that the newly developed instrument is valid, this study suggests that there is a difference between blind and sighted people regarding their creative imagery abilities. This result is further discussed in the next section.

6.2. Discussion

The research question: "*Is it possible to measure the creative imagination of blind and sighted people with the same measurement instrument and therefore enable the comparison of both groups?"* can only partially be answered with the results of this study. The results seem to

show that it is possible to measure and compare the creative imagery abilities of sighted and blind individuals with a modality independent instrument. However there are still uncertainties to definitely draw this conclusion. First, the developed instrument has not been validated. Secondly, although the sensory modality of the stimulus does not appear to influence the sensory modality of the mental representations but is mainly influenced by the participant's visual acuity, the modality of the stimulus may have had an effect on the transformativeness of the mental representations. Lastly, the little research that has been done on the creative imagination of blind people makes it difficult to compare the findings of this study to previous studies.

If it is assumed that the developed instrument is valid, the results of the experiment suggest that blind people have lower creative imagery abilities than sighted people. This can be explained by the constructs of vividness and transformativeness on which blind participants scored significantly lower than sighted participants. No differences were found on the construct of originality between the creative mental representations of the three conditions. The sensory modality of the mental representation seems thus to influence the creative imagery abilities.

6.2.1. Vividness

Lower scores on the construct of vividness for the creative mental representations that were expressed by participants in the blind/tactile condition mean that the creative mental representations of blind participants were less expressive representations than those of sighted participants. Expressive representations are characterized by high complexity, like metaphorical and symbolic content, and a high level of detail.

A logical explanation of this difference would be the absence of the visual sense. Studies have shown that the vividness of visual mental representations is higher than mental representations in other sensory modalities for sighted people (Schifferstein, 2009; Switras,

1978) and Campos (2004) showed that for a person who lost sight, auditory and haptic mental representations are more vivid than visual mental representations. However, mental representations do not have to appear in one sensory modality only (Struiksma et al., 2009). For example, when one imagines a sun, not only the color of the sun can be imagined but also the feeling of the heat of the sun. As blind people may not have visual experience, or their visual experience was gained a long time ago, their mental representations may contain no or less visual details. Sighted people may more easily add visual details to their mental representations because of recent visual experiences in addition to details related to other sensory modalities which may make their mental representations more vivid than those of blind people. However, other studies have shown that the loss of one of the senses may result in cross modal plasticity phenomena, that is the ability of the brain to reorganize and make functional changes to compensate for a sensory deficit (Cohen et al. 1999). It should however be noted that the susceptibility of the brain to compensate for a sensory deficit reduces enormously after puberty (Cohen et al. 1999). The average age of the blind participants was 20.8 when they lost sight, which may indicate that the cross modal plasticity phenomena occurred to a lesser extent. This could have resulted in lower vividness scores for the blind participants as their loss of sight was not optimally compensated.

The results of the qualitative analysis contradict the results of the quantitative analysis as it shows that blind participants mentioned more metaphorical and symbolic details in their creative mental representations than sighted participants. This difference could be explained by the study of Cornoldi et al. (1979). They showed that low-imagery or abstract words (e.g. damage) were rated higher on vividness by blind people in comparison to sighted people. Because they imagine low-imagery words more vividly, it may also be easier to imagine metaphorical and symbolic details as they are of a low-imagery character as well.

More research seems needed to better understand the influence of visual acuity on the vividness of creative imagination. According to previous research there seem to be differences in reproductive imagination across sensory modalities of the mental representations, and between low- and high imagery words (Campos, 2004; Cornoldi et al., 1979; Schifferstein, 2009; Switras, 1978). However no studies investigated the differences in vividness of creative imagination between blind and sighted individuals.

6.2.2. Transformativeness

Lower scores on the transformativeness of the creative mental representations that were expressed by the blind/tactile condition mean that the perceived initial graphic was less often transformed to something creative using cognitive operations such as multiplication, distortion or amplification. Those results were in line with the hypothesis that blind people score less on the transformativeness of their mental representations than sighted people because it takes more effort for blind people to transform their mental representations (Marmor & Zaback, 1976; Millar, 1976; Röder et al., 1997).

Another explanation that could explain lower scores on transformativeness is the modality of the mental representations. Studies have shown that blind people have more difficulties in experiencing 2D representations than sighted people as they are not familiar to them (Heller, 2006; Millar 1975, 1991). Eardley and Pring (2006) also found that blind people were less successful in generating representations in two dimensions than in three dimensions. The tactile graphics were perceived in 2.5D (i.e. enhancing a 2D image by raising lines) which may have made it more difficult for blind participants to generate mental representations of the graphic than for sighted participants even when they are blindfolded. This is supported by the findings of Ballesteros and Reales (2004) who showed that even sighted people are more

effective in identifying objects in three dimensions than in two dimensions when they cannot visually perceive the object and may also explain the results found in the qualitative analysis. The results of the qualitative analysis show that the sighted/visual condition rotated the initial graphics significantly more often than the tactile conditions and that there was no difference between both tactile conditions. Despite the earlier observations that the sensory modality of the stimulus seemed not to influence the sensory modality of the mental representation, the sensory modality of the stimuli may have influenced the transformativeness of the creative mental representations of the participants. In further development of the newly developed measurement instrument, the modality in which the stimuli is displayed should therefore be reviewed.

6.2.3. Implications of lower creative imagery abilities

The results of the quantitative analysis indicated that blind participants had lower creative imagery abilities than sighted people. Lower creative imagery abilities, may indicate more difficulties in various cognitive processes. Imagination has shown to be beneficial for experiencing empathy (Gaesser & Schacter, 2014), envisioning the future (Wilson & Gilbert, 2005) and has a big share in the learning process because imagination helps to form relations between two distinct concepts (Klottrup & Egan, 1992). Low abilities in creative imagination may thus indicate that one could have difficulties in envisioning future events, showing empathy, learning new things, and, more superficial, creating new concepts.

For example, research that investigated the relationship between visual acuity and cognitive functioning shows that visual impairment was associated with declining cognitive function (Baltes & Lindenberger, 1997; Salthouse, 2015), with worsening vision having a stronger association with declining cognition as showed in a longitudinal study (Zheng et al., 2018). However, those studies have not been able to explain the relationship between visual

acuity and cognitive decline. Creative imagination may explain this relationship, as creative imagination is shown to play an important role in the learning process (Egan, 1992). This example shows that future research into the creative imagery abilities of blind individuals may help us better understand differences between sighted and blind people in various cognitive processes.

6.2.4. Quantitative and qualitative approach

In this study, the creative mental representations were analysed both quantitatively and qualitatively to better understand the differences between the three conditions. The creative mental representations may vary widely and are for each participant unique. The qualitative approach was useful to identify the modalities and details of the mental representations while the quantitative approach made it easier to compare the different conditions on their representations despite the various descriptions. Therefore it is recommended to analyse the creative mental representations both quantitatively and qualitatively when comparing groups of people in future studies.

6.2.5. Limitations and Future Research

This study was the first to compare blind and sighted people on creative imagination and shows that there is still much unknown about the relationship between visual acuity and creative imagination and more research is needed to be able to get a clearer picture of the differences between sighted and blind people in creative imagination.

6.2.5.1. Reliability and validity. The inter-rater reliability of both the qualitative and quantitative analysis was low. Therefore the results of this study should be handled carefully. The low inter-rater reliability could be attributed to the inexperience of the second raters, and the lack of time which could otherwise be used to train the second raters. Also, the assessment criteria

and the coding scheme could have been defined better. The original assessment criteria of the TCIA (Jankowska & Karwowski, 2015a) were used to assess the drawed creative mental representations on the three constructs. The assessment criteria may have been less applicable to the spoken descriptions used in the present study, even though none of the criteria specifically applied to drawings. The researcher of the present study could not get hold of the manual that was compiled by Jankowska & Karwowski (2015b) for the judges that assessed the drawings. A future study may inform this document to get better insight into the assessment of the creative mental representations and to make adjustments to the criteria so they are better applicable to spoken descriptions. In case of the qualitative data, it was noticed that, even after the second round of analysis, the main codes 'originality' and 'associations' were often reversed. A better definition of the codes should help to improve the inter-rater reliability.

A reason that could harm the internal validity of the results is a selection bias, as the age difference between the conditions is substantial. Age can influence the imagination. Vygotsky (2004) mentions that after puberty, when the developments of imagination and reason come together, the development of imagination falls rapidly and reason takes over. The participants in the blind/tactile condition were older than the participants in the sighted conditions. This may have influenced the results, despite controlling for age in the quantitative analysis. Future research on creative imagination should have similar groups of participants in terms of age.

It is recommended to look at the concurrent validity, by testing the correlation between the newly developed instrument and the original TCIA. The original TCIA has shown to be an instrument with good psychometric properties by studying the validity and reliability of the TCIA (Jankowska & Karwowski, 2015). Investigating the concurrent validity of the two measures may indicate the validity of the newly developed instrument.

6.2.5.2. Effect of the sensory modality of the mental representation on creative imagination. Despite the differences found between blind and sighted people on creative imagery abilities, a closer examination of the influence of the sensory modality of the mental representation of the stimulus on creative imagery abilities is needed. As the sensory modality of the mental representation seems to be influenced by the visual acuity of the participant (Cattaneo & Vecchi, 2011), visual acuity may not only directly affect creative imagery abilities but also indirectly.

A next study could try to assess creative mental representations that were created with a different sensory modality of a mental representation in mind. For example, a person is asked to think of a certain smell, which then has to be completed with unrestricted elements, changed and developed so something even more unusual is created. A similar approach is taken with a different sense and the expressed descriptions can be compared. This study could give an indication of the influence of the sensory modality of a mental representation on creative imagery abilities without being influenced by visual acuity.

6.2.5.3. Modality of the stimuli. It was suggested earlier in this study that the 2.5D modality of the tactile graphics may have influenced the creative imagery abilities of the participant. Another reason to review tactile graphics is that they are mainly used to assist blind participants in daily activities, like tactile maps to help blind people find their way (e.g. Holloway et al., 2018) and tactile textbook figures to explain difficult concepts in the STEM (Science, Technology, Engineering, and Mathematics) domain (e.g. Jayant et al., 2007). In this study, however, they were used to elicit creative mental representations which may be an unfamiliar purpose of a tactile graphic for a blind person. One of the participants often participated in experiments that assessed the quality of the tactile graphics which made it

difficult to come up with creative ideas. The normally, informative goal of tactile graphics may raise the question whether they are suitable to elicit creative mental representations.

6.2.6. Take-home message.

A first insight has been given on the differences between blind and sighted people on their creative imagery abilities. This explorative study seems to indicate that it is possible to measure and compare blind and sighted people on creative imagination with a modality-independent instrument. The first results suggest that the creative imagery abilities of blind individuals are lower than those of sighted people, as the blind participants scored lower on the constructs of vividness and transformativeness.

Despite these promising initial findings, there is still a lot unclear about the causations of the lower creative imagery abilities of blind people. More research is not only needed into the influence of the sensory modality of the mental representation on creative imagery abilities but also further investigations on the role of visual acuity in this process. Further research on the difference between blind and sighted people on creative imagination can help to find explanations for differences in other cognitive processes between both groups. Those explanations can be used to design targeted interventions to improve the abilities of either blind or sighted individuals.

7. References

Aleman, A., van Lee, L., Mantione, M. H. M., Verkoijen, I. G., & de Haan, E. H. F. (2001). Visual imagery without visual experience: evidence from congenitally totally blind people. *Neuroreport*, *12*(11), 2601–2604. https://doi.org/10.1097/00001756-200108080-00061

Amabile, T. M. (1988). A model of creativity and innovation in organizations. Research in Organizational Behavior, 10, 123–167.

Ballesteros, S., & Reales, J. M. (2004). Visual and Haptic Discrimination of Symmetry in Unfamiliar Displays Extended in the z-Axis. *Perception*, *33*(3), 315–327. https://doi.org/10.1068/p5017

Baltes, P. B., & Lindenberger, U. (1997). Emergence of a powerful connection between sensory and cognitive functions across the adult life span: A new window to the study of cognitive aging? *Psychology and Aging*, *12*(1), 12–21. https://doi.org/10.1037/0882-7974.12.1.12

Beghetto, R. A., & Kaufman, J. C. (2010). Nurturing creativity in the classroom. New York, NY: Cambridge University Press. http://dx .doi.org/10.1017/CBO9780511781629

Campos, A. (2004). The Vividness of Imagery in a Person who has been Blind for Three Years. *Journal of Visual Impairment & Blindness*, *98*(5), 309–313. https://doi.org/10.1177/0145482x0409800506

Cattaneo, Z., & Vecchi, T. (2011). *Blind Vision*. Amsterdam University Press.

Chaturvedi, S. R. B. H., & Shweta, R. C. (2015). Evaluation of inter-rater agreement and inter-rater reliability for observational data: an overview of concepts and methods. Journal of the Indian Academy of Applied Psychology, 41(3), 20-27.

Clarke, V., & Braun, V. (2016). Thematic analysis. *The Journal of Positive Psychology*, *12*(3), 297–298. https://doi.org/10.1080/17439760.2016.1262613

Cohen, L. G., Weeks, R. A., Sadato, N., Celnik, P., Ishii, K., & Hallett, M. (1999). Period of susceptibility for cross-modal plasticity in the blind. Annals of Neurology, 45(4), 451–460. https://doi.org/10.1002/1531-8249(199904)45:4<451::aid-ana6>3.0.co;2-b

Cornoldi, C., Calore, D., & Pra-Baldi, A. (1979). Imagery Ratings and Recall in Congenitally Blind Subjects. *Perceptual and Motor Skills*, *48*(2), 627–639. https://doi.org/10.2466/pms.1979.48.2.627

Dedicon (n.d.) Over Dedicon. Retrieved on 30-10-2020 from https://www.dedicon.nl/over-dedicon

Dziedziewicz, D., & Karwowski, M. (2015). Development of children's creative visual imagination: a theoretical model and enhancement programmes. *Education 3-13*, *43*(4), 382–392. https://doi.org/10.1080/03004279.2015.1020646

Eardley, A. F., & Pring, L. (2006). Remembering the past and imagining the future: A role for nonvisual imagery in the everyday cognition of blind and sighted people. *Memory*, *14*(8), 925–936. https://doi.org/10.1080/09658210600859582

Easton, R. D., Greene, A. J., & Srinivas, K. (1997a). Transfer between vision and haptics: Memory for 2-D patterns and 3-D objects. *Psychonomic Bulletin & Review*, *4*(3), 403–410. https://doi.org/10.3758/bf03210801

Easton, R. D., Srinivas, K., & Greene, A. J. (1997b). Do vision and haptics share common representations? Implicit and explicit memory within and between modalities. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(1), 153–163. https://doi.org/10.1037/0278-7393.23.1.153

Egan, K., & Judson, G. (2009). Values and Imagination in Teaching: With a Special Focus on Social Studies. *Educational Philosophy and Theory*, *41*(2), 126–140. https://doi.org/10.1111/j.1469-5812.2008.00455.x

Feng, Z., Logan, S., Cupchik, G., Ritterfeld, U., & Gaffin, D. (2017). A Cross-Cultural Exploration of Imagination as a Process-Based Concept. *Imagination, Cognition and Personality*, *37*(1), 69–94. https://doi.org/10.1177/0276236617712006

Gaesser, B., & Schacter, D. L. (2014). Episodic simulation and episodic memory can increase intentions to help others. *Proceedings of the National Academy of Sciences*, *111*(12), 4415–4420. https://doi.org/10.1073/pnas.1402461111

Galton, F. (1880). Statistics of mental imagery. Mind 5, 301–318. doi: 10.1093/mind/os-V.19.301

González, M. A., Campos, A., & Pérez, M. J. (1997). Mental Imagery and Creative Thinking. *The Journal of Psychology*, *131*(4), 357–364. https://doi.org/10.1080/00223989709603521

Grebot, E., & Paty, B. (2005). The Subcapacities of Imagery and Suggestibility. The Role of Three Subcapacities (Vividness, Controllability, and Stability) of Mental Imagery (Visual, Auditory, and Somesthetic) in Two Dimensions of Suggestibility (Ideational and Involuntary Motricity). Bulletin de psychologie, (5), 549-565. https://doi.org/10.3917/bupsy.479.0549

Guilford, J. P. (1950). *Creativity*. Am. Psychol. 5, 444–454. doi: 10.1037/h0063487

Halpin, G., Halpin, G., & Torrance, E. P. (1973). Effects of blindness on creative thinking abilities of children. *Developmental Psychology*, *9*(2), 268–274. https://doi.org/10.1037/h0035159

Hassabis, D., Kumaran, D., & Maguire, E. A. (2007). Using Imagination to Understand the Neural Basis of Episodic Memory. *Journal of Neuroscience*, *27*(52), 14365–14374. https://doi.org/10.1523/jneurosci.4549-07.2007

Heller, M. A. (2006). Picture perception and spatial cognition in visually impaired people. In Touch and Blindness: *Psychology and Neuroscience*, ed. S. Ballesteros and M. Heller. Mahwah, N.J.: Lawrence Erlbaum Associates.

Hershfield, H. E., Goldstein, D. G., Sharpe, W. F., Fox, J., Yeykelis, L., Carstensen, L. L., & Bailenson, J. N. (2011). Increasing Saving Behavior Through Age-Progressed Renderings of the Future Self. *Journal of Marketing Research*, *48*(SPL), S23–S37. https://doi.org/10.1509/jmkr.48.spl.s23

Holladay, J. T. (2004). Visual acuity measurements. *Journal of Cataract and Refractive Surgery*, *30*(2), 287–290. https://doi.org/10.1016/j.jcrs.2004.01.014

Holloway, L., Marriott, K., & Butler, M. (2018, April). Accessible maps for the blind: Comparing 3D printed models with tactile graphics. In *Proceedings of the 2018 chi conference on human factors in computing systems* (pp. 1-13).

James, W. (1890). *The principles of psychology.* Holt: New York.

Jankowska, D. M., & Karwowski, M. (2015a). Measuring creative imagery abilities. *Frontiers in Psychology*, *6*, 1591. https://doi.org/10.3389/fpsyg.2015.01591

Jankowska, M.D., & Karwowski, M.(2015b). Test Twórczych Zdolności Wyobrażeniowych.Podręcznik. [Test of Creative Imagery Abilities: A Manual]. Warszawa: Akademia Pedagogiki Specjalnej (unpublished manuscript).

Jayant, C., Renzelmann, M., Wen, D., Krisnandi, S., Ladner, R., & Comden, D. (2007, October). Automated tactile graphics translation: in the field. In *Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 75-82).

Kerr, N. H. (1983). The role of vision in "visual imagery" experiments: evidence from the congenitally blind. Journal of Experimental Psychology: General, 112(2), 265.

Klottrup, A., & Egan, K. (1992). Imagination in Teaching and Learning. Ages 8-15. *British Journal of Educational Studies*, *40*(4), 415. https://doi.org/10.2307/3121055

Kosslyn, S. M., Margolis, J. A., Barrett, A. M., Goldknopf, E. J., & Daly, P. F. (1990). Age Differences in Imagery Abilities. *Child Development*, *61*(4), 995. https://doi.org/10.2307/1130871

Lacey, S., Flueckiger, P., Stilla, R., Lava, M., & Sathian, K. (2010). Object familiarity modulates the relationship between visual object imagery and haptic shape perception. *NeuroImage*, *49*(3), 1977–1990. https://doi.org/10.1016/j.neuroimage.2009.10.081

Lacey, S., & Sathian, K. (2012). Representation of object form in vision and touch. *The neural bases of multisensory processes.*

LeBoutillier, N., & Marks, D. F. (2003). Mental imagery and creativity: A meta-analytic review study. *British Journal of Psychology*, *94*(1), 29–44. https://doi.org/10.1348/000712603762842084

Lequerica, A., Rapport, L., Axelrod, B. N., Telmet, K., & Whitman, R. D. (2002). Subjective and Objective Assessment Methods of Mental Imagery Control: Construct Validations of Self-Report Measures. *Journal of Clinical and Experimental Neuropsychology*, *24*(8), 1103–1116. https://doi.org/10.1076/jcen.24.8.1103.8370

Lieberman, J. N. (2014). *Playfulness: Its relationship to imagination and creativity.* Academic Press.

Lombard, M., Snyder-Duch, J., & Bracken, C. C. (2002). Content Analysis in Mass Communication: Assessment and Reporting of Intercoder Reliability. *Human Communication Research*, *28*(4), 587–604. https://doi.org/10.1111/j.1468-2958.2002.tb00826.x

MacInnis, D. J., & Price, L. L. (1987). The Role of Imagery in Information Processing: Review and Extensions. *Journal of Consumer Research*, *13*(4), 473. https://doi.org/10.1086/209082

Marks, D. F. (1973). Visual imagery differences in the recall of pictures. *British J. Psychol.* 64, 17–24. doi: 10.1111/j.2044-8295.1973.tb01322.x

Marmor, G. S., & Zaback, L. A. (1976). Mental rotation by the blind: Does mental rotation depend on visual imagery? *Journal of Experimental Psychology: Human Perception and Performance*, *2*(4), 515–521. https://doi.org/10.1037/0096-1523.2.4.515

Martin, K. A., Moritz, S. E., & Hall, C. R. (1999). Imagery Use in Sport: A Literature Review and Applied Model. *The Sport Psychologist*, *13*(3), 245–268. https://doi.org/10.1123/tsp.13.3.245

Merckelbach, H., Horselenberg, R., & Muris, P. (2001). The Creative Experiences Questionnaire (CEQ): a brief self-report measure of fantasy proneness. *Personality and Individual Differences*, *31*(6), 987–995. https://doi.org/10.1016/s0191-8869(00)00201-4

Merriam-Webster. (n.d.). Imagination. In Merriam-Webster.com dictionary. Retrieved November 18, 2020, from https://www.merriam-webster.com/dictionary/imagination

Millar, S. (1975). Visual Experience or Translation Rules? Drawing the Human Figure by Blind and Sighted Children. *Perception*, *4*(4), 363–371. https://doi.org/10.1068/p040363

Millar, S. (1976). Spatial representation by blind and sighted children. *Journal of Experimental Child Psychology*, *21*(3), 460–479. https://doi.org/10.1016/0022-0965(76)90074-6

Millar, S. (1991). A reverse lag in the recognition and production of tactual drawings: Theoretical implications for haptic coding. *The psychology of touch*, 301-325.

Mills, C. W. (2000). *The sociological imagination.* Oxford University Press.

Nunnally, J.C. and Bernstein, I.H. (1994) The Assessment of Reliability. *Psychometric Theory*, 3, 248-292.

Palmiero, M., Cardi, V., & Belardinelli, M. O. (2011). The Role of Vividness of Visual Mental Imagery on Different Dimensions of Creativity. *Creativity Research Journal*, *23*(4), 372–375. https://doi.org/10.1080/10400419.2011.621857

Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nature Reviews Neuroscience*, *20*(10), 624–634. https://doi.org/10.1038/s41583-019-0202-9

Pring, L., & Goddard, L. (2003). Autobiographical memory in individuals born totally blind. *Touch, blindness, & neuroscience*, 55-63.

Reales, J. M., & Ballesteros, S. (1999). Implicit and explicit memory for visual and haptic objects: Cross-modal priming depends on structural descriptions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*(3), 644–663. https://doi.org/10.1037/0278-7393.25.3.644

Ren, F., Li, X., Zhang, H., & Wang, L. (2012). Progression of Chinese Students' Creative Imagination from Elementary Through High School. *International Journal of Science Education*, *34*(13), 2043–2059. https://doi.org/10.1080/09500693.2012.709334

Renzi, C., Cattaneo, Z., Vecchi, T., & Cornoldi, C. (2013). Mental imagery and blindness. In *Multisensory imagery* (pp. 115-130). Springer, New York, NY.

Ribot, Th. (1906). *Essay on the Creative Imagination.* Chicago, IL: Open Court.

Röder, B., Rösler, F., & Hennighausen, E. (1997). Different cortical activation patterns in blind and sighted humans during encoding and transformation of haptic images. *Psychophysiology*, *34*(3), 292–307. https://doi.org/10.1111/j.1469-8986.1997.tb02400.x

Runco, M. A., Nemiro, J., & Walberg, H. J. (1998). Personal explicit theories of creativity. The Journal of Creative Behavior, 32(1), 1-17. https://doi.org/10.1002/j.2162-6057.1998.tb00803.x

Salthouse, T. A. (2015). Continuity of cognitive change across adulthood. *Psychonomic Bulletin & Review*, *23*(3), 932–939. https://doi.org/10.3758/s13423-015-0910-8

Sathian, K., & Zangaladze, A. (2002). Feeling with the mind's eye: contribution of visual cortex to tactile perception. *Behavioural Brain Research*, *135*(1–2), 127–132. https://doi.org/10.1016/s0166-4328(02)00141-9

Schaefer, C. E. (1970). Development of an Originality Scale for the Franck Drawing Completion Test. *Perceptual and Motor Skills*, *31*(2), 402. https://doi.org/10.2466/pms.1970.31.2.402

Schifferstein, H. N. J. (2009). Comparing Mental Imagery across the Sensory Modalities. *Imagination, Cognition and Personality*, *28*(4), 371–388. https://doi.org/10.2190/ic.28.4.g

Scott, H. R., & von Stumm, S. (2017). Imagination. *Encyclopedia of Personality and Individual Differences*, 1–4. https://doi.org/10.1007/978-3-319-28099-8_2279-1

Shaw, G. A., & DeMers, S. T. (1986). The relationship of imagery to originality, flexibility and fluency in creative thinking. *Journal of Mental Imagery*, 10(1), 65–74.

Simpson, R. M. (1922). Creative Imagination. *Am. J. Psychol.* 33, 234–243. doi: 10.2307/1414133

Struiksma, M. E., Noordzij, M. L., & Postma, A. (2009). What is the link between language and spatial images? Behavioral and neural findings in blind and sighted individuals. *Acta Psychologica*, *132*(2), 145–156. https://doi.org/10.1016/j.actpsy.2009.04.002

Switras, J. E. (1978). An Alternate-Form Instrument to Assess Vividness and Controllability of Mental Imagery in Seven Modalities. *Perceptual and Motor Skills*, *46*(2), 379–384. https://doi.org/10.2466/pms.1978.46.2.379

Switras, J. E. (1979). Survey of mental imagery: test manual. *Metuchen, NJ.*

Thinus-Blanc, C., & Gaunet, F. (1997). Representation of space in blind persons: Vision as a spatial sense? *Psychological Bulletin*, *121*(1), 20–42. https://doi.org/10.1037/0033-2909.121.1.20

Thomas, D., & Brown, J. S. (2011). *A new culture of learning: Cultivating the imagination for a world of constant change* (Vol. 219). Lexington, KY: CreateSpace.

Tisdall, W. J., Blackhurst, A. E., & Marks, C. H. (1971). Divergent thinking in blind children. Journal of educational psychology, 62(6), 468.

Torrance, E. P. (1962). Guiding creative talent. Englewood Cliffs, NJ; New York, NY: Prentice-Hall. doi: 10.1037/13134-000

Torrance, E. P. (1974). *Torrance Tests of Creative Thinking: Norms Technical Manual*. Lexington, MA: Ginn.

Vanlierde, A., & Wanet-Defalque, M.-C. (2004). Abilities and strategies of blind and sighted subjects in visuo-spatial imagery. *Acta Psychologica*, *116*(2), 205–222. https://doi.org/10.1016/j.actpsy.2004.03.001

Vygotsky, L. S. (2004). Imagination and Creativity in Childhood. *Journal of Russian & East European Psychology*, *42*(1), 7–97. https://doi.org/10.1080/10610405.2004.11059210

Ward, T. B. (1994). Structured Imagination: the Role of Category Structure in Exemplar Generation. *Cognitive Psychology*, *27*(1), 1–40. https://doi.org/10.1006/cogp.1994.1010

Weibel, D., Martarelli, C. S., Häberli, D., & Mast, F. W. (2018). The Fantasy Questionnaire: A Measure to Assess Creative and Imaginative Fantasy. *Journal of Personality Assessment*, *100*(4), 431–443. https://doi.org/10.1080/00223891.2017.1331913

White, K. D., Ashton, R., & Brown, R. M. D. (1977). The measurement of imagery vividness: Normative data and their relationship to sex, age, and modality differences. *British Journal of Psychology*, *68*(2), 203–211. https://doi.org/10.1111/j.2044-8295.1977.tb01576.x

Wilson, T. D., & Gilbert, D. T. (2005). Affective Forecasting. *Current Directions in Psychological Science*, *14*(3), 131–134. https://doi.org/10.1111/j.0963-7214.2005.00355.x

World Health Organization (2020). International statistical classification of diseases and related health problems (11th ed.). https://icd.who.int/

Zhang, M., Weisser, V. D., Stilla, R., Prather, S. C., & Sathian, K. (2004). Multisensory cortical processing of object shape and its relation to mental imagery. *Cognitive, Affective, & Behavioral Neuroscience*, *4*(2), 251–259. https://doi.org/10.3758/cabn.4.2.251

Zheng, D. D., Swenor, B. K., Christ, S. L., West, S. K., Lam, B. L., & Lee, D. J. (2018). Longitudinal Associations Between Visual Impairment and Cognitive Functioning. *JAMA Ophthalmology*, *136*(9), 989. https://doi.org/10.1001/jamaophthalmol.2018.2493

8. Appendices

Appendix A

Coding scheme

Fase	Hoofdcode	Sub-code	Definitie
Ideeën fase	Associaties	Associaties binnen hetzelfde onderwerp	Veel ideeën die onder één onderwerp of thema vallen.
Ideeën fase	Associaties	Uiteenlopende associaties	Verschillende ideeën die onder verschillende onderwerpen of thema's vallen.
Ideeën fase	Associaties	Associëren vanuit vingers	Ideeën die vanuit het voelen opkomen. "*Dit voelt als de structuur van een ..."*
Ideeën fase	Genereren van ideeën	Nadenken tussen ideeën	Er zit veel tijd tussen de ideeën waarin wordt nagedacht. Pauzes tussen de ideeën
Ideeën fase	Genereren van ideeën	Spuwen van ideeën	Ideeën worden achter elkaar opgenoemd. De ideeën lijken vanzelf te komen.
Ideeën fase	Ideeën meteen kort uitleggen	Ideeën meteen kort uitleggen	In de ideeën fase wordt meteen kort uitgelegd hoe dat gemaakt moet worden of hoe het er uit ziet.
Ideeën fase / Beschrijvingsfase	Actie	Actie	Het idee of de beschrijving bevat beweging of acties.
Ideeën fase / Beschrijvingsfase	Draaien/kantelen van het figuur	Draaien/kantelen van het figuur	Het figuur wordt gekanteld door de participant.
Ideeën fase / Beschrijvingsfase	Orginaliteit	Alledaags	Er worden alledaagse ideeën of objecten genoemd.
Ideeën fase / Beschrijvingsfase	Orginaliteit	Metaforisch of symbolisch	Een metaforisch of een symbolisch idee wordt genoemd, bijvoorbeeld een spreekwoord.
Ideeën fase / Beschrijvingsfase	Orginaliteit	Fantasierijk	Er wordt een of meerdere niet veel voorkomend idee(ën) of object(en) genoemd.

Beschrijvingsfase	Gedetaileerde beschrijving	Detail	In de beschrijvingsfase wordt een gedetailleerde beschrijving van het idee gegeven.
Beschrijvingsfase	Gedetaileerde beschrijving	Achtergrond	Niet alleen het object waarin het originele figuur in is verwerkt wordt beschreven maar ook andere objecten of omgeving wordt beschreven.
Beschrijvingsfase	Gedetaileerde beschrijving	Kleur	Er wordt kleur gebruikt in het idee/beschrijving.
Beschrijvingsfase	Gedetaileerde beschrijving	Verhaal	Er wordt een verhaal om het idee heen verzonnen. Dingen die niet allemaal op één tekening zouden kunnen worden afgebeeld wordt verteld.

Appendix B

Items of the Fantasy Questionnaire in English and Dutch (the Dutch translation has not been validated) (Weibel et al., 2018).

Dimension	Item English	Item Dutch
Imaginative Fantasy	Many of my fantasies have a realistic intensity.	Veel van mijn fantasieën hebben een realistische intensiteit.
	I am never bored because I start fantasizing when things get boring.	Ik verveel me nooit want ik begin te fantaseren als dingen saai worden.
	When I think of something cold, I actually get cold.	Als ik aan iets kouds denk, krijg ik het echt koud.
	In my daydreams I can hear the sound of a tune almost as clearly as if I were actually listening to it.	In mijn dagdromen kan ik het geluid van een deuntje bijna net zo duidelijk horen alsof ik er echt naar luister.
	Sometimes my thoughts seem as real as actual events in my life.	Soms lijken mijn gedachten net zo echt als de werkelijke gebeurtenissen in mijn leven.
	The sounds I hear in my daydreams are usually clear and distinct.	De geluiden die ik hoor in mijn dagdromen zijn meestal duidelijk en te onderscheiden.
	Sometimes I become so involved in a daydream that I am not aware of things happening around me.	Soms raak ik zo verwikkeld in een dagdroom dat ik me niet bewust ben van wat er om me heen gebeurt.
	I am good at blocking out external distractors when I am involved in something.	Ik ben goed in het blokkeren van externe afleiders als ik ergens bij betrokken ben.
	My daydreams are often stimulating and rewarding.	Mijn dagdromen zijn vaak stimulerend en lonend.
	I am the kind of person whose thoughts often wonder.	Ik ben het soort persoon wiens gedachten zich vaak afdwalen.
	I don't like to waste my time daydreaming.	Ik hou er niet van om mijn tijd te verspillen met dagdromen.
	I have gone through the motions of living while the real me was far away	Ik ging door waar ik mee bezig was terwijl ik met mijn hoofd heel ergens

	from what was happening to me.	anders was.
	If I wish I can imagine some things so vividly that they hold my attention as a good movie or story does.	Als ik wil, kan ik me sommige dingen zo levendig voorstellen dat ze mijn aandacht vasthouden zoals een goede film of goed verhaal dat doet.
	When I read a book, the feelings of the character with whom I identify influence my own mood.	Als ik een boek lees, beïnvloeden de gevoelens van het personage met wie ik me identificeer mijn eigen stemming.
Creative Fantasy	A really original idea sometimes develops from a really fantastic dream.	Een heel origineel idee ontstaat soms uit een werkelijk fantastische droom.
	Sometimes I think about new inventions.	Soms denk ik aan nieuwe uitvindingen.
	I am a creative person.	Ik ben een creatief persoon.
	I have been told to have a lot of fantasy.	Er is mij verteld dat ik veel fantasie heb.
	My ideas are usually considered as very creative.	Mijn ideeën worden meestal als erg creatief beschouwd.
	Products of my fantasy such as texts and drawings generate themselves almost automatically.	Producten van mijn fantasie zoals teksten en tekeningen genereren zichzelf bijna automatisch.
	I solve tasks in different ways, i.e. in unexpected, surprising and unconventional ways.	Ik los taken op verschillende manieren op, namelijk op onverwachte, verrassende en onconventionele manieren.
	I take the time to express my fantasies.	Ik neem de tijd om mijn fantasieën te uiten.
	I have many ideas that are unusual and novel.	Ik heb veel ideeën die ongebruikelijk en nieuw zijn.
	I can think around obstacles and find new solutions.	Ik kan om obstakels heen denken en nieuwe oplossingen vinden.
	I have a lot of fantasy.	Ik heb veel fantasie.

Appendix C

Assessment criteria TCIA-2

Score	Levendigheid	Orginaliteit	Transformativiteit
Uitleg	De levendigheidsschaal meet de mate van visualisatie en uitwerking van de gegenereerde beelden. Een **hoog level** van levendigheid wordt herkent door bijvoorbeeld een **overvloed aan details** bij de voltooiing van het aanvankelijke figuur, een duidelijke beschrijving van **beweging en dynamiek** in de tekening en een complexe presentatie van **metaforische en symbolische inhoud**.	De originaliteitsschaal meet de nieuwheid van de gegenereerde beelden. Een **hoge mate van originaliteit** blijkt bijvoorbeeld uit: de weergave van **nieuwe objecten, activiteiten, processen en gebeurtenissen** in de tekening die aanzienlijk verschillen van de werkelijk bestaande; een verrassende en **nieuwe presentatie van culturele artefacten** zoals kunstwerken; een grappige presentatie van de inhoud, wat een goed **gevoel voor humor** suggereert.	De Transformativiteitsschaal meet het vermogen om de gegenereerde beelden te wijzigen. De **scorecriteria** verwijzen naar basisbewerkingen voor het transformeren van visuele beelden, zoals: **vermenigvuldiging** - het vermenigvuldigen van een element van het beeld; **hyperbolisatie** - buitensporige vervorming van verhoudingen, bijvoorbeeld door een element van het beeld te benadrukken; **versterking** - detail aan het beeld toevoegen.
0	Het originele figuur is niet aangevuld, maar werd geïnterpreteerd, d.w.z. kreeg de titel.	Presentatie van **alledaagse** voorwerpen (dingen, planten, dieren, mensen, plaatsen). Hun vormen, functies en eigenschappen zijn echt, en hun activiteiten, processen, toestanden en gebeurtenissen zijn typerend.	Vermenigvuldiging van het originele figuur.

1	Eenvoudige, vaak schematische aanvulling van het originele figuur.	Individuele, eenvoudige wijzigingen van vorm, functies en eigenschappen van **algemeen bekende** objecten (dingen, planten, dieren, mensen, plaatsen) evenals typische activiteiten, processen, toestanden en gebeurtenissen.	Recreatie, eenvoudige voltooiing van het originele figuur en het toevoegen van een relatief onafhankelijk object(en).
2	Complexe, gedetailleerde voltooiing van het originele figuur.	Complex, aanzienlijk veranderd met betrekking tot de realiteit, wijziging van vorm, functies en eigenschappen van algemeen bekende objecten (dingen, planten, dieren, mensen, plaatsen) evenals typische activiteiten, processen, toestanden en gebeurtenissen.	Complexe wijziging van de originele figuur - de uitwerking op meerdere aspecten.