*Cerebral Cortex*, 2025, **35**, 42–48

https://doi.org/10.1093/cercor/bhae456

Advance access publication date 27 November 2024

**Original Article**

# On the bright side of blindsight. Considerations from new observations of awareness in a blindsight patient

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**Blindsight refers to the ability to make accurate visual discriminations without conscious awareness of the stimuli. In this study, we present new evidence from naturalistic observations of a patient with bilateral damage to the striate cortex, who surprisingly demonstrated the ability to detect colored objects, particularly red ones. Despite the slow and effortful process, the patient reported full awareness of the color aspect of the stimuli. These observations cannot be explained by traditional concepts of type 1 or type 2 blindsight, raising intriguing questions about the boundaries between objective and subjective blindness, as well as the nature of visual experience and epistemic agency. Moreover, these findings underscore the significant role that blindsight could play in future research, especially in understanding how higher cortical functions are involved in emotions and feelings. This highlights the necessity for further exploration to better understand the visual features that contribute to the phenomenon of affective blindsight.**

*Key words*: cortical blindness; hemianopia; blindsight; residual vision; color processing; consciousness.

## Introduction

In the early 1970s, a new phenomenon of vision without awareness upended the debate about the neural basis of conscious vision. “Blindsight,” a term coined by Weiskrantz et al. (1974), refers to the ability of individuals with damage to the primary visual cortex to respond to visual stimuli despite lacking conscious visual awareness of any stimulation in the impaired visual field. While these individuals adamantly assert their blindness within all, or parts, of their visual field, experimental evidence demonstrates their ability to accurately detect and respond to visual stimuli presented within these blind regions when prompted to do so.

Blindsight has been observed for a wide range of physical parameters of visual stimuli (Weiskrantz 1986). While research is ongoing, there is consensus that the possible pathways that could enable blindsight include connections to extrastriate occipital, parietal, and temporal visual areas from either the lateral geniculate nucleus of the thalamus (LGN) (Schmid et al. 2010; Ajina and Bridge 2018, 2019) or from the superior colliculus and (Barbur et al. 1993); Tamietto and de Gelder 2010. Blindsight was also observed for affective stimuli with studies showing that emotional expressions from faces and whole bodies can be correctly discriminated in such patients (de Gelder et al. 1999). Discrimination of affective stimuli in the absence of an early visual cortex was clearly compatible with the view notion forcefully defended by Ledoux (1996) that subcortical processes are sufficient to control complex behaviors nonconsciously. Ledoux’s notion of two processing routes, one subcortical in charge of rapid, automatic adaptive behavior and the other cortical and in charge of orchestrating conscious experience, did fit very well the findings of blindsight. In support of LeDoux’s theory, amygdala activation to emotional expressions was observed in the patients with primary visual cortex lesion (Morris et al. 2001; Tamietto and de Gelder 2010).

In general, affective perception has not occupied a central place in research on consciousness, which has tended to focus on more purely cognitive phenomena and tasks. For example, the visual stimuli used in blindsight experiments are typically defined objectively (brightness, wavelength, shape, notion, etc.), with the participant expected to report on the stimulus, not on their subjective experience of it. The same methodology was followed for affective blindsight as for cognitive blindsight, and it aimed to establish that the patients’ reports truly reflected stimulus attributes without any subjective awareness involvement. Over time, it became clear from studies of affective blindsight as well as evidence from experiments on nonconscious perception of affective stimuli that subjective experience had to be considered. While, for numerous domains of visual perception, the goal is to achieve objective reports, for affective stimuli, subjective experience (and thereby consciousness) is important. This is the core of the views on how to link subcortical and cortical routes developed over the last decade by LeDoux (2016, 2023) and LeDoux and Brown (2017). However, our goal is not to discuss these developments, as important as they are for increasing awareness about the role of consciousness in the field.

**Received:** August 15, 2024. **Revised:** October 25, 2024. **Accepted:** November 4, 2024

In this paper, we report some recent observations made with blindsight patient TN that we believe add novel and important information to the ongoing discussions about the role of the primary visual cortex and conscious experience. Blindsight is central to understanding consciousness (LeDoux 2012; LeDoux et al. 2020). Therefore, the new findings we report may extend and possibly move forward those discussions, including the debates on the neural basis of subjective experience forcefully defended by Ledoux.

We first briefly present the case of patient TN (section The Case of TN—Case Description and Previous Findings). Next, we describe the context and motivation for our observations (section Naturalistic Observations and Unconstrained Behavior in TN) and report the novel observations (section Behavioral Observations on Color). In the section Blindsight with Consciousness, we highlight some aspects of that challenge and some current explanations of blindsight by consciousness theories. In the final section, we comment on the relevance of our new findings for affective blindsight and theories of emotion and consciousness.

## The case of TN—case description and previous findings

The case of TN was first reported in 2005. He had been trained as a medical doctor and was still working when, at the age of 52, he suffered two consecutive strokes. The first occurred in the left parieto-temporo-occipital cerebral area and resulted in hemianopia, hemiplegia, and transcortical sensory aphasia. The hemiplegia and aphasia receded rapidly, leaving only the right hemianopia. A second hemorrhage then occurred 36 days later in the right occipital lobe, producing a loss of the left visual field and thus complete cortical blindness. During this early period, TN described a loss of any visual sensation and described his world as one of total darkness. On one occasion, while he was seated in his hospital room facing a window that overlooked a glaring sunset, he was questioned about the presence of his subjective sensation of light but reported having none whatsoever.

Structural magnetic resonance imaging (MRI) showed a left hemisphere lesion that included most of the occipital lobe, with minimal sparing of the medial ventral part of the inferior occipital gyrus and anterior part of the lingual gyrus. This lesion extended anteriorly to the middle part of the fusiform gyrus, leaving the parahippocampal gyrus grossly intact. Laterally, the lesion extended to the medial inferior temporal gyrus. Dorsally, the hemorrhage reached the superior parietal lobule and spared the ventral part of the precuneus. The right hemisphere lesion was smaller and included most of the occipital lobe, with limited sparing of the medial part of the posterior lingual gyrus and medial part of the precuneus. The anterior border stretched toward the middle part of the fusiform gyrus and included the posterior inferior temporal gyrus but spared the parahippocampal gyrus. No anatomic input to striate areas could be detected in either the left or the right hemisphere using DTI.

The initial findings with TN pointed to the presence of affective blindsight. Affective blindsight, first described by de Gelder et al. (1999), refers to the ability to guess the emotional expression of a face (or body) in the absence of a functional striate cortex and without visual awareness. In TN, affective blindsight was initially suspected in his spontaneous behavior. Indeed, on one occasion, while one of us (AP) was carrying out a follow-up clinical bedside evaluation, TN was observed to smile in response to the examiner's smile, although he claimed not to see the examiner's face. When formal testing was carried out, it was found that he was above chance when guessing the emotional expression on photographs of faces in a series of two-alternative forced-choice tasks. In addition, a functional MRI (fMRI) procedure revealed amygdala activation for emotional expressions compared to neutral faces, with no other brain areas apparently activated.

Three years later, TN was invited to participate in a new series of studies. During this period, another serendipitous observation was made. While walking down a corridor (led by an examiner due to his blindness), TN suspiciously adjusted his trajectory, seemingly to avoid contact with a panel that was slightly askew and thus a potential risk of collision. A more systematic examination of his navigational abilities revealed a surprisingly well-preserved ability to avoid obstacles in his path, again despite his acknowledged loss of vision, and was captured on video (de Gelder et al. 2008). Later unpublished observations of TN's movements were made while he wore earmuffs, or while he was blindfolded, further confirming that his abilities relied on visual, and not on auditory input (additional observations are reported below).

Further investigations were then carried out using different paradigms, to characterize his residual visual function.

With respect to emotional faces, spatial filtering of the stimuli showed that as with unfiltered faces, the low-spatial-frequency components of fearful faces gave rise to right amygdala activation, while this was not found with high-spatial-frequency components of the faces (Burra et al. 2019). This suggested that the visual information present in the low spatial frequencies triggered amygdala activation and affective blindsight. From an electrophysiological standpoint, oscillatory rhythms in the brain continued to be observed following visual stimulation but were shifted to anterior electrodes, suggesting the activity of an alternate pathway for visual function (Del Zotto et al. 2013; Tipura et al. 2017). Along these lines, an electroencephalography (EEG) exploration of TN's electrical brain responses to emotional faces pointed to an early modulation of frequencies over anterior electrodes, beginning at around 100 ms after stimulus presentation. This further indicated a rapid involvement of the alternate visual pathways when processing emotional faces.

Extending to other categories of stimuli, human bodies (compared to other objects) were also found to produce a differential activation in the fMRI paradigm (Van den Stock et al. 2014), while no difference was found across other objects. TN's ability to process gaze direction was also explored (Burra et al. 2013). Using fMRI, increased right amygdala activation was found in response to directed, compared with averted, gaze. Activity in this region was further found to be functionally connected to a larger network associated with face and gaze processing. Interestingly, gazes oriented laterally failed to produce shifts of spatial attention as judged by his reaction times to sounds lateralized in the direction of gaze or not. This effect was not due to a lack of cross-modal integration since audiovisual associations were made between increasing and decreasing sounds and looming vs receding visual stimuli (Seirafi et al. 2015).

In the spatial domain, Hervais-Adelman et al. (2015) demonstrated bilateral activation of middle temporal areas as well as superior temporal sulcus (STS) and inferior parietal lobe (IPL) in TN's brain when light points were presented in a looming motion, as opposed to receding, rotating, or static conditions.

Another relevant observation revealed that TN was at a chance level when guessing left or right presentations of a luminous target on a screen by raising his left or right index finger but was above chance when pointing to the same stimulus with his index (Buetti et al. 2013).

## Naturalistic observations and unconstrained behavior in TN

In the investigations described above, we were not primarily interested in the so-called phenomenological dimensions of visual experience. For this reason, experiments were carried out in highly determined environments that did not allow for the richness of the subjective experience of this patient to be captured.

Following the periods of experimentation, however, we spent two afternoons with TN discussing his experiences in daily life and in his work environment given his blindness. During this period, he attempted to communicate his subjective visual experience to the authors. This led to incidental behavioral testing that was spontaneously set up in situ in an attempt to illustrate his descriptions and gain a better understanding of them. With his consent, we videotaped our interactions throughout these conversations.

By revisiting the videotaped discussions, we carefully examined both TN's behavior and verbal descriptions. In reporting them here, we stick to descriptive language referring to visual experiences and avoid imposing theoretical or philosophical categories.

One of the most striking findings to emerge in this naturalistic setting was TN's ability to pick out colored objects and to describe what color vision "felt like."

## Behavioral observations on color

TN reported that he was able to detect the presence of objects in his environment, albeit without any awareness of shape and thus without the ability to recognize meaningfully what the object was. He was confident, however, that he was able to detect color on occasion. To test this claim, objects that were immediately available around him were given to him, and he was asked on each occasion if he could detect or "see" the color.

### *Observation 1*

A red and a yellow tulip were handed to him. He was informed of the two colors and was asked if he could tell us which of the two was the red one. Initially unable to distinguish the stem from the flower itself, his hands were guided to the region of the petals so that he grasped the flowers in the region of the petals (one flower in each hand). He then was seen to observe the flower for approximately 5 s, before spontaneously handing the red one to the examiner, stating "yes, yes, it's this one," with a verbal intonation that suggested that the answer was self-evident.

### *Observation 2*

One red and one brown bellow were given to TN, one in each hand. He was informed that one was red and the other brown and was again asked to identify the red one. He was seen to look at the yellow in his right hand (red), then the left, then back to the right with ~6 s, concluding correctly which was the red object.

### *Observation 3*

This was repeated with two A4-size paperback brochures with yellow and red covers. This time, TN immediately identifies the red one as it is handed to him. He holds the second book and looks at it for around 3 s and then correctly indicates "this one is whitish-yellow."

When asked to comment on his ability and his subjective feelings related to color vision, he states (in French), "I can't say [/explain] it," then says jokingly, "I don't know, it comes to me (moving his hands towards his eyes), it stings my eyes [in French: 'ça pique'], as I said to you, it pops out, 'paf!' and it stings my eyes."

### *Observation 4*

The red A4-size brochure with the red cover is held at about 2 m distance. He is told that the examiner is holding a large object and is asked to say when he "sees" the color (without specifying which one). For the first 10 s approximately, he is adamant that he cannot see any color. He says, "I know there's an object, but I can't tell the colour'. The brochure is slowly moved until it is at arm's length. then says: "wait, wait, wait, wait… yes, the colour is coming, but… red hasn't quite emerged yet, but…". He continues to look at the object for another 10 to 15 s; then, suddenly, he exclaims "yes there it is, I see the red colour now… it *is* red."

### *Observation 5: Lego blocks (1)*

A cube made of 3 green Lego and another of 3 red Lego blocks is placed in front of TN. He is made aware of the 2 objects. The colors are not specified; however, since our conversation is around color, he understands without prompting that he is expected to identify them. TN spontaneously selects the green block on the right and holds it up to his eyes for about 5 s. He then puts the green block down and selects the (left) red block, which he then holds up and manipulates for about 10 s, varying its distance very slightly (by no more than 2 or 3 cm). He then smiles and says "well, I should have [asked]… is it still the same thing [the same task]"? This is acknowledged by the examiner, to which TN immediately responds, "then it's red" (handing the block to the examiner in a conclusive fashion). He then comments, "I have to find the correct angle, you see, it didn't find it immediately and I had to turn to around until 'paf!', it stung, it pierced my eye and I saw it."

### *Observation 6: Lego blocks (2)*

Green and red Lego blocks are assembled to form another shape. These are again placed on the coffee table in front of him, and he is asked to perform the task once again. He spontaneously picks up the shape on the left, which is red. He manipulates the object, rotating it, bringing it very close to his face (~20 cm), and then holding it out, almost at arm's length. After about 15 s, he says "yes" and begins to hand it to the examiner but then revises and keeps the object in his left hand and reaches out with his right hand to take the second (green) shape, which he then observes while rotating and manipulating in the same manner. After about 25 s of carefully observing the green object, he hands the red one (still in his left hand) to the examiner, saying "I think it's this one." He again comments on his performance, saying he was able to answer "because again something stung [my eye]. There, I responded with more conviction because something stung me, whereas for this one (he holds up the green shape), I haven't felt that yet."

### *Observation 7: Lego blocks (3)*

A red and a green block are placed on the coffee table in front of him (the green block on the left), and he is asked to reach toward the red block without holding the forms. He replies adamantly that this is impossible as he cannot see them and would not be able to see the color. While he explains this, the examiner picks up the blocks and places them again on the table in the same position, asking him to try again. Hardly finishing his sentence, TN looks down toward the table and immediately says "it's here," and, with a single motion, he grasps the red block.

The same blocks are again placed in front of him (red block on the right), and he is told to try again. Rather than reaching out, he leans forward and explores the blocks without manipulating them for about 5 s. He then reaches out and grasps the green block. The examiner tells him that he has selected the green block. At this point, TN replies "Oh! You wanted me to select the red one? No, no, I can't do it like that! Because I have to… (rotates the green Lego he is holding and performs exaggerates hand movements), "I can't see like that, it's too weak…".

### *Observation 8: Lego blocks (4)*

The red block is placed on the table, and he is told it's red. He observes for around 10 s without touching it and says, "I can't tell like that, I would have to bring it closer."

The red and green blocks are again placed on the table at his request. The examiner voices aloud which is green and which is red this time. TN observes both blocks closely without picking them up. After ~8 s, he picks up the green block and manipulates it for about 4 s before putting it down and picking up the red block. This, in turn, he manipulates for about 13 s, rotating it, approaching it to within 10 cm of his face, and moving it away. He then suddenly exclaims "Ah! that's the red one" and hands it to the examiner with no further hesitation.

### *Observation 9*

An examiner walks in with a bright red shawl over her shoulders and stops facing TN while he is in conversation. Without any further prompting, TN says, "There, there are lots of colours moving around here." Then, he said jokingly, "A lot of red is moving in and around."

### *Observation 10: Lego blocks (5)*

A yellow and a green Lego block are placed on the table, and TN is informed of the 2 colors, with an emphasis on the fact that there are no red blocks. TN picks up the green block first, exploring it for 6 s before picking up the yellow block and manipulating that one for some 25 s. He then puts down the yellow one and continues to explore and manipulate the green one for another 10 s. He once again picks up the yellow block and explores it for 16 s and then suddenly correctly states: "Ah, there, this one is yellow."

Although he now deduces that the remaining block in his hand must be green, he further manipulates for over 40 s in an attempt to "see" the green color (always by rotating the block and varying its distance from his face). He then indicates uncertainty with a facial expression of doubt asking whether the block might be white. The examiner again indicates that it is the green one he is holding. TN acknowledges and continues to examine it for another 10 s asking, "is it a 'green' green?" When told that it is indeed a very distinct green, he places it back on the table indicating that he has not "seen" it.

### *Observation 11: Lego blocks (6)*

Four blocks, one green, one red, one blue, and one yellow, are placed on the coffee table in front of him, and he is asked to find the red one. He begins by selecting the green block and explores it for 40 s. He then picks up the red one and explores it for 20 s before saying, "there are colors here… this is the red one!"

### *Observation 12: Lego blocks (5)*

A yellow and a blue Lego block are placed on the table and TN is informed of the 2 colors. He is asked to find the blue one. He first picks up the yellow one, which he explores for 35 s. He then picks up the blue block, which he explores for around 40 s before concluding "it might be this one." In this case, his certainty seems much lower than for his preceding responses for red blocks. When told that his response was correct, he stated, "there was a little something in the blues, a little something… *very* little!"

### *Summary*

Although we did not control for the luminance of the colored objects, the fact that we got the same result using a variety of objects with different sizes and textures leads us to firmly believe that TN was—as he claimed—responding to color as people generally understand it and as he himself did before the onset of his blindness. As is obvious, however, his color vision was no longer immediate and effortless. He often required time to explore the object by manipulating it and varying its distance from his eyes. Importantly, his subjective experience appeared to emerge suddenly, as if in an all-or-nothing manner. Indeed, on a number of occasions, he would exclaim in an "aha" manner when he identified the color. Interestingly, this arose more often with the color red than with other colors; indeed, he was unable to reach a conclusion with green blocks and was clearly hesitant about blue, although he responded correctly. This presumably ties in with the special psychological significance and emotional impact of red that has been demonstrated in many other contexts (Humphrey 1976).

It is obvious from these descriptions that the luminance of the different colors was not controlled for; however, a variety of objects with different sizes, and textures were used, each yielding the same result. Moreover, TN's visual exploration followed a similar pattern.

## Blindsight with consciousness

In reviewing these discussions with TN, several important points appear important for what the study of blindsight can contribute to understanding subjective experience and consciousness.

### *Subjective vs. objective blindness*

During many testing sessions spread over the years, one observation was constant in several blindsight patients. Whenever evidence of residual vision was found and shared with the blindsight patients, this was met with disbelief and puzzlement. The patient always self-identified as a blind person and did not see themself as having any visual abilities. In line with this, as much as our findings were noteworthy to us, we could not really generate interest in them from the patient. This created the impression that our discovery of residual visual skills was not really relevant for the patient in terms of how they experienced their condition themself or what really mattered to them. Indeed, the patients continued to be subjectively blind, even though residual visual abilities were objectively noted. This squares with the subjective comments often made when feedback is given to the patient about their behavior in the experimental tasks. When informed that their performance in a forced choice task is well above average and provides evidence of residual functional vision, it is not infrequent for patients to shrug this off, as this does not meet with their lived impressions. It therefore appears that the yardstick for vision in this context is the subjective experience of seeing and not the objective correspondence between a visual object and what the viewer reports of it.

Yet, in stark contrast to the above, our current observations of TN reveal that under some conditions and for some stimuli, near-normal visual behavior is observed, with normal stimulus awareness and quality as well as epistemic agency. In these cases, examples of which are reported here, objective and subjective visual abilities converge, as they do in the intact brain. These instances of what seems to be normal visual behavior in a patient with complete cortical striatal damage are as puzzling as the well-known examples of blindsight, which show good objective visual performance in the absence of subjective reports. As NH has put it, typically, the blindsight patient no longer "owns" their vision and, as far as they are concerned, "it has nothing to do with them" (Humphrey 2022).

### *Epistemic agency*

The comments TN makes in his responses are authoritative and are given without any doubt or hesitation. This contrasts baldly with the experimental observations of most studies on blindsight. In these settings, TN gives authoritative responses. When selecting the correct color object, he is certain about the correctness of the answer, and, if in doubt, he does not hesitate to comment on it. His responses have the hallmarks of epistemic agency in the sense that he can justify, motivate, and account for his beliefs about the objects in front of him. This performance is very different from the behavior observed in habitual blindsight procedures using forced choice tasks, where the patient is provided with response alternatives from which to select. The experimenter will typically introduce the task by stating to the patient that they will likely not be able to see what is presented to them but are asked to make a guess. During debriefing the patient will frequently comment on the fact that they did not see anything but were randomly guessing with little confidence in their answers. In contrast, we notice in TN's behavior here that he is confident in his visual experience which appears to be similar to the visual experience of sighted individuals, and very different from the visual behavior of patients tested with forced choice procedures. Despite the absence of the striate cortex, TN nevertheless experiences these visual stimuli in a way that presents behaviorally in a strikingly similar manner to normal vision.

### *The quality of the visual report*

If the ability to discriminate red is indeed a form of blindsight, its textbook definition would not expect it to be associated with consciousness. However, we repeatedly noted that TN was fully aware of the color when picking out the red object. On the face of it, this observation makes it difficult to define blindsight as vision without consciousness, and whoever observes TN picking out the red cube will fail to understand how this behavior qualifies as blindsight. When making the correct choice of color, TN is fully aware that he has selected the appropriate stimulus as instructed, repeating the color's name, making comments on his search, and providing commentaries that testify to his understanding that he is giving the correct answer. Conversely, in cases where he voices doubts, he is seen to hesitate and indicates that he cannot pick out the correct object, apparently aware of his shortcomings.

TN appears to have the same idea of red as he did prior to his strokes. Indeed, he knows from past experience what seeing red means, yet he does not signal at any moment that there is any difference between the red he sees now, or the word red as he uses it now, and his prestroke experience of it. Had this been the case, the consequences would arguably have given rise to a lack of confidence, which is not noted in his answers. In all likelihood, TN must experience red as he did before his brain damage, and this experience yields the same familiar subjective qualities as before.

It is commonly assumed that, in the absence of the striate cortex, whatever visual information triggers the blindsight percept must be different from what occurs under normal circumstances even if, for all intents and purposes, it conforms to the response categories of the experimenter. However, incomplete or divergent processing routes may give rise to a different subjective experience. It could be that the content of the subjective report is "normalized" by the conceptual framework of the experimental questions. Accordingly, qualitative differences have been reported in patients with unilateral lesions when they are asked to match color or motion stimuli (but not brightness) appearing in their intact and lesioned field (Kentridge et al. 2007; Morland et al. 1999), suggesting that the visual experience in blindsight is indeed different from normal vision. Yet, our current observations of TN are at odds with this conclusion. On the face of it, a vision that relies on other pathways than the principal geniculostriate route is qualitatively on par.

It is a matter of debate whether blindsight patients tested in forced-choice experiments have any subjective visual experience of the stimuli presented and, if so, if their subjective experience is similar, different, or only impoverished in comparison to normal vision (Overgaard et al. 2008; Weiskrantz 2009). Since visual information necessarily leads to verbal reports via different pathways than in the intact brain, the patient's report is likely based on atypical visual information. Whatever visual information triggers the blindsight percept must therefore be different from what occurs under normal circumstances even if, for all intents and purposes, it conforms to the response categories of the experimenter. Incomplete or divergent processing routes may give rise to a different subjective experience, while the content of the subjective report is "normalized" by the conceptual framework of the experimental questions. Accordingly, qualitative differences have been reported in patients with unilateral lesions when they are asked to match color or motion stimuli (but not brightness) appearing in their intact and lesioned field (Morland et al. 1999; Kentridge et al. 2007). This suggests that the visual experience in blindsight is different from normal vision and underscores the importance of not assuming that a correct answer from a blindsight patient directly reflects their visual experience of the stimulus. Between the stimulus presentation and the patient's response, there are multiple layers of neural processing that may influence the outcome.

Our current observations of TN seem at odds with this conclusion of degraded or qualitatively altered vision. On the occasions where TN responds correctly and knows clearly that he is correct, he does not signal any anomaly in his experience.

## Subjective awareness, consciousness, and imperfect vision

Our novel findings reveal a novel bright side of blindsight and, at the same time, stress the need to explore further its dark side. On the bright side, TN's behavior reported here shows that vision that relies on other pathways than the principal geniculostriate route can still be associated with full epistemic agency with qualities no different from normal vision. Now, on the dark side, it is currently not well understood what computations in the damaged visual system sustain this. Clearly, TN's reports are patchy, incomplete, and partial. Some colors are experienced, while others remain unreported and there is no normal object perception of which color experience would be one aspect. One suggestion is that TN's positive responses may be driven by one or more visual features computed along alternative and intermediate-level visual pathways that do not include complete cortical processing and with concept-based object representation but still have enough features to lead to conclusive reports and qualitative experience. A better understanding of the intermediate levels of visual processing in subcortical and cortical networks is needed here.

On the other hand, the residual skills of blindsight patients may be richer than assumed so far.

The present findings emerged from testing under naturalistic conditions that may allow more variability in the manifestations of blindsight behavior than classical experimental designs (Humphrey 1974). For example, the lack of reported awareness may be due to a mismatch between the patients' patchy vision and what is stipulated by the experimental instructions. Note that TN does not see a red *cube* and would not be able to perceive a red *flower* or a red *book* but clearly sees the color red. Cowey rejected the idea that affective blindsight was possible based on the argument that faces were highly complex cognitive stimuli (Cowey 2004). This view assumes an all-or-nothing picture of visual perception and consciousness. However, partial, feature-based information may drive visual responsiveness in the damaged brain. For example, when shown a whole-body expression of fear, one feature, limb contraction, is sufficient to trigger brain activity typically reported for seeing fearful face and body expressions (Poyo Solanas et al. 2020, 2024). If the damaged visual system still processes some discriminative features, the patient will nevertheless report guessing because the task instructions stipulate object recognition.

Partial as opposed to concept-driven visual processing may be important for understanding how visual processes and awareness are related also in the intact brain, specifically in the case of affective stimuli. For example, instructions to name the emotional expression of a stimulus significantly reduce activity in neural emotion circuits including in amygdalae (e.g. de Gelder et al. 2012; Pichon et al. 2012). In the context of blindsight, where visual processes are more local and fragile, these top–down cognitive effects from task demands may even have a more negative impact on the patient's reporting of subjective affective experiences.

So far, blindsight patients tested with affective stimuli did not report any subjective experience, and their behavior with affective stimuli is reported as pure guessing and triggered by "innate" emotion circuits (LeDoux 1998; Damasio 2005; Panksepp et al. 2017). Yet, correct guessing is associated with valence-specific physiological and neural activity (Pegna et al. 2005; Tamietto et al. 2009). Correct guesses may be driven by feature-based and incomplete stimulus processing, which is not enough to satisfy the experimental demands (hence. the patient reports guessing). The damaged brain may not succeed in a full conceptual representation of the events that trigger them and therefore not report visual awareness. To evaluate this hypothesis in the context of blindsight, research methodologies are required that do not focus solely on the visual cognitive report and do not limit response options to a forced choice format.

The observations presented here illustrate that in the absence of stringent experimental demands patients may reveal residual competencies that occupy some middle ground between behavior without awareness and full-blown conscious perception. A better understanding of the visual and interoceptive processes intermediate between blunt blind guessing and full conscious perception is urgently needed here.

Note that some videos are available on the website beatricedegelder.com. The complete set is available on request.

## Acknowledgments

We thank R. Kentridge, D. Dennett, and A. Marcel for ongoing discussions on these topics.

## Author contributions

Beatrice de Gelder (Conceptualization, Funding acquisition, Project administration, Writing—original draft, Writing—review & editing), Nicholas Humphrey (Conceptualization, Writing—review & editing), and Alan J. Pegna (Conceptualization, Writing—original draft, Writing—review & editing).

## Funding

This work was supported by the European Research Council (ERC) Synergy grant (Grant Agreement 856495; Relevance), by the Horizon-CL4-2021-Human-01-21 (Grant Agreement: 101070278; Re-Silence), and by the Horizon 2020 Program H2020-FETPROACT-2020-2 (Grant Agreement 101017884; GuestXR).

*Conflict of interest statement*: None declared.

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*Cerebral Cortex*, 2025, **35**, 42–48
https://doi.org/10.1093/cercor/bhae456
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