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Bridging Visual System and Embodied Perception

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ABSTRACT

This paper addresses an important gap at the intersection of cognitive science, perception studies, and artificial intelligence: how systems can bridge the divide between visual input and embodied subjective experience. While visual consciousness remains a hard problem, this article attempts to address one tiny piece of the difficulty. This study proposes a conceptual framework where visual-body mapping serves as the foundational mechanism for defining experienced reality. Rather than treating reality as absolute truth, we conceptualize it as dynamic interaction between internal cognitive processes and external environmental references, situated within a broader conceptual awareness structure. Through systematic layered inquiry (Q1, Q2, and Q3) combined with hypothetical thought experiments, we apply logical reasoning to explore perceptual boundaries and examine how conceptual frameworks shape our understanding of reality. The central contribution demonstrates that perceived "reality" emerges from the interplay of timing dynamics, structural positioning, and embodied perception. This visual-body mapping framework offers a forward-looking perspective for how AI systems might achieve human-like perception in the future - by recognizing the critical role of information processing speed and embodied perception in shaping real visual perception. From a scientific perspective, this paper outlines how possibly humans may experience visual reality, suggests two key implications: first, it provides a technological foundation for advancing human-centered AI innovation (robotics, intelligent machines, interface design, etc.). Second, it contributes a novel theoretical perspective on embodied cognition within cognitive science, suggesting new pathways for understanding how perception emerges through physical embodiment. While technological implementation may present challenges, it establishes valuable theoretical foundations and future experimental directions for future research in human-machine perception.

Keywords: Embodied Cognition, Visual Perception, Perceptual Processing, Predictive Coding, Perceptual Coherence, Cognitive Mapping, Perceptual Principles for Artificial Systems, Embodied Perception

INTRODUCTION

Study Context & Background Problem

How do we experience the world as we do? The nature of visual awareness has puzzled both philosophers and scientists for centuries. From the hard problem of consciousness [1] to modern computational models [2], the mystery remains high: how does a brain transform light into a meaningful visual experience?

Light carries external data in the form of images [3, 4]. Even in simplified conditions, such as black and white image, humans still perceive depth and structure [5]. This suggests that the brain does not passively receive images but actively constructs a 3D world of reality. Additionally, the same grey level can appear different depending on its surroundings [6], showing that contrast is not purely physical but also influenced by perception.

Science today typically describes vision as a process beginning with science physics interactions - such as light reflecting off objects with color - followed by neural activity in the brain, resulting in the experience of seeing the object's color. Yet this explanation, while biologically grounded, does not fully account for how subjective colorful experience arises. The fact that different observers can perceive different colors when viewing the same object [7], suggests that perception is not a one-to-one representation of the external objective world, but rather a construction shaped by internal interpretation. The idea that the real objective world exists beyond our mental experiences, as suggested by [8] in Brains and Realities, reinforces the view that we may live within a subjective reality. These observations raise critical challenges - not only for neuroscience but also for artificial intelligence systems that attempt to replicate or simulate human visual experience.

With advances in AI and neuroscience, an important question emerges: Can AI truly experience visual awareness, or is it simply simulating the surface of perception without genuine visual awareness? While artificial vision has achieved the estimation of 'seeing' depth from a single image [9], the structure of how visual awareness is perceived remains an open challenge (how light turns into a meaningful visual experience?).

Because of that unresolved challenge, while we respect the view that perception is entirely constructed within the mind, this paper offers a complementary direction. It proposes that visual awareness may involve not just totally internal reconstruction but also the real-time mapping of sensory input (vision) onto the physical world. Rather than challenging existing beliefs, this approach is intended to support progress in cognitive science and provide practical value, particularly for AI, robotics, and mechatronics engineering fields that may benefit from exploring alternative interpretations.

The subjective contents of human visual awareness are suggested to be either encoded in or emerge from neural activity [10, 11]. Furthermore, visual awareness is commonly described as the personal visual or subjective visual experience [11]. However, the exact mechanism by which human's brain gives rise to visual experience remains unclear [11]. Given this unsolved problem which likely spans a process from point A to point Z, this paper situates itself somewhere around point X. Therefore, it aims to explain how we ultimately link perception to the physical world to form what we call reality - this may be a very interesting way, but it is also a practical one, offering insights into this complex phenomenon.

While many pieces of the puzzle are still missing, this understanding (X) hopes to fill part of the unspoken gap and may help shape the future of AI and visual 'awareness', offering a conceptual basis that could support future models of artificial visual perception systems. It is believed that before exploring what consciousness is, visual awareness serves as a good starting point [11]. Visual awareness, then, is quite a broad concept that includes a range of subjective visual experiences [11]. Based on this perspective, this paper does not address the full scope of consciousness, but rather focuses more narrowly on the plausibility that visual perception maps onto the physical world in a way that makes humans believe they are experiencing 'real' reality (including the body itself).

This exploration proceeds by way of thought experiments and structured reasoning. As Nobel Laureate Richard Axel noted, "Put simply, we do not have a logic for the transformation of neural activity into thought and action" [12]. Others have similarly called for a new conceptual framework [13]. In response, this paper proposes a new way (a framework) of understanding visual perception - one that plausibly explains how perception might map onto the external world - guided by an explanatory structure that seeks to make sense (logic) of what we actually experience.

Problem Statement & Research Contribution

The problem statement addressed in this study concerns the unresolved mechanisms behind the subjective nature of visual awareness. Although modern neuroscience and cognitive science have made significant strides in understanding how the brain processes information, the mechanisms behind the subjective experience of reality remain unresolved; the concept remains a hard problem [1]. Visual processing is often described in terms of neural processing, which aligns these processes with mental imagery or direct vision, but does not fully explain how this process becomes the final subjective experience of reality. Any clue, theory, or conceptual argument could help - like placing one LEGO piece into this big gap.

The research contribution of this study is a new specific theoretical framework, developed through the exploration of distortion perspective in the philosophical inquiries of Q1, Q2, and Q3. This framework conceptualizes visionary imagery as being mapped onto physical reality. This model is not a full solution, but it offers a partial, practical way to clarify the transformation of vision into a subjectively experienced of the external world. This paper suggests a bold idea: Visual reality is a kind of real-time map of the outside world, connected to physical form, bounded by time and space.

Extending Embodied Cognition (EC) and Embodied Perception

EC has established that thought and perception are shaped by the body's interaction with the world. We respectfully build on this foundation by addressing a special direction in our framework. While EC traditionally frames the body as a contextual influence, we propose that visual-body mapping is not secondary, but foundational to how reality is constructed and stabilized.

This paper framework suggests the broaden idea of EC, where perception is actively formed through synchronized mapping between visual input processing and bodily structure. To highlight this deeper structural role, we suggest the term embodiception - the process by which embodied mapping generates partly of more comprehensive visual consciousness. Other term such as 'embodiness' (embodied consciousness) or 'embodimap' may further describe this view. But the goal is not to depart from EC, but to extend it - inviting renewed attention to the active role of the body in structuring perception itself.

While embodied perception, in this paper, refers to the alignment between internal visual representations and external physical objects, resulting in the experience of reality as directly present to the perceiver. It emphasizes that perception is not purely visual, but, is spatially grounded in physical context through active engagement of the perceiver with the physical world.

CONCEPTUAL FRAMEWORK & THESIS STANDING.

Thought Experiment Approach

To explore any clue of the fundamental nature of visual awareness, this study employs a thought experiment approach. Thought experiments serve as effective tools in science and philosophy, enabling the exploration of alternative explanations, the extension of existing theories to novel contexts, and the provision of counterexamples to prevailing theories, advancing theoretical insights [14].

By constructing controlled mental scenarios, guided by scientific principles [15], we can isolate key variables and test the logical consistency of our assumptions about perception and reality. Throughout history, thought experiments have played a crucial role in reshaping scientific perspectives. Notable examples include Einstein’s chasing a beam of light, Schrödinger’s cat paradox, and Maxwell’s demon, each so intellectually provocative viewpoints and inspired future breakthroughs.

This approach is particularly useful in discussions of visual awareness because it bypasses the limitations of empirical observation. Instead of relying on existing beliefs about subjective experience, which remain a hard problem [1], we examine visual awareness of visual reality from a conceptual standpoint, questioning not only how we see but also whether what we see truly represents reality.

By engaging with structured hypothetical scenarios, this paper challenges the conventional understanding of vision and reality. Perhaps in Inquiry Q3, this discussion will eventually lead to a new thought experiment called "The Scary Moving Ghost Hand." This concept introduces a surprising scenario designed to provoke a deeper understanding of the nature of reality.

The first thought experiment framework lays the groundwork for the inquiries in this article; each inquiry is designed to challenge assumptions about perception and its role in shaping reality. While Inquiry Q1 provides the foundation, Q2 and Q3 deepen and build upon it, seeking cracks in our everyday assumptions. What follows is more than an explanation. It is an invitation to question what vision truly shows us. This line of thought begins in 2.2 (grounding premise Q1) and deepens through 3.2 (Q2) and 3.3 (Q3), where familiar experiences are re-examined, and assumptions begin to shift.

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Inquiry Q1: Questioning Vision and Reality (Foundational for Premise Q1)

Before we challenge the assumption that vision reflects reality, we begin with a simple, relatable scene. This scenario may appear ordinary at first, something we would naturally trust without question, but it serves as the foundation for a deeper inquiry. By starting with what feels familiar, we follow a path that gently invites investigation, gradually revealing the hidden tension between what we see and what may truly be present.

Imagine a quiet stage, a space with a single chair placed at its center (Y) in Fig. 1. A woman is seated on the chair. After a while, she stands and walks away. A man approaches, preparing to sit. Naturally, one assumes the chair is now empty; both you, as the observer, and the man see the seat as unoccupied. This assumption seems unquestionable: if vision confirms that the chair is empty, then surely, the chair must be empty.

But does sight always guarantee physical truth? Can something still exist even if vision suggests otherwise? If vision and physical reality ever contradict one another, which should be considered the ultimate reference for what is real? This setup establishes a fundamental agreement: For reality to be truly coherent, vision (map) and physical presence must align. It serves as a controlled premise (Premise Q1) - where everything appears normal, before we later challenge this assumption.

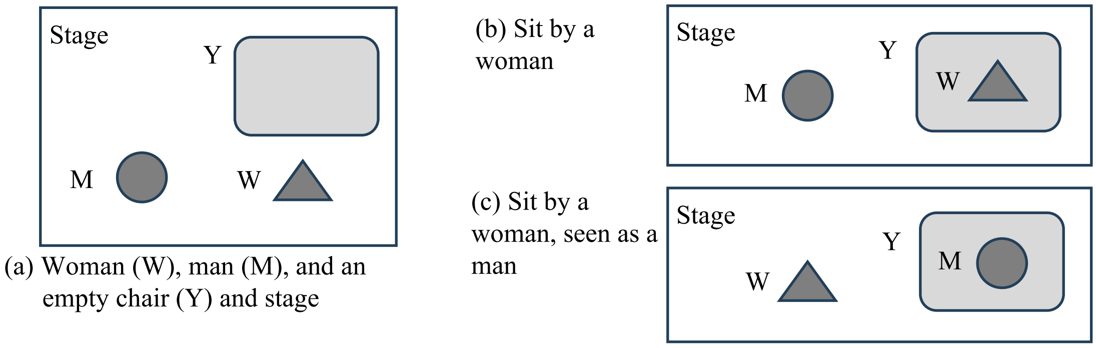

Fig. 1. A visual aid for Inquiry Q1 and Q2 (provided for reflection, though the discussion remains clear on its own) - placement (c) below (b) serves to reflect vision and reality in Q2.

DISCUSSION OF INQUIRY

A Guiding Framework of the Paper: The Role of Q1, Q2, and Q3

In understanding reality as a process of visual mapping to be completed, three key inquiries must be considered. Inquiry Q1 (2.2) establishes how visual mapping shapes the normal experience of reality in our daily lives. Yet, does this mapping always align with physical presence, or can it lead to contradictions? The initial assumption made here is that the premise is universal. Stick to the premise under two stress tests - Q2 and Q3 - and look for each exception.

Are there any hidden variables? This is a deductive test. Avoid assuming answers in advance, the goal is to test the validity of premise Q1 without bias, with the final aim of discovering any new hidden variable. Moving to Inquiry Q2 (3.2), what if the premise of Q1 no longer holds? Can physical reality appear different depending on the observer's position? Should we still accept that Q1 remains valid?

(a) If true, it supports the universal premise.

(b) If totally false, then Q1 is totally false.

(c) If partially true, but special condition (C2) exists, then either: (i) C2 falsifies Q1; (ii) C2 is part of the system under certain stress (suggesting a hidden variable).

Finally, Inquiry Q3 examines the implications of visual mapping at close range for self-movement. Q3 is designed to probe what kind of hidden variable is actually hidden in Q2, or even Q1 (which seems unsteady). Here, the special point of light enters the discussion: Does it merely enable vision, or does it actively shape how we perceive reality? Is this consistent with any leading theory today? Note: Although each inquiry may appear ordinary or somewhat strange, each has its own path or scenario to be explored - thereby opening a space and potentially introducing new paradigms to our understanding of reality.

Inquiry Q2: The Shifting Observer's Perspective and the Fracturing of Space

In the previous inquiry, we examined how ordinary perception can create a sense of certainty. Now, we continue by shifting the observer's position. Everything may seem the same at first, especially if clarity can still be maintained. But what if changing position alone begins to shape a different understanding? Can something as simple as where we stand influence what we believe to be true? Note: Some wording in this section adopts a philosophical tone to reflect the nature of the inquiry.

Imagine you are observing a stage - not from the front row, but from a shifted position - somewhere far, yet sharply focused. Your vision system has been replaced by a specialized, biological, telescope-like tool with multiple lenses, capable of seeing with perfect clarity, extending your gaze beyond the boundaries of ordinary perception. You can now view distant events with precision, as if you were observing the surface of another planet. Suppose for a moment that humans can live on a planet closer to the Sun. Through this enhanced system, the scene before you appear clear and detailed, despite its vast distance.

On the stage, a woman, a man, and a chair are present. You watch as the woman sits down. She rises after a while, walks away, and leaves the seat empty, just like before. Shortly after, a man, who had been observing the scene, steps forward and sits down in the now-vacant chair. To confirm your observation, you contact a friend who is situated closer to the stage. Using an advanced quantum communication device, one that transmits data almost instantaneously, you ask, "Who is sitting in the chair now, the man or the woman?" Your friend replies, "The woman."

This answer appears to contradict the observer's perception. If vision were the ultimate arbiter of truth, such contradictions should not occur. However, this suggests that vision does not directly represent physical reality, but instead functions as a system that generates perceptual outputs. This becomes clearer when the same scene is interpreted differently depending on observational position, as illustrated in Fig. 1(b) and (c).

Moments later, your friend adds, "The man sat there briefly, but soon after, the woman returned and reclaimed her seat. The man left. Now, the woman is sitting there." You continue observing, waiting for your system to align and synchronize with the actual state of reality. After a few minutes, the image of the woman finally appears in the chair, confirming your friend's version of what happened.

At this point, the vision system can be described as a push-button and image-sticker mechanism. When triggered by input, the system generates an image and projects it into awareness (C2). However, this image is not necessarily coupled to the physical source of the event. Instead, perception operates as an output-based system rather than direct access to the physical body. This limitation is analogous to the Doppler Effect, where the received signal differs from its source due to system constraints rather than misrepresentation.

But this raises a deeper question: Which version is real - the perceived image or the physical body itself? Within this framework, the brain operates as a push-button and image-sticker mechanism that projects updates into awareness. Consequently, reality seems like a sequence of image updates rather than an immediate representation of the physical world. From this perspective, the assumption in Q1 - that vision directly reflects physical reality - becomes unstable. Note: The concept of "distance error" is set aside, as the focus is the assumption in Q1.

Conclusion: This Q2 setup challenges a fundamental assumption - can vision be trusted as the ultimate reference for reality? The earlier premise in Q1 - where visual perception reflects physical truth, now appears unstable. Instead, the push-button and image-sticker scenario (C2), illustrated in Fig. 1(b) and (c), shows how one may perceive a man, while in reality it is a woman. Such a realization invites deeper investigation in Q3 - to explore further consequences that may offer meaningful clues and probe any hidden variable or new critical understanding.

Note 1: Though speculative, this scenario is grounded in logical modeling of perceptual delay and system-based interpretation - inviting further reflection. Note 2: The scenario in C2 is also referred to as *Force Mapping*, interchangeable with the philosophical term as *push-button* and *sticker mechanism.*

Inquiry Q3: Perception and The Fragile Sense of Unity

The stage dissolves. The man, the woman, the chair, fade away. All that remains is you. So far, the inquiry has focused on external scenes. Now, we shift inward, questioning whether the unity of your own body is still a unity. Note: Early in the discussion - also a condensed philosophical tone.

In this final section, imagine yourself standing in an empty space, free from any distractions. You raise your right arm, then move it to the left, forming a horizontal line, that creates a 90-degree angle. The motion feels fluid, and you sense your muscles are shifting. Everything appears synchronized - your hand motion and your visual perception are one and the same.

But now, suppose your vision system is delayed. Much like a slow transmission from a distant star, the image of your arm takes time to reach your eyes. You move, yet for a moment, you see nothing. Then, the image arrives - but it is not the present. It is a trace of what has already occurred.

To imagine this more clearly, picture the light from your hand not going directly to your eyes, but bouncing off a faraway planet before returning. The image you finally see is still your hand - but from three seconds ago. Whether the delay results from extreme distance or slow speed, the result is the same: what you see is no longer now.

You attempt to reconcile this. The body moves in real time, while your vision lags behind. Which version do you trust - the one you feel, or the one you see? A fracture emerges. The unity of motion and sight, once unquestionable, now crumbles. Imagine a friend observing you from a different position, but using a system that does not rely on light - one that allows them to perceive your motion instantly, without any delay. They see your arm move instantly, while your own eyes display the past. When you both describe the same event, which story should be believed?

Now, consider a controlled experiment. You are in the laboratory setting where the effective speed of light is treated as a variable parameter. At its natural speed, light bridges the gap between movement and perception so seamlessly that no delay is perceived. However, as this propagation speed is reduced, the separation between action and perception becomes more pronounced. You lift your arm, yet the visual representation remains momentarily unchanged. Seconds pass before the delayed image catches up.

In that interval, do you truly exist? In what form? Or has your existence fractured into two - one governed by physical reality, the other by visual awareness of the body? In that moment, the feeling of unity between self-image and physical body fades away.

But what if the lights were infinitely fast again? What if no gap existed? In that case, your perception would once again match your movement, and the unity between your self-image and body would remain unbroken. It is only when the speed of light slows or when the delay is exposed - that we see the truth. The unity of self-image and body is fragile, actually - it looks strong, but can easily snap, maintained together by light acting as a master clock.

And so, we reach an unsettling realization. What you see may never be what truly is. The body you trust, the world you observe - are all governed by the silent command of the speed of light. The unity you once assumed was natural may, in fact, be nothing more than the illusion of unity. Reality, once thought to be a unified experience, now reveals itself as a layered projection.

Finally, this framework suggests that the very high speed of light plays a critical role in maintaining temporal alignment between perception and bodily action, enabling a stable experience of unity. This rapid mapping of sensory information to bodily states may help explain why perceptual coherence is typically maintained under normal conditions. Q3 findings are consistent with prior discussions on embodied presence [16] and particularly regarding the continuous updating and synchronization between sensory input and predictive mechanism [17].

While the brain may rely on predictive processing for rapid sensory updating, the present framework highlights the importance of fast sensory transmission in maintaining perceptual coherence. Together, these processes may help stabilize the alignment between bodily perception and experienced reality, consistent with predictive processing discussions on perception, brain, and action [18].

What if the speed of light were even faster than it already is - extremely super-fast? In that case, the temporal gap between body and vision (its image or "visual skin") would become negligible, leading to near-continuous alignment between movement and perception. Under both long-distance conditions (Q2) and varying temporal-speed conditions ranging from slow to normal (Q3), perceptual mismatches would be significantly reduced or no longer noticeable. This suggests a gradual continuity across Q1, Q2, and Q3, rather than a strict separation between them.

DISCUSSION

Q1 states a thesis: if visual input is correctly mapped onto the physical body, a coherent embodied reality is consistently experienced. The thesis then becomes a principle testable premise within this conceptual framework.

While Q2 shows the thesis becoming unstable, it also reveals that the mapping process can operate reflexively (C2), leading to altered perceptions when the mapping is disrupted. Q3 introduces the speed of light as a critical external factor. When the speed is significantly reduced, the system struggles to maintain coherent embodied perception, reflecting the importance of rapid sensory updating. extending the inquiry further, if perceptual updating were hypothetically instantaneous, the mapping process would approach near-perfect coherence across all the inquiry scenarios.

The uniqueness of Q2 is that, while it shows a failure of the proposed thesis, at the same time, it demonstrates that the mapping process is indirectly applied to a certain extent (C2). which we also called: force mapping. Q3 indirectly connects with predictive coding, which is an increasingly popular theory in brain study [16, 17]. This theory emphasizes the system's continuous prediction process and its use of input data to minimize prediction errors.

Finally, within this conceptual analysis, every object that moves and maps our reality must remain intact - mapped in real time - supporting a coherent sense of perceived reality. This likely requires rapid predictive processing together with high-speed sensory feedback. The combination of predictive systems and rapid visual updating may contribute to maintaining stable perceptual coherence in experience, consistent with predictive coding approaches.

Extending this discussion, we highlight applications of vision in search and rescue robots [19, 20] as an illustrative example of how perceptual processing principles may be so important in real-world systems. This is relevant in contexts where rapid visual updating is critical, particularly when response time must be minimized while maintaining safety for both robots and victims [19]. Human-like perceptual processing may play a key role in the effectiveness of such operations.

CONCLUSION

As Chalmers wrote 30 years ago: "There is nothing that we know more intimately than conscious experience, but there is nothing that is harder to explain" [21]. His return in Reality+ [22] suggests that the hard problem of consciousness remains unsolved. This paper introduces a conceptual framework developed through logical reasoning and philosophical reflection to explore the implications of the thesis on visual experience of reality. It focuses on the idea that visual perception is not simply the passive reception of images, but an active process that maps the visual system to the physical world. This mapping process helps generate the sensation of directly perceiving external objects at the locations where they are believed to be. This interpretation (proposed as a conceptual framework) offers a perspective for understanding how visual experience becomes connected to the external physical world (related to embodied cognition in cognitive science) and may also provide insights into how AI or machine systems could one day replicate similar forms of perception.

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