PhiMiSci
Philosophy and the Mind Sciences

Molyneux and motor plasticity

Shaun Gallagher[a] (s.gallagher@memphis.edu)

Abstract
Most discussions of neural plasticity in the context of the Molyneux question focus on changes in the visual cortex, early on during critical periods, or post-surgery after patients are given sight. There are good reasons, based on enactive approaches to perception to ask about plastic changes in the dorsal visual pathway and motor control areas. This essay explores the implications of such changes for the Molyneux question.

Keywords
Dorsal visual pathway · Egocentric spatial framework · Motor control · Neural plasticity · Sensory-motor contingencies

This article is part of a special issue on "Molyneux's question today", edited by Gabriele Ferretti and Brian Glenney.

1 The Molyneux Question

Ernst Cassirer (1951) called the Molyneux question the central question of eighteenth-century epistemology and psychology, and it was still being discussed by psychologists, neuroscientists, and philosophers throughout the 20th century. Molyneux's question to John Locke: Would someone who is congenitally blind and who is then "made to see," by means of surgery for example, be able to distinguish between a cube and a sphere which he had learned by means of his haptic sense? I'm later going to highlight some of the specifications that Molyneux provides for any experiment that would answer this question – that the objects be made of the same material, and that they be placed on a table in front of the person to be tested, and that the person must use sight alone, prior to touching the objects.

I argue in this paper that these specifications are important. I also argue that the key to answering Molyneux's question involves properly understanding plastic

[a] University of Memphis.

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

changes, not just in the visual areas of the brain, but also in areas involved in motor control. After a brief history of how philosophers have answered Molyneux's question, I look at the empirical-experimental literature in relation to the issue of plasticity. I then consider the significance of plasticity in the context of the enactive view of perception.

It's well known that most philosophers and psychologists, including Locke and Molyneux himself, have answered 'No' to this question, although a few have answered 'Yes'. Both the 'yes' and 'no' answers are usually based on what Gareth Evans (1985) called "background theories of perception." A negative answer to the question usually implies a theory of perception in which access to a meaningful external world is not direct but mediated in a process that synthesizes sensations belonging to different sense modalities. Berkeley, Condillac. Diderot, and Wm. James agree with Locke on this. Locke (1979) thus begins a tradition of the most frequently given answer: 'no'. Because perception is not innate; it must be learned. Perception is educated by experience -- but the eyes of the blind man have not been educated. Moreover, vision does not communicate with the tactile sense; and experience in one sense modality does not educate other sense modalities. Experience in this Lockean sense consists of frequent and repeated sensation which leads to the formation of habit or custom, which shapes judgment, and which in turn, alters and improves modality specific perception. The 'no' answer has also been reinforced by empirical results from experiments with patients who have had sight restored after cataract surgery or corneal transplants. For the Molyneux patient, in the initial visual perception post-surgery, "everything is at first confused and apparently in motion. Discrimination between coloured surfaces and the correct apprehension of movement do not come until later, when the subject has learned 'what it is to see' […]" (Merleau-Ponty, 2012) – likewise the visual discrimination of cubes and spheres.

Positive answers to the Molyneux question are more rare, and they may imply a more immediate perceptual access to the world on the basis of an innate intermodal system in which different sense modalities are already in communication. Alternatively, as Leibniz (1896) responded, one needs to consider the contribution of higher-order cognition – geometrical knowledge that would allow the patient to reason out what he was seeing. Leibniz is usually said to be answering a question different from Molyneux's which specifically asks whether the patient would succeed with vision alone – not with vision plus reason.

Empirical studies have advanced our understanding on these issues and have shown:

1. That the idea that sense modalities do not naturally communicate, or that the education of one sense modality does not educate other sense modalities is not quite right.

2. That plasticity plays a major role in working out an answer to the Molyneux question.

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

3. And that Molyneux patients can help us understand more about plastic changes in the visual system.

The idea that sense modalities do naturally communicate points in the direction of a 'yes' answer at the same time that the realization about plasticity motivates a 'no' answer. In this regard it's helpful to look at the developmental context.

2 The developmental context and neural plasticity

The traditional view on development, consistent with the Lockean view, is "that vision must be very imperfect in an infant that opens its eyes for the first time, or in a blind person just after his operation" (Diderot, 1977). As James (1950) famously put it, the experience of the newborn is "a blooming, buzzing confusion." On this view, the newborn is equivalent to the Molyneux patient. But this has been challenged by more recent experimental studies.

First, consider the characteristics of newborn vision. Infants have sufficient acuity to resolve details at close range; they are capable of contrast sensitivity to perceive spatial patterns; their visual experience involves cortical activity, signaling some degree of control (and not just subcortical functionality). Indeed, infants demonstrate overt control of attention and selection of objects via their eye movements; active searching for visual stimulation; the ability to habituate to one stimulus and to show preference for novel visual stimuli. They also show preference for some objects over others (e.g., moving objects rather than stationary objects; three-dimensional objects rather than two-dimensional ones; high contrast rather than low-contrast stimuli; patterns with curved rather than straight lines) (Atkinson et al., 1989). In addition, they are capable of short-term visual memory (Slater, 1989); they are sensitive to motion parallax so that distant objects appear to move less than closer objects when the infant moves its head. Directly relevant to the Molyneux question, they have the capacity to discriminate geometrical shapes, such as triangles, squares, and circles (Landau et al., 1981; Slater et al., 1983; Slater, 1989; Slater & Morison, 1985a). Their vision is characterized by shape constancy, that is, across changes in orientation or slant, neonates are capable of recognizing the real shape of an object (Slater & Morison, 1985b); and feature constancy – recognition of invariant features of an object across certain varying features, such as moving versus stable objects (Slater, 1989). Newborn vision is not perfect, but it does manifest some subtle and sophisticated properties.

Andrew Meltzoff (1993; Meltzoff & Borton, 1979), in an experiment titled "Molyneux babies," has shown that infants shortly after birth are able to see and visually discriminate shapes learned tactilely (also see Sann & Streri, 2007, 2008; Streri, 1987; Streri & Gentaz, 2003, 2004). He used smooth versus nubbed pacifiers which the infants first explored tactilely with their tongues without seeing the pacifiers, and then successfully differentiated between them visually (measured by looking times). This suggests that perceptual modalities do communicate, and

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

they teach themselves very quickly. This gives us reason to believe, in light of a variety of empirical studies, that, *pace* Diderot, newborns are not equivalent to Molyneux patients. But if perception is intermodal right from the beginning, then what accounts for this difference? The answer involves plasticity. To see this, consider Gareth Evans's (1985) positive response to the Molyneux question.

Assuming that the empirical 'no' answer may be based on poorly functioning vision due to complications of surgery (inflammation, etc.), Evans proposed a thought experiment: By means of direct electrical stimulation of the visual cortex, a pattern of experienced light flashes (phosphenes) in the shape of a square or circle could be caused in a patient with congenital blindness. The direct experience would bypass any problems of imperfect vision caused by surgery. Evans argued that under such circumstances the patient would indeed be able to tell which is the circle and which the square – a difference originally learned by touch. This positive answer depends not just on eliminating problems due to surgery, but on the idea that the way vision and touch are intermodal depends on a common egocentric spatial frame of reference that applies to both. The square would sit within my egocentric space in the same way whether I access it by vision or by touch – and it would sit differently than does the circle.

A real experiment has approximated Evan's proposal. An artificial vision system developed by Dobelle (2000) completely by-passes a non-functional retina by feeding a signal directly to the blind individual's cortex. A video camera mounted on glasses worn by the user feeds the images to a portable computer attached to the user's belt. The computer has dedicated software for on- line edge detection. Signals representing the relative positions of the detected edges are converted into electrical impulses that are used to activate electrodes arranged on a rectangular matrix mounted on a plaque implanted on the individual's cortex. Thus, the relative spatial structure of the edges in the video scene is preserved in the spatial structure of the electrode activations. Activation causes the subject to experience flashes (phosphenes) in the surrounding space. The spatial structure of these flashes preserves the spatial structure of the videoed edges. Unfortunately, the results from such experiments are unclear due to imperfect implant technology. Instead of complications from the eye surgery, there are complications from the surgery needed to implant the electrodes. In addition, however, test subjects were not congenitally blind. One subject, blind at age 36, had some success. Another subject, age 62, blind at age 5, was unable to see the phosphenes. (see Jacomuzzi et al., 2003 for further discussion).

Whether this procedure could settle the matter in the future may depend on the precise nature of the implanted device. If the device is designed to directly stimulate the subject's visual cortex (as is currently the case) then it will likely lead to a negative answer. If, in contrast, the implant were designed to act *in place of* the visual cortex (i.e., as an artificial visual cortex), it might support a positive answer. The reason this difference matters is due to neural plasticity.

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences, 5.* https://doi.org/10.33735/phimisci.2024.11596

Neural plasticity tells us why Evan's positive answer is wrong, and why the Molyneux patient is different from the newborn with respect to perception. This explanation was originally framed in terms of critical periods, discovered by experimenting with cats (Hubel & Wiesel, 1963), and clinically by examining results of childhood cataract surgery. Starting with newborn vision (see above) proper (mature) development of neurons in the ocular dominance columns of the visual cortex require visual experience during a critical period. Deprivation of visual stimulation during the critical period (as in experimental monocular deprivation, or in congenital blindness) stunts the development of neurons.

This means that the neuronal structure in the visual cortex of the Molyneux patient is not identical to the visual cortex of neonate's, or to the normally developed visual cortex. "Will the Molyneux patient visually be able (or have the visual capability) to distinguish the cube from the sphere?" The answer is clearly 'no' – and that is also the answer even if you bypass the eyes and go directly to the visual cortex (as in Evans). The Molyneux patient will not be able to see in an adequate fashion, and therefore will not be able to distinguish cube from sphere. This 'no' answer is not because sense modalities do not communicate (Meltzoff-like experiments show that modalities are intermodal from the beginning), but rather because of the facts of neurological development or deterioration through critical periods. Accordingly, Degenaar (1996), reflecting the conclusions drawn from the work on critical periods, suggested that "congenitally blind people cannot be made to see once their critical period is passed" (p. 132).

More recent research on plasticity, however, should lead us to discount the concept of critical periods. "[T]he human brain retains significant potential for plasticity, which extends well after the end of the traditionally conceived critical period" (Hallett, 1999; Occelli, 2020, p. 220; but see Huber et al., 2015; and Beyeler et al., 2017 for some limitations in this regard). The brain remains plastic even in adulthood – and this is consistent with more recent experiments with Molyneux patients.

Plasticity explains why 'no' is the correct answer to the empirical Molyneux question; at least at first, using vision alone, the Molyneux patient will not be able to distinguish cube from sphere. In contrast, however, the "in principle" Molyneux question ignores plasticity: *If* the Molyneux patient *could be made to see* the shapes in question, therefore assuming no plastic changes in the visual cortex, could he distinguish cube and sphere? Molyneux actually stipulated that the blind man is "made to see"; assuming the patient can see the shapes, then the question is whether in that case he would be able to distinguish the shapes. Consider a hypothetical subject (see Gallagher, 2005). This subject

- has been blind from birth
- has suffered no neuronal deterioration in the visual cortex
- is able to discriminate a cube from a sphere by touch, and

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*.
https://doi.org/10.33735/phimisci.2024.11596

- is either given sight or, following Evans, is subject to direct cortical stimulation, eliminating any surgical side effects or technical complications.

Given (a) no neuronal deterioration and (b) intermodal sensory modalities, then the answer should be ‘yes’. Accordingly, it seems possible that one can say empirically ‘no’, but in principle, ’yes, and have these answers be consistent.

3 An enactive response to Molyneux

What theoretical role does plasticity play in enactive approaches to cognition? Consider Alva Noë’s view on the Molyneux question. He argues for a ‘yes’ answer. At first it seems that he offers a contrast to Evans’ argument that a common egocentric spatial frame of reference provides the basis for a correlation between vision and touch; instead, Noë rightly argues that vision operates on a different set of sensory-motor dependencies than does touch. That seems to suggest that intersensory coordination will not be so easy for the Molyneux patient.

> This is the key to the enactive approach to Molyneux’s question. The sensorimotor dependencies that govern the seeing of a cube certainly differ from those that govern the touching of one, that is, the ways cube appearances change as a function of movement is decidedly different for these two modalities. *At an appropriate level of abstraction,* however, these sensorimotor dependencies are isomorphic to each other, and it is this fact – rather than any fact about the quality of sensations, or their correlation – that explains how sight and touch can share a common spatial content. (Noë, 2004, p. 102, emphasis added)

The appropriate level of abstraction, however, corresponds with Evans’ appeal to the common egocentric spatial frame of reference. With respect to the spatial properties of perception, there is an abstract structure or frame of reference for our sensory-motor experience which is not specific to a particular sensory modality but is a function of possible bodily movements associated with perception. This is not Leibniz’s geometrical reasoning, but it’s more like an embodied geometrical know-how. The spatial properties of various objects, such as a cube and sphere, are associated with transmodal sensory-motor profiles, which are, at an appropriate level of abstraction, isomorphic across the modalities.

> If something looks square, then one would need to move one’s eyes or head in characteristic ways to look at each of the corners. One would have to move one’s hands the same way (at the appropriate level of abstraction) to feel each corner. (Noë, 2004, p. 102)

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

Accordingly, Noë's 'yes' answer is very similar to Evans's 'yes' answer (*minus* the thought experiment, *plus* a more enactive concept of the egocentric spatial frame of reference). Like Evans, however, Noë fails to take plasticity into account, and his argument starts to break up on the rocks of empirical studies. The problem is not that Noë's discussion of the empirical literature on the Molyneux question focuses narrowly on Cheselden's (1728) studies. Although he mentions von Senden's (1962) 20th-c studies he does not discuss them, and the most recent major set of studies, Project Prakash, didn't get going until 2005. Rather, the problem is that he tries to side-step the empirical conclusions.

All of these studies continue to tell us that 'no' is the right answer to Molyneux's question. To get around the empirical issues, Noë points to something central and definitional in the enactive story: Perception is not just sensory, it's sensory-motor. He argues that sight (in the full sense of visual perception) was not restored in Cheselden's patients; only sensory input was restored.

> Cheselden's boy did not have his vision restored by the surgery [...]. To see one must understand the sensorimotor significance of these impressions. This necessary knowledge is absent in Cheselden's boy. He hasn't yet learned to see. (Noë, 2004, pp. 102–103)

Like Locke, Noë holds that one needs to learn to see, in the sense of learning sensory-motor contingencies (which are different for vision and touch) – and you can't get to the proper level of abstraction – the common egocentric frame of reference – until you have that kind of knowledge or know-how. So the 'no' answers are wrong because sight was not restored.

Here, however, is a complication from one of the Prakash studies. Within 48-hours post- operation, patients are able to match a visual stimulus object with a visual target object (an intramodal "vision-to- vision" task) on the basis of shape. That is, the patients' visual perception of form was sufficient for visually discriminating between test objects. Their visual perception was already operating in a way that allowed them to see and distinguish different shapes (Schwenkler, 2012). Accordingly, it would be difficult to argue that they were not visually perceiving or actually seeing the shapes, as Noë suggests. In that case either (contra Noë) vision does not depend on sensory-motor contingencies, or sensory-motor know-how is not absent, which implies either the patients did not have to learn to see, or 48 hours is sufficient time for learning those contingencies.

Importantly, however, and problematic for Noë if he wants to maintain the 'yes' answer and insist that the Molyneux patient is not yet seeing, the fact is that the patients can pass the *intra*-modality tests, but not the *inter*-modality tests – it takes them closer to 5 days to pass the latter (Held et al., 2011). For the 5-day tests, patients are given only natural real-world visual experience, but no training. Here the researchers opt for an explanation that would be perfectly consistent with Noë's account: patients rely on "strategies using two-dimensional features, such as corners, edges and curved segments, that would be apparent across both domains"

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

(Held et al., 2011, p. 552). In Noë's terms, the patients, only at that point had true visual perception and were able to make the connections at the appropriate level of abstraction, allowing them to access or establish the transmodal sensory-motor profiles – it just took them 5 days to learn this. At that point visual perception is established and they are able to distinguish shapes crossmodally in the proper way.

To maintain Noë's 'yes' answer, one would have to accept his definition of perception such that perception only happens when the proper sensory-motor knowledge is operative; and assume at 48 hours it's not yet perception, but mere sensory differentiation. This would require us to endorse the odd claim that the patients in the Prakash study are initially able to visually distinguish different shapes although not able to visually "perceive" (or "see") different shapes. If the patient can see and distinguish shapes in the visual-visual condition, but not at first in the tactile-visual condition, then the answer to the empirical question remains 'no'.

4 The role of plasticity

Should we start to formulate our answer to the Molyneux question 48 hours or 5 days after surgery? This is where the unmentioned plasticity could help. Noë's argument is worked out without mention of neural plasticity. Evans' thought experiment is undermined by the pre-surgery early critical period plasticity; Noë's enactive view is complicated by the later post-surgery plasticity. There is a great deal of complexity about different functions that are affected both by early plasticity and later plasticity (Occelli, 2020). In the context of the Molyneux question, whenever plasticity has been discussed, it has been limited to plasticity in the sensory areas – especially in the visual cortex (e.g., Fine et al., 2003; Hubel & Wiesel, 1963; Huber et al., 2015). I suggest that the enactive approach should make us consider plasticity in the motor areas – or more specifically, the complex plasticity involved in sensory-motor integration areas (see Ortiz-Terán et al., 2016).

I want to focus on the role of the dorsal visual pathway – which leads directly to motor control areas of the brain, and includes, for example, the parietal posterior cortex, involved in egocentric spatial processing (Chebat et al., 2020) – and the role of sensory-motor integration. I'll suggest that the dynamical processes of not only brain areas, but also of brain-body coupling, undergo plastic changes in Molyneux cases. I'll first point quickly to some work in this area that provides clues for how to think about these kinds of pervasive plastic changes. I'll then suggest an enactive empirical design to test this idea.

The clues can be found in cases of aproprioception. Consider two examples. First, the well- known case of IW who suffered the selective loss of proprioception and touch at the age of 19 years (Cole, 1995; Gallagher & Cole, 1995). A second more recent case is KS who lives with the complete *congenital* absence of somatosensory signals, proprioception, touch, temperature, pain, smell and taste; although vision, hearing and vestibular balance are still intact) (Gallagher, 2022; Miall et al.,

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

2021). As one might expect, there are some differences in their behavioral performance: KS is surprisingly quicker on motor planning for reaching tasks than IW or controls. Miall et al. study reaction times in KS and IW, asking them to indicate whether they can reach an object placed on a table at which they are sitting. Setting aside the differences in sense modality deficits (for KS and IW, deficits in proprioception rather than vision) this design is not totally unrelated to one of Molyneux's questions to Locke: "Whether [a Molyneux patient] Could know by his sight, before he stretch'd out his Hand whether he Could not Reach them."

The difference between IW and KS on this test may involve plastic changes relevant to the dorsal visual stream and motor control areas. IW, who was capable of normal movement until he was 19, had to learn to move differently, without proprioception, and primarily by visual control. IW controls most of his movement with "top-down" conscious vision involving the slow, ventral pathway rather than the faster dorsal route (Renault et al., 2018). Although the loss of touch and proprioception in IW was due to peripheral damage, this likely led to some plastic changes in processes that involve intersensory integration. In motor control areas, proprioception (and touch) are usually closely integrated with the visual signals delivered via the dorsal stream that typically serves motor control/body-schematic functions. IW's system, up to the age of 19, had included sensory integration of vision with touch and proprioception; this integration was disrupted at the onset of the deafferentation. The dorsal visual signals arriving at motor-control areas would be confused at not finding integration partners, proprioception and touch, leading to delayed and possibly derailed processing and inevitable plastic changes in these areas. IW thus turns to ventral visual processing to manage motor control.

In contrast, in KS, one suspects that her dorsal visual pathway delivered, from the very beginning, a fast processing of visual input that did not have to get integrated with somatosensory signals (which were genetically absent), but could automatically update some aspects of the motor system in a more straightforward streamlined processing. From the beginning her visual system could attune her motoric processes in a way that is quicker, more direct and less complex.

Congenital absence of vision and the surgical establishment of vision in Molyneux patients would involve both prior (critical period) and subsequent (to surgery) plastic changes, analogously affecting the same dorsal pathway/motor-control system. Post-surgery vision would be a new addition requiring integration, and the requirement of new plastic changes would explain why it takes some time to establish the sensory-motor know-how and, consistent with the empirical results, why the results are never perfect. In the Molyneux patient, the vision established in 48 hours may be a ventral pathway process primarily; sensory-motor integration and the establishment of sensory-motor contingencies, depending on the dorsal pathway and areas involved in sensory-motor integration, seemingly take 5 days or longer.

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

Assuming an enactive view of perception, i.e., that it is action-oriented, I have previously suggested an experiment that focuses on the dorsal pathway/motoric processes, specifically testing sensory-motor contingencies. (Gallagher, 2005)

The dorsal pathway test

- On a table in front of the newly sighted subject there are two "apples," one a piece of fruit, and the other an iPhone – they could be any two objects that elicit different hand and finger postures when grasping.
- One should ask the newly sighted subject to hand one of the objects to the experimenter; and then the other object.
- The shape of the subject's hand just prior to grasping the object will tell us whether she is able to distinguish the shape of the object by her sight, before she touches them.
- One would have to think that she had learned to grasp such objects via the tactile modality alone, so that, on the one hand, if her visually guided grasps are appropriately shaped to the objects prior to touching them, then there is some very basic level (rather than some appropriate level of abstraction) where sensory-motor contingencies operate intermodally, and the answer to the Molyneux question (or at least this version of it) would be 'yes'.
- On the other hand, if her grasp is not well-formed in relation to the relevant object, the answer would have to be 'no'.

The results of this experiment could, in principle, address a deficiency of Noë's analysis. Here we come back to Molyneux's instructions. The fact that Molyneux's cube and sphere are meant to be table-top undermines Noë's claim about the common aspects of visual and tactile perceptions, at some level of abstraction – i.e., that "one would need to move one's eyes or head in characteristic ways to look at each of the corners. One would have to move one's hands the same way [...]." (Noë, 2004, p. 102). On the table top, given the size of cube and sphere, visual perception would be all at once and without the need for moving head or eyes to corners, as one would do with touch alone. Visual and tactile would remain quite different in terms of sensory- motor contingencies, and no level of abstraction would be relevant.

The proposed experiment would also allow us to get at the sensory-motor contingencies more directly as they are reflected in motoric behavior – in instances of reaching and grasping. It also presents an alternative to the traditional focus on the question of object recognition that typically gets explained in terms of representational processes (Toribio, 2020) narrowly confined to visual cortex. Instead, it

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

exploits the fact that very basic perceptual affordances are processed by the dorsal visual pathway (specifically constraining the shape of the grasp in reaching-grasping, such as preparing to pick up an apple or an iPhone) (Chong & Proctor, 2020; Jeannerod, 1996).

One complication: the distinction between ventral and dorsal visual pathways (Milner & Goodale, 2006) is likely not absolutely clear-cut since there is some neurological integration of the streams (see, e.g., Ferretti, 2018; Jacob & Jeannerod, 2003 for some detailed considerations; likewise, Noë, 2011; Noë, 2012, who is skeptical of the neuropsychological data about ventral and dorsal pathways). Still, in the case of congenitally ocular blindness both ventral and dorsal pathways will have undergone early plastic changes, and sensory-motor integration may still not be established even if, in the best scenario, the patient had the early visual acuity described in the post-surgical visual-visual condition by Held et al (2011). Accordingly, Gabriele Ferretti (2018) anticipates that the Molyneux patient's grasp (in my proposed experiment) would not be well formed and the answer would be "no". Indeed, something very close to this experiment has been run, and the results suggest that we would not have to wait 5 days, or even 48 hours for sensory-motor integration.

Chen et al. (2016), in a variation of the dorsal pathway test, tested a 44 month-old child upon removal of her eye bandages 16 hours after surgery to correct congenital cataracts.

> After 6 min she started to fixate on and track objects […]. Within 2 min of presenting [an] orange slice the observer saw her tracking an orange slice […] but she did not grasp it. She then started to fixate on and reach, usually inaccurately, toward orange slices held by her interpreter. She leaned forward so her face was close to the orange slice, then reached past it and brought her hand back toward herself to grasp it […]. Despite many misses and adjustments […] [at] 19 min, she started fixating on orange slices held by three people and reached toward them with increasing accuracy. By 23 min, she accurately reached for them with relatively smooth ballistic movements and grasped them in a natural manner on almost every trial. (Chen et al., 2016, p. 1070)

The child had about 20 minutes of practice or experience that allowed for an integration of tactile and visual modalities in dorsal stream/motor-control dynamics. Indeed, Chen et al. describe it as a case of rapid (plastic) integration. Ferretti (2018), however, refers to it as a case of "re- calibration" in eye-hand coordination. The different terminology points to an ambiguity between what could count as calibration (or re-calibration) of already existing capacities *versus* the kind of plastic changes that would constitute an integration of sense modalities based on learning (see Occelli, 2020). Sensory-motor recalibration or adaptation, for example, takes place as the result of wearing prism glasses that shift the visual field a certain angle to left

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

or right (Rode et al., 2015; Rossetti et al., 2015). One could assume that a similar re-calibration would need to occur with respect to the shape of one's grasp if one dons glasses that change the apparent size of the object. Such re-calibrations seem to be just a re-attunement or fine-tuning of intermodal correlations that already exist, similar to the re-focusing process that may take some time after one moves from complete darkness into bright light. Occelli (2020), however, commenting on the 5-day test in the Prakash experiments, suggests this sort of re-calibration. "The rapidity by which crossmodal transfer is established suggests that the neural substrates responsible for crossmodal interactions are already present, but in a covert manner." Such re-calibrations seem rather different from establishing or re-establishing neural connections via the effects of longer-term plasticity.

5 Conclusion

By pursuing the Molyneux question we end up with more questions than answers. Assuming that visual perception does not begin before bandage removal, is the relevant measure intra-modality object recognition (after 48 hours), or inter-modality tests (after 5 days) (Held et al., 2011), or sensory-motor coordination that depends on the dorsal visual pathway (after 23 minutes) (Chen et al., 2016)? If we settle on one of these measures, the empirical answer may still be ambiguous. It depends on (1) how strictly one stays with Molyneux's question which specifies that the Molyneux patient is "made to see"; (2) What background theory of perception one holds, or how precisely in this regard we define visual perception – must it involve motricity and not just sensory processing, for example (Noë, 2004)? (3) What sort of neural plasticity is involved (dorsal-motoric *versus* visual cortex; early critical periods versus late post-operation; calibration of covert connections *versus* establishing and integrating new neural connections)? (4) How close does the formulation support the in-principle question rather than the empirical question?

The age of the subject (3-4 years) in Chen et al.'s experiment *versus* older patients in the more standard experiments, may also be an important factor to consider. Answers to Molyneux can take different shapes depending on how one addresses these issues, and it may be impossible to see definitively which is 'yes' and which is 'no'.

References

Atkinson, J., Braddick, O., & Bremner, G. (1989). *Development of basic visual functions* (A. Slater, Ed.; pp. 7–42). Lawrence Erlbaum.

Beyeler, M., Rokem, A., Boynton, G. M., & Fine, I. (2017). Learning to see again: Biological constraints on cortical plasticity and the implications for sight restoration technologies. *Journal of Neural Engineering*, *14*(5), 051003. https://doi.org/10.1088/1741-2552/aa795e

Cassirer, E., Gay, P., & Cassirer, E. (1951). *The philosophy of the Enlightenment* (F. C. A. Koelln & J. P. Pettegrove, Trans.). Princeton University Press.

Chebat, D.-R., Schneider, F. C., & Ptito, M. (2020). Spatial competence and brain plasticity in congenital blindness via sensory substitution devices. *Frontiers in Neuroscience*, *14*, 815. https://doi.org/10.3389/fnins.2020.00815

Chen, J., Wu, E.-D., Chen, X., Zhu, L.-H., Li, X., Thorn, F., Ostrovsky, Y., & Qu, J. (2016). Rapid integration of tactile and visual information by a newly sighted child. *Current Biology*, *26*(8), 1069–1074. https://doi.org/10.1016/j.cub.2016.02.065

Cheselden, W. (1728). VII. An account of some observations made by a young gentleman, who was born blind, or lost his sight so early, that he had no remembrance of ever having seen, and was couch'd between 13 and 14 Years of age. *Philosophical Transactions of the Royal Society of London*, *35*(402), 447–450. https://doi.org/10.1098/rstl.1727.0038

Chong, I., & Proctor, R. W. (2020). On the evolution of a radical concept: Affordances according to gibson and their subsequent use and development. *Perspectives on Psychological Science*, *15*(1), 117–132. https://doi.org/10.1177/1745691619868207

Cole, J. (1995). *Pride and a daily marathon* (1st MIT Press ed). MIT Press.

Degenaar, M. (1996). *Molyneux's problem: Three centuries of discussion on the perception of forms.* Kluwer Academic Publishers.

Diderot, D. (1977). Letter on the blind. In M. J. Morgan (Ed.), *Molyneux's question: Vision, touch, and the philosophy of perception* (pp. 31–58). Cambridge University Press.

Dobelle, Wm. H. (2000). Artificial vision for the blind by connecting a television camera to the visual cortex: *ASAIO Journal*, *46*(1), 3–9. https://doi.org/10.1097/00002480-200001000-00002

Evans, G. (1985). Molyneux's question. In G. Evans (Ed.), *Collected papers.* Oxford University Press.

Ferretti, G. (2018). Two visual systems in Molyneux subjects. *Phenomenology and the Cognitive Sciences*, *17*(4), 643–679. https://doi.org/10.1007/s11097-017-9533-z

Fine, I., Wade, A. R., Brewer, A. A., May, M. G., Goodman, D. F., Boynton, G. M., Wandell, B. A., & MacLeod, D. I. A. (2003). Long-term deprivation affects visual perception and cortex. *Nature Neuroscience*, *6*(9), 915–916. https://doi.org/10.1038/nn1102

Gallagher, S. (2005). *How the body shapes the mind.* Oxford University Press.

Gallagher, S. (2022). Bodily self-awareness and body-schematic processes. In A. J. T. Alsmith & M. R. Longo (Eds.), *The Routledge Handbook of Bodily Awareness* (1st ed., pp. 137–149). Routledge. https://doi.org/10.4324/9780429321542-14

Gallagher, S., & Cole, J. (1995). Gallagher, s. And cole, j. 1995. Body schema and body image in a deafferented subject. *Journal of Mind and Behavior*, *16*, 369–390.

Hallett, M. (1999). Review : Plasticity in the human motor system. *The Neuroscientist*, *5*(5), 324–332. https://doi.org/10.1177/107385849900500518

Held, R., Ostrovsky, Y., De Gelder, B., Gandhi, T., Ganesh, S., Mathur, U., & Sinha, P. (2011). The newly sighted fail to match seen with felt. *Nature Neuroscience*, *14*(5), 551–553. https://doi.org/10.1038/nn.2795

Hubel, D. H., & Wiesel, T. N. (1963). Receptive fields of cells in striate cortex of very young, visually inexperienced kittens. *Journal of Neurophysiology*, *26*(6), 994–1002. https://doi.org/10.1152/jn.1963.26.6.994

Huber, E., Webster, J. M., Brewer, A. A., MacLeod, D. I. A., Wandell, B. A., Boynton, G. M., Wade, A. R., & Fine, I. (2015). A lack of experience-dependent plasticity after more than a decade of recovered sight. *Psychological Science*, *26*(4), 393–401. https://doi.org/10.1177/0956797614563957

Jacob, P., & Jeannerod, M. (2003). *Ways of seeing. The scope and limits of visual cognition.* Oxford University Press.

Jacomuzzi, A. C., Kobau, P., & Bruno, N. (2003). Molyneux' question redux. *Phenomenology and the Cognitive Sciences*, *2*(4), 255–280. https://doi.org/10.1023/B:PHEN.0000007370.68536.2d

James, W. (1950). *The principles of psychology.* Dover.

Jeannerod, M. (1996). *The cognitive neuroscience of action.* Blackwell.

Landau, B., Gleitman, H., & Spelke, E. (1981). Spatial knowledge and geometric representation in a child blind from birth. *Science*, *213*(4513), 1275–1278. https://doi.org/10.1126/science.7268438

Leibniz, G. W. (1896). *New essays concerning human understanding* (A. G. Langley, Trans.). Macmillan & Co.

Locke, J. (1979). *An essay concerning human understanding.* Clarendon Press.

Meltzoff, A. N. (1993). Molyneux's babies: Cross-modal perception, imitation, and the mind of the preverbal infant. In N. Eilan, R. Mccarthy, & B. Brewer (Eds.), *Spatial representation: Problems in philosophy and psychology* (pp. 219–235). Basil Blackwell.

Meltzoff, A. N., & Borton, R. W. (1979). Intermodal matching by human neonates. *Nature*, *282*(5737), 403–404. https://doi.org/10.1038/282403a0

Merleau-Ponty, M. (2012). *Phenomenology of perception* (D. A. Landes, Trans.). Routledge.

Miall, R. C., Afanasyeva, D., Cole, J. D., & Mason, P. (2021). Perception of body shape and size without touch or proprioception: Evidence from individuals with congenital and acquired neuropathy. *Experimental Brain Research*, *239*(4), 1203–1221. https://doi.org/10.1007/s00221-021-06037-4

Milner, D., & Goodale, M. (2006). *The visual brain in action.* Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198524724.001.0001

Noë, A. (2004). *Action in perception.* MIT Press.

Noë, A. (2011). Perception without representation. In N. Gangodadhyay, M. Madary, & F. Spicer (Eds.), *Perception, action, and consciousness* (pp. 245–256). Oxford University Press.

Noë, A. (2012). *Varieties of presence.* Harvard University Press.

Occelli, V. (2020). Molyneux's question and neuroscience of vision. In G. Ferretti & B. Glenney (Eds.), *Molyneux's Question and the History of Philosophy* (pp. 216–234). Routledge.

Ortiz-Terán, L., Ortiz, T., Perez, D. L., Aragón, J. I., Diez, I., Pascual-Leone, A., & Sepulcre, J. (2016). Brain plasticity in blind subjects centralizes beyond the modal cortices. *Frontiers in Systems Neuroscience*, *10*. https://doi.org/10.3389/fnsys.2016.00061

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596

Renault, A. G., Auvray, M., Parseihian, G., Miall, R. C., Cole, J., & Sarlegna, F. R. (2018). Does proprioception influence human spatial cognition? A study on individuals with massive deafferentation. *Frontiers in Psychology*, *9*, 1322. https://doi.org/10.3389/fpsyg.2018.01322

Rode, G., Lacour, S., Jacquin-Courtois, S., Pisella, L., Michel, C., Revol, P., Alahyane, N., Luauté, J., Gallagher, S., Halligan, P., Pélisson, D., & Rossetti, Y. (2015). Long-term sensorimotor and therapeutical effects of a mild regime of prism adaptation in spatial neglect. A double-blind RCT essay. *Annals of Physical and Rehabilitation Medicine*, *58*(2), 40–53. https://doi.org/10.1016/j.rehab.2014.10.004

Rossetti, Y., Jacquin-Courtois, S., Calabria, M., Michel, C., Gallagher, S., Honoré, J., Luaute, J., Farnè, A., Pisella, L., & Rode, G. (2015). *Testing cognition and rehabilitation in unilateral neglect with wedge prism adaptation: Multiple interplays between sensorimotor adaptation and spatial cognition.*

Sann, C., & Streri, A. (2007). Perception of object shape and texture in human newborns: Evidence from cross-modal transfer tasks. *Developmental Science*, *10*(3), 399–410. https://doi.org/10.1111/j.1467-7687.2007.00593.x

Sann, C., & Streri, A. (2008). The limits of newborn's grasping to detect texture in a cross-modal transfer task. *Infant Behavior and Development*, *31*(3), 523–531. https://doi.org/10.1016/j.infbeh.2008.03.001

Schwenkler, J. (2012). On the matching of seen and felt shape by newly sighted subjects. *I-Perception*, *3*(3), 186–188. https://doi.org/10.1068/i0525ic

Senden, M. von. (1962). Space and sight: The perception of space and shape in the congenitally blind before and after operation. *Philosophy*, *37*(139), 80–81.

Slater, A. (1989). Visual memory and perception in early infancy. In A. Slater & G. Bremner (Eds.), *Infant development* (pp. 43–71). Erlbaum.

Slater, A., & Morison, V. (1985a). Selective adaptation cannot account for early infant habituation: A response to dannemiller and banks. *Merrill-Palmer Quarterly of Behavior and Development*, *31*, 99–103.

Slater, A., & Morison, V. (1985b). Shape constancy and slant perception at birth. *Perception*, *14*(3), 337–344. https://doi.org/10.1068/p140337

Slater, A., Morison, V., & Rose, D. (1983). Perception of shape by the new-born baby. *British Journal of Developmental Psychology*, *1*, 135–142.

Streri, A. (1987). Tactile discrimination of shape and intermodal transfer in 2- to 3-month-old infants. *British Journal of Developmental Psychology*, *5*(3), 213–220. https://doi.org/10.1111/j.2044-835X.1987.tb01056.x

Streri, A., & Gentaz, E. (2003). Cross-modal recognition of shape from hand to eyes in human newborns. *Somatosensory & Motor Research*, *20*(1), 13–18. https://doi.org/10.1080/0899022031000083799

Streri, A., & Gentaz, E. (2004). Cross-modal recognition of shape from hand to eyes and handedness in human newborns. *Neuropsychologia*, *42*(10), 1365–1369. https://doi.org/10.1016/j.neuropsychologia.2004.02.012

Toribio, J. (2020). Molyneux's question and perceptual judgments. In G. Ferretti & B. Glenney (Eds.), *Molyneux's Question and the History of Philosophy* (pp. 266–283). Routledge.

Gallagher, S. (2024). Molyneux and motor plasticity. *Philosophy and the Mind Sciences*, *5*. https://doi.org/10.33735/phimisci.2024.11596