

Many Molyneux Questions

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I. Molyneux's problem regarding spheres and cubes

Molyneux's Question (MQ) is famous.

Suppose a blind man can tell by touch the difference between a sphere and a cube: Suppose then the cube and sphere placed on a table, and the blind man to be made to see. Quaere, whether by his sight, before he touched them, he could now distinguish, and tell, which is the globe, which the cube.

Locke, who reported the Question (*Essay* II. ix. 8), seems to take this to be a problem about ideas of shape. We have ideas of a sphere and of a cube. Molyneux prompted him to ask, in effect, whether these ideas were modality specific. That is, he asked whether there is a single abstract idea of a sphere that spans both vision and touch, or two distinct ideas, one for each modality. And similarly for the cube. Locke believed that ideas of shape are modality specific and that the blind man has not yet formed the visual counterpart. Consequently, he gave MQ a negative answer; the tactual ideas give the newly-sighted man no help with the visual ones, according to him. (This interpretation does not do full justice to Locke's view; we qualify it in section III.)

Following one well-established tradition in the literature (tracing back to Diderot, perhaps), Gareth Evans takes a somewhat different view of the topic that MQ raises, suggesting

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that the problem is a more general one about space, rather than about shape as such.¹

Specifically, he thinks that the most pressing version of the Question (and the one that Locke, Condillac, Berkeley, and Leibniz took themselves to be disputing) was about "the relation between the perceptual representation of space attributable to the blind, and the perceptual representation of space available in visual perception" (370).

Evans contends that distinct modalities within a single organism must share a single, "behavioural" representation of space, and that, since perceptual representations of shape are always spelled out in such inter-/a-modal spatial terms, there is a greater possibility of intermodal perception of shape (inter alia), hence for a positive answer to (a generalized version of) Molyneux's Question than Locke supposed.² In retrospect, it is striking that both Locke's and Evans's responses to Molyneux are rooted in extremely general views that would apply uniformly to a wide range of questions taking this form:

Suppose that you are reliably able to identify objects as instances of a feature F by means of one sense modality. Are you in virtue of this ability alone reliably able to identify objects as instances of F by means of another modality? (Assume, for the sake of vividness, that you have newly acquired the second modality. Are you able to identify instances of F by means of the newly acquired modality?)

¹ Evans, "Molyneux's Question." In his *Collected Papers* (Oxford: Oxford University Press, 1985): 364-399. For a discussion of the difference between shape and space in this context, see John Schwenkler, "Does Visual Spatial Awareness Require the Visual Awareness of Space?" *Mind and Language* 27 (2012):308-329.

² Matters of historical reconstruction aside, the idea that Evans's recasting is the best or only understanding of the Question is dubious. However, it is noteworthy that the switch of focus has seemed quite natural to many philosophers and, indeed, has not even been much commented upon.

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According to both Locke and Evans, Molyneux raised a monolithic issue—a question that can be answered in a single, general way for all values of F. The starting point of our inquiry is that this is over-simple. The scientific literature contains investigations of many questions of the above form; as we'll see, some are answered positively, others negatively. The answer to each individual question of this type is empirical and each has to be investigated separately. Contrary to Locke, there is no overarching issue at play here. Accordingly, we have to arrive at a new approach to these questions.

In this paper, we suggest, first, that each admissible question of the above form is about the spatial, temporal, or spatiotemporal integration of sensory information. The bulk of our argument is directed at different ways of organizing questions about integrative processes across modalities, and aims to use these organizational principles to generate new MQs. Vision and touch display both similarities and differences with regard to how they deal with different spatiotemporal dimensions, and we'll suggest a number of Molyneux-type questions based on these. In section II and III, we present some variations on MQ, some of which are familiar in the literature, and in subsequent sections, we suggest new versions, some wholly unfamiliar, as in section V, and others that are novel adaptations of problems that are known in other contexts. In sum, we present a much-augmented set of principles and questions concerning the inter-modal transfer of spatiotemporal organization. We anticipate that these questions will be significant in the context of the on-going discussion of cross-modal perception.

II. On the perception of wholes and parts

Return to Evans's shift of focus from shape to space. Every shape is a set of points.

Consequently, the representational resources needed to represent points in space suffice to

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represent shape. This proposition might be used to motivate Evans's reduction of MQ to a question about the inter-modality of the representation of space. One might hold, in other words, that underlying every idea of shape is a more fundamental idea of space or of spatial position. The former is modality specific, one might think, just in case the latter is.³

This reductive move is a mistake. It is true that there is a mathematical analysis of shape properties in spatial terms. For example, in Cartesian geometry, the surface of a sphere is definable as the set of points in space satisfying the equation

$$(x - x_0)^2 + (y - y_0)^2 + (z - z_0)^2 = r^2 \text{ (where the center of the sphere is } \langle x_0, y_0, z_0 \rangle \text{ and the radius is } r).$$

However, the availability of a geometric analysis of shape in spatial terms tells us little about the nature of perceptual representations/ideas of shape, which may or may not be similarly constructed.

To see the point, consider the following case:

Cookie Cutter Imagine a circular cookie cutter impressed motionless upon your back. This creates a set of contact points that jointly constitute a circle. You have a distinct tactual impression of each of these points individually (or at least of a multiplicity of short line segments constituted by them).

Many philosophers of the twentieth century were moved by the atomist principle that all visual perception concerning extended regions of the retinal image is grounded in perceptual representations of points within that region. It would follow that perception of extended shapes is

³ To be clear, we have no view about whether Evans himself followed any such line of thought.

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built exhaustively by combining perceptions of the points that constitute the shape. *Cookie Cutter* undermines this assumption. Atomists would similarly be tempted by the view that *feeling* a circle is nothing different from feeling a collection of points that together form a circle. Clearly, however, this is not analytically sufficient to ensure that you tactually feel a circle. Indeed, nothing we have said so far guarantees that the feature of circularity as such is within the representational repertoire of tactual perception (i.e., that tactual perception has a representational capacity for circularity). After all, *every* shape is reducible to a set of spatial positions, yet one does not have the ability in either vision or touch to discern every shape, or to differentiate each from all others.

Cookie Cutter gives us reason to doubt that the *perceptual representation* of circularity, or by extension sphericity, is composed of ideas of position. This point is reinforced by reflection on certain kinds of pathology known as “visual form agnosias,” in which “patients with normal acuity cannot recognize something as simple as a square or circle”.⁴ For example, Goodale et al (1991) reported that after brain damage due to carbon monoxide induced hypoxia, their patient DF was unable visually to identify whole objects such as her mother’s forearm though she retained the visual ability to discern the fine visual details, such as hairs on the forearm, that are parts of the whole.⁵ DF’s brain had, in short, lost the ability to integrate visual parts into a whole. Conversely, some patients with Balint’s syndrome successfully report visually perceived whole shapes and yet are unable to report on or reach toward the points in space where those whole

⁴ Martha J. Farah, *Visual Agnosia*, Cambridge MA: MIT Press, 1990, 1.

⁵ M. A. Goodale, A. D. Milner, L. S. Jakobson, and D. P. Carey, “A neurological dissociation between perceiving objects and grasping them,” *Nature* 349 (1991): 154-156.

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shapes are located. There is thus a double dissociation between perception of spatial points and perception of shape; each is possible when the other fails.

These cases invite us to consider a within-modality version of MQ:

Suppose that a mature woman who has been sighted since birth is plainly shown a circle. Suppose further that she is able to see every part of it. Would she be able to identify the whole object as a sphere by sight alone?

The case of DF shows that the answer to this question varies from person to person.

Independently of any tactual knowledge that she might employ, this mature woman was consistently unable to perform the identification task. This puts *Cookie Cutter* into perspective.

In *Cookie Cutter*, unimpaired perceivers lack the ability to integrate shape information. We might call this a "normal agnosia," a limitation of the sense of touch in normal perceivers. We conclude that you may have awareness of points satisfying the geometric analysis of circularity and yet not have a perceptually given idea of circularity.

These clarifications point to a version of MQ that is about the perceptual representation of shape per se, as opposed to space. So conceived, Molyneux's original question generalizes to this:

if a congenitally blind person tactually reliably represents/discriminates/
reidentifies a range of shape features, will she (immediately, with certainty,
etc.) visually represent members of that same range of shape features once her
sight is restored?

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This question is independent of assumptions about ideas of space. We can ask whether ideas of particular shapes transfer across modalities both on the assumption that the idea of space transfers across modalities, and on the contrary assumption that it does not transfer.

In confronting the implications of this version of MQ, we should bear in mind a further complication raised by Reid's observation that there are significant structural differences between the representational resources distinct modalities bring to the task of representing any shape feature F. Reid contends that touch and vision differ structurally in the way they represent space and shape: according to him, touch does, while vision does not, represent space and shape wholly in terms of perspective-invariant relations⁶. Simply put, the variations felt when we haptically explore a sphere are different from those seen when we view a sphere from different angles. Whether or not we ultimately endorse these substantive views about touch and vision (and whatever we make of their ultimate significance), we should surely accept Reid's underlying methodological assumption --- viz., that the structure of the world leaves options open to individual perceptual modalities (which, therefore, needn't coincide in the options they select) for how their representation of the world is put together. There's no direct match required between the structure of the worldly feature, F, and the structure of a modality's representation of F, or, a fortiori, between the structures selected by different modalities for the representation of F.⁷

This leads us to a version of *Cookie Cutter* that highlights the question of inter-modal transfer:

⁶ *An Inquiry Into the Human Mind on the Principles of Common Sense*, ch. 6-7

⁷ Jonathan Cohen, "Sensory Substitution and Perceptual Emergence," in Fiona Macpherson (ed.), *Sensory Substitution and Augmentation* (London: Proceedings of the British Academy, in press) emphasizes problems of such intermodal differences in both representational scope and structure, and their implications for the operation of sensory substitution devices. These questions must be taken case by case, and on an empirical basis.

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Suppose that a cookie cutter of shape *S* is impressed on the back of a perceptually unimpaired subject, and that another cookie cutter is plainly shown to her in such a way that she can see every part of the impressed edge. Can she say whether the cookie cutter she sees has the same shape as the one she feels?

How widely can MQ, and the issues it highlights, be generalized? On their broadest construal, MQs ask whether there is intermodal transfer between representations of some feature *F* in two distinct modalities. Of course, such questions will be gripping only for features that can be represented in multiple modalities. This explains why MQ concerns features, like shape, standardly thought to be common sensibles. One way to answer MQ, then, is to go through a list of common sensibles, experimentally checking for (automatic, immediate, etc.) intermodal transfer of each feature. But as we said earlier, there's another wrinkle that is of interest here. The general problem suggested by MQ is that of integrating information over regions of space, time, and space-time. In what follows, we show that different sense-modalities face different problems of integration in different spatial and temporal dimensionalities. As a consequence, inter-modal transfer of feature-recognition faces different obstacles in these different dimensions. This leads us to consider variations of MQs organized around these dimensional variations. This will be our focus in what follows.

III. The two- and one-dimensional questions

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In his recounting of MQ, Locke says that vision acquaints us only with a "plane variously coloured." In other words, he thinks that, contrary to the simplified account offered above, there is no simple idea of a sphere. Rather, he believes, vision gives us something like Figure 1.



Figure 1: Do we have visual awareness as of a sphere in the above, or only of a circular plane variously coloured?

According to him, we are directly aware of a pattern of many coloured patches within a circular outline. There is some feature of this pattern that we learn by experience to associate with the tactile idea of depth, thereby allowing us to infer that what we see has depth. Thus, the idea of a sphere is complex in Locke's view. It has, as components, a visual idea of coloured patches constituting a circle added by association to a tactile idea of depth.

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Acknowledging this complication in Locke's thinking, John Mackie argued that Locke's negative answer to Molyneux might be based on what he takes to be the role of association in the extraction of depth information, not on the modal specificity of visual ideas.⁸ The newly sighted man looks at the globe and the cube. He is directly aware only of two-dimensional planes variously coloured. He has no visually activated complex idea of two distinct three-dimensional shapes because he lacks the association between the visual ideas and the tactile idea of depth in the two cases.⁹

Mackie suggests a two-dimensional version of MQ, which we formulate as follows:

Suppose then the cube and sphere placed on a table, and the blind man to be made to see. Quære, whether by his sight, before he touched them, he could now distinguish, and tell, which appears as a circle variously coloured, which as a rectilinear figure.

Mackie says that though Locke had answered the original, three-dimensional Question negatively, he might have given a positive answer to the two-dimensional Question. For Locke held that simple ideas of primary qualities resemble the qualities themselves. Since shape is a primary quality, it follows that both the visual and the tactual idea of a circle resemble a circle. Depending on how exactly this similarity works in the two modalities, and on whether we possess the ability to recognize similarity/difference between ideas that both stand in resemblance relations to the very same primary quality, it is possible that it would be sufficient to

⁸ Mackie, *Problems From Locke* (Oxford: Clarendon Press, 1976), chapter 2.

⁹ Is the newly-sighted man aware right away of coherent two-dimensional displays of colour similar to those available to those sighted since birth? This is what Locke thought, but the assumption is dubious, and infects some treatments of the problem up until the present time. (cf. John Schwenkler, "On the matching of seen and felt shape by newly sighted subjects," *i-Perception* 3.3 (2012): 186-188.)

secure immediate recognition (29). Mackie is, in effect, raising an interesting complication in the question of inter-modal transfer -- the possibility of an external reference point.¹⁰

Mackie is right to notice the consistency of different answers to versions of MQ in different dimensionalities, in this case a difference between the 3D and the 2D MQs.¹¹ But his line of thought about the two-dimensional MQ is not in fact supported by experiments reported by Ostrovsky et al (2009) and Held et al. (2011).¹² Project Prakash was a surgical clinic that removed cataracts from Indian children and adolescents and replaced them with intraocular lens implants. When sight was thus surgically restored to congenitally blind patients, it was found that they could not visually identify two-dimensional shapes (displayed on a computer screen) that they could identify by touch. The newly sighted subjects did not exhibit an immediate transfer of their tactile shape knowledge to the visual domain, these experimenters write. This supports a

¹⁰ For one possible Lockean understanding of how this immediate recognition might proceed, see Jonathan Bennett, "Substance, Reality, and Primary Qualities," *American Philosophical Quarterly* 2 (1965): 1-17; Bennett suggests that since the cube has points and surfaces distinguishable from one another, and the sphere does not, the newly sighted man should be able to discern the visual ideas. It has been contested whether this kind of differentiation is perceptual or not—perhaps it is intellectual. In the opposite direction—i.e., in favour of a negative answer—one should note that the sense of touch is unlike vision in that its input is *not*, in any straightforward sense, a two-dimensional array, but rather an array of contact points on the skin together with (possibly incomplete) proprioceptive information about the three-dimensional disposition of these contact points. This brings to the fore the Reidian point about possible *differences* between the kinds of information that are available to the two modalities. How does translation from one to the other work, and how does this affect inter-modal transfer? The answers to these questions, which bridge the two- and three-dimensional versions of MQ, are not a priori obvious.

¹¹ On this point, see also James van Cleve, "Reid's Answer to Molyneux's Question," *Monist* , 90, 2 (2007): 251-270 and Kevin Connolly, "How to Test Molyneux's Question Empirically," *I-Perception* 4 (2013): 508-510.

¹² Y. Ostrovsky, E. Meyers, S. Ganesh, U. Mathur, and P. Sinha, "Visual Parsing After Recovery From Blindness," *Psychological Science* 20 (12) (2009): 1484-1491. R. Held, Y. Ostrovsky, T. Gandhi, S. Ganesh, U. Mathur, and P. Sinha, "The newly sighted fail to match seen with felt," *Nature Neuroscience* 14 (5) (2011): 551-553.

negative answer to two-dimensional MQ (and presumably the three-dimensional version as well).^{13,14}

Mackie's two-dimensional version of MQ is illuminating. We note that it is easy to construct a one-dimensional version.

Suppose that the newly sighted man was shown a rope stretched tight and one that droops in a catenary curve. Could he distinguish and tell by sight alone which was which?

Diderot used an example of this sort to argue that the blind lack a "simultaneous" representation of space, as Evans called it. A blind person has to run her finger over such ropes, and Diderot argued that her concept of shape therefore integrated spatial information gathered over an extended interval of time. But, he continues, sighted persons are capable of seeing the straight and the curved in a single instant. Thus, blind people have a different kind of representation of the straight and the curved. There is a formal similarity between Diderot's formulation and the argument from Reid mentioned earlier. Reid argues that tactile and visual representations of shape are structurally different, which allows one to construct a model for a negative answer to shape-MQ. Diderot does the same for what he supposes to be the concept of shape that blind

¹³ Similar negative results were reported much earlier, e.g., in the celebrated "Cheselden case" of a congenitally blind Molyneux subject restored to vision by the removal of cataracts (William Cheselden, "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*, 402 (1728): 447-450.: For more on the history of Molyneux cases, see M. von Senden, *Raum- und Gestaltauffassung bei operierten Blindgeborenen* (Leipzig: Barth, 1932), translated by P. Heath: *Space and Sight: The Perception of Space and Shape in the Congenitally Blind Before and After Operation* (London, Methuen, 1960).

¹⁴ Of course, these results do not, all by themselves, confirm Locke's treatment of the matter. As we have noted, there is also the possibility that the newly sighted find it difficult to form a coherent two-dimensional visual expanse, and that there are difficulties in transitioning between the way three-dimensionality is presented in the two modalities.

people have; it includes a temporal element while that of the sighted person does not. (Note the extrapolation from shapes to space here.)

While Diderot's reasoning is eye-opening, there is evidence that complicates his negative answer. Evans (369) quotes a memoir of a blind author, Pierre Villey, who reports that his memory of three-dimensional objects "appears immediately, and as a whole." This report, if credible, shows that the ideas he forms do not in fact have the temporal structure Diderot assumed they would have. They also raise the possibility of a shared representation of space that forms a template for temporally sequential haptic exploration. It is worth noting in this context that we engage in temporally extended visual exploration of three-dimensional objects¹⁵—for example, we walk around large objects, taking in their three-dimensional shape. Matches between visual and haptic exploration remain empirically obscure.

IV. Learning and MQ: Graded transfer

Project Prakash experimenters also studied how visual parsing is learned—i.e., how newly sighted people learn to segregate the visual scene into distinct objects.¹⁶ They note, in an echo of Locke's "planes variously coloured" remark, that "Real-world images typically comprise many regions of different colors and luminances."¹⁷ They tried to find out how newly sighted patients learn to resolve such "scenes variously coloured" into discrete objects. Figure 2 shows some of

¹⁵ See Mohan Matthen, "How to be sure: sensory exploration and empirical certainty," *Philosophy and Phenomenological Research* 88 (2014): 38-69, and "Active Perception and the Representation of Space," in D. Stokes, M. Matthen, and S. Biggs (ed.) *Perception and Its Modalities* (New York: Oxford UP, 2015): 44-72.

¹⁶ Y. Ostrovsky, A. Andalman, and P. Sinha, "Vision After Congenital Blindness," *Psychological Science* 17 (2006): 1009-1014.

¹⁷ *Ibid.*, 1484

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their results. They write that in these patients, "prominent figural cues of grouping, such as good continuation and junction structure, were largely ineffective for image parsing." By contrast with these "Gestalt cues" (as we shall call them), motion cues were almost immediately significant.

When one shape, such as a sphere, moves in front of and across another shape, such as a cube, it creates a constantly changing joint boundary. Sighted people immediately see the three-dimensional scene for what it is. As it turns out, newly sighted people learn this very quickly. In other words, they are quick to learn motion cues of three-dimensional arrangement, but much slower to learn Gestalt cues. (But, of course, they had a pre-existing tactual idea of three-dimensional layout.)

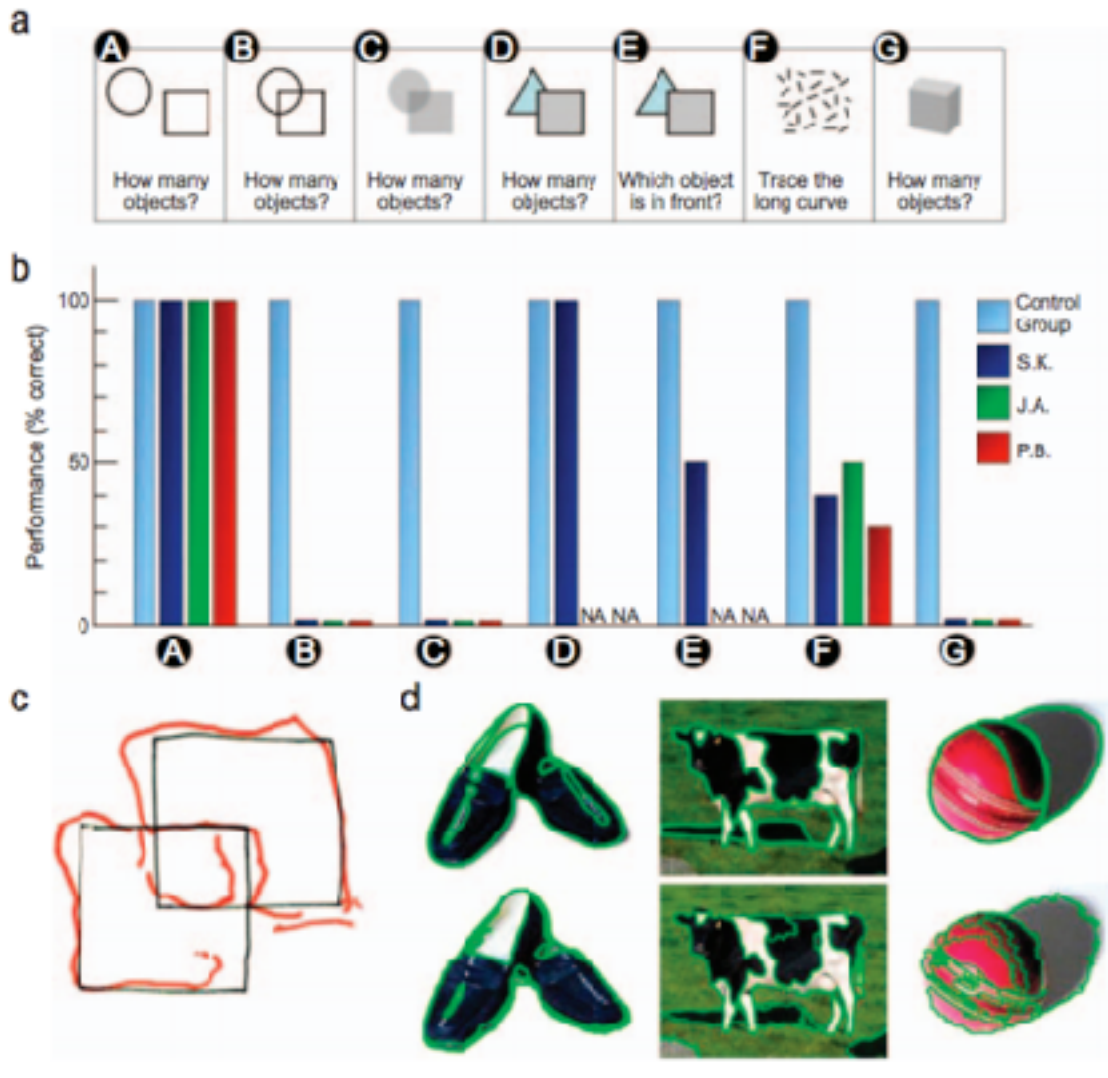


Figure 2: Support for Mackie's interpretation of Locke. Newly sighted patients have difficulty recognizing occlusion in displays B to E. Some had difficulty identifying the longest curve in F, and none were able to resolve display G into faces of a cube. (c) indicates how a simple display resolves into three distinct shapes. The patients were unable to parse the displays on the top row of (e); the bottom row shows how a simple luminance-contrast algorithm performed. (From Ostrovsky et al 2009; used by permission.)

This reveals an aspect of the Molyneux Question that we haven't considered so far.

Different visual cues (Gestalt cues, motion-based cues) are associated with different shape- and space-related properties, but these associations are learned at different rates. This shows that, contrary to Locke, learning by association (or classical conditioning) is not by itself sufficient to

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explain how newly sighted persons learn visually to recognize three-dimensional shapes and spatial distributions. If it were, then the associations between Gestalt cues and depth should be no more difficult to learn than those between motion cues and depth. The associations exploited here are domain-specific. So the learning must involve something more than mere association. Specifically, associations between visual representations of motion and tactual ideas of depth are not created equal. As Held et al (see note 10) write: "The rapidity of acquisition suggests that the neuronal substrates responsible for cross-modal interaction might already be in place before they become behaviorally manifest."

Here then is another version of Molyneux's Question:

Suppose that a cube and a sphere are placed on a table, one in front of and partially obscuring the other. How long after restoration of sight would a previously blind person be able to distinguish the two objects? Would he be quicker to distinguish the two objects if one of them were moved?

On the classical idea that all learning is associative and all associative pairings between two simple features are made at the same rate, the answer to the second question should be no. But this is not experimentally supported. Just as there are differences among modalities with regard to how they process the different forms of information their receptors provide, so also there is a difference in learning mechanisms regarding the significance of various available cues of environmental variables.

V. Zero-dimensional versions of MQ

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As we saw above, Evans framed MQ as a problem about the perceptual representation of space (as opposed to shape). Though we disagree with Evans's view that the MQs posed above should always reduce to such questions, it is possible to ask versions of MQ closely related to the above that take spatial position and spatial relations as their targets. And indeed, we can ask zero-dimensional versions of MQ about the possibility of intermodal transfer for representations of such spatial features exemplified at single points:

Suppose we have two vibrators each fitted with a light that can be turned on independently of the vibrator. Both are placed on the newly sighted man's body, one on the palm of the hand and the other on the forearm. Now the room lights are switched off so that the man is sitting in the dark. One (and only one) of the vibrators and one (and only one) of the lights is turned on. He feels one vibrator and one light. Can he tell whether the active vibrator is lit up?

This version of the Molyneux problem requires the newly sighted man to identify the *position* of a tactual feature with the position of a feature identified by sight. Suppose he feels a vibration on the palm of the hand. His problem is to say whether the light is shining from the place where his hand is.

Similar zero-dimensional questions can be posed regarding the motor system's representation of space. Motor (and associated proprioceptive and tactual) representations of position are body-centered. So, if a foreign object (say a grain of sand on the inside of your glove) pushes against your finger-tip, it will tactually seem to be stationary, even if your hand and finger should move (either by your own agency or passively). Presumably this is because

your tactile sense is linked to the motor system; it tracks the part of your body that you are able to move. Now, let Dr Molyneux ask:

Suppose that a rubber hand is placed alongside a newly sighted man's hand.

Let a flashing light be placed next to one of these. Now, suppose that both hands are stroked with a brush. Can the man tell by sight alone whether the light is next to his own hand?

This is a problem concerning the coordination of visual representation of *external* position (of the brush) and tactile representation of bodily position (of the stroking). We know that when this experiment is conducted with normally sighted patients, but with their own hand hidden from view, these subjects report that they feel the rubber hand being stroked (Botvinik and Cohen 1998).¹⁸ This is an error of visuotactile coordination. So it is at least possible that in the rubber-hand MQ, the newly sighted man will lack the necessary visuotactile coordination, and therefore be unable to identify where the stroking is happening in the visual world.

Along the same lines, but with the opposite effect, consider this: If a spotlight suddenly appears from some direction, would the newly sighted man immediately turn towards it? There is no evidence that this zero-dimensional MQs has a negative answer. (Project Prakash workers report on no such failure.)¹⁹

¹⁸ Matthew Botvinik and Jonathan Cohen "Rubber hands 'feel' touch that eyes see," *Nature* 391 (6669) (1998): 756

¹⁹ Van Cleve (op. cit., n 11) suggests a different kind of zero-dimensional problem. Noting that Aristotle classes number among the common sensibles, van Cleve asks whether the newly-sighted man, presented with a single dot on the left and a pair of dots on the right, could tell by sight alone which was which. Van Cleve says that "there would be something bizarrely defective about the subject who is stymied by the cross-modal number recognition task" (267-268). He may be right about this, but it is not clear to us that this is an MQ. Do visually presented pairs of dots look similar to tactually known pairs, or are they determined to be pairs by counting previously subitized perceptual units? Van Cleve inclines to the first view, but we are not sure.

We can pose similar questions about relations in one spatial dimension obtaining between zero-dimensional points.

Two vibrators are placed on the newly sighted man's skin. A light (without vibrator attached) is also placed on his skin. All three are switched on. Can he tell by vision alone whether the light is in between the vibrators?

The newly sighted man is able to estimate distances by haptic touch. He is shown three non-collinear lights, A, B, and C. Length AB is shorter than length ACB. Can he tell by vision alone that AB is a shorter length than ACB?

These zero-dimensional problems are about the inter-modal transfer of position information and basic geometrical relations such as the triangle equality. As such, these versions of MQ are plausibly understood as concerning the intermodality of perceptual representation of space but not about perceptual representation of shape.²⁰

VI. A temporal version of MQ

Moving away from space-related versions of MQ, we now ask a version of MQ about time. A blind person is aware of the time it takes for things to happen. For instance, if two people speak, she is able to say who started and ended first. Again, if she hears a rhythmic pattern, she can beat out the time with her finger. Now she is made to see. She sees two people speaking behind a

²⁰ That said, John O'Keefe and Steven Nadel *The Hippocampus as Cognitive Map* (Oxford: Clarendon Press, 1978) argue that the representation of space derives not from information received through the senses, but from how this information is deployed in the hippocampal formation. This might be taken to suggest that the perceptual representation of space is not modal at all, or that it is amodal/"premodal" (Matthen, "Active Perception") and that these zero-d MQs would get a 'yes' answer for reasons that have nothing to do with inter-modal transfer.

sound-blocking window -- their lip movements coincide with their speech sounds. Or she sees a rhythmic stream of light flashes.

Question: can she tell by sight alone which of the individuals spoke for longer or began/ended first? Can she beat time to the stream of light flashes?²¹ (Note that these are audiovisual and visuomotor versions of MQ, not visuotactile as in the original.)

There are certain ways of thinking about the experience of time that suggest (given natural assumptions) that this temporal version of MQ should receive a positive answer either a priori or on the basis of some general principle that applies equally to all the cases being discussed.²²

Some think that the temporal structure of our experience is inherited from the temporal structure of the events we experience.²³ This implies that a flash seems to be before a bang just in case the flash precedes the bang.²⁴ So, the events will always seem to occur in the order they actually occur—illusions of temporal order are impossible. As long as the temporal structure of

²¹ Evans alludes to temporal MQ, though was apparently of two minds about how to approach it (372).

²² For example, Louise Richardson, "Space, Time and Molyneux's Question," *Ratio* 27 (4): 483-505. 2014 takes it as a datum that temporal MQs are unlike spatial MQs in meriting obvious positive answers, and she attempts to explain why this should be so. What we say below suggests that this alleged datum is incorrect.

²³ See the following by Ian Phillips: "Perceiving temporal properties," *European Journal of Philosophy* 18(2) (2008), 176- 202; "Indiscriminability and experience of change," *Philosophical Quarterly* 61(2011), 808-827; "The Temporal Structure of Experience," in D. Lloyd and V. Arstila (eds.) *Subjective Time: the Philosophy, Psychology, and Neuroscience of Temporality* (Cambridge MA: MIT Press, 2014).

²⁴ More precisely, the claim should be that the timing of the sensory experiences matches the times that information about the flash and the bang are received. We see a distant flash of lightning before we hear the thunder that accompanies it because the sound arrives after the flash.

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the extended events mentioned above matches, as it is stipulated to do, there is no special problem of intermodal transfer over and above that of within-modality matching. On this reading, MQ must be answered positively if there is within modality recognition of a temporal relation.

Another route to a positive answer to temporal MQ goes through the Kantian idea that time is "nothing other than the form of inner sense" (A33/B49). According to this way of thinking, temporal experience is itself not proprietary to any single, externally directed perceptual modality -- on the contrary, it is always discerned, introspectively, by self-awareness of experience itself.²⁵

Some extend this view to the experience of temporal relations, holding that experience of simultaneity/succession of two events just amounts to the simultaneity/succession of the experiences of those two events. This would imply an Introspective Reflection Principle (IRP) for the perception of time, according to which two events are experienced as standing in temporal relation R if and only if the experiences of the two events stand in the temporal relation R. For example, IRP would predict that a flash of light is experienced as occurring

²⁵ Barry Dainton "Temporal Consciousness", The Stanford Encyclopedia of Philosophy (Spring 2014 Edition), Edward N. Zalta (ed.), URL = <<http://plato.stanford.edu/archives/spr2014/entries/consciousness-temporal/>>.2014 ascribes something like this view to Locke, Berkeley, and (more tentatively) to Hume, as well as to Kant and Brentano; it is also endorsed by Louise Richardson *op. cit.*

simultaneously with/one second before a drum beat if and only if the experience of the flash occurs simultaneously with/one second before the experience of the drum beat.²⁶

There is a wide range of evidence that threatens both these approaches, especially over periods so brief that experience of temporal relations must be extracted, some say “constructed,” by automatic or “sub-personal” processes. One simple illustration of the threat comes from the finding that subjects are unable to detect onset asynchronies between visual and auditory stimuli within roughly 250ms:²⁷ within this window (whose breadth varies interpersonally), subjective simultaneity is susceptible to adaptation, and differs for different cross-modal combinations. Thus, subjects will experience two events as occurring simultaneously even though sensory information regarding them is received at different times.²⁸ Theoretical explanations of how experience of temporal order arises in these cases often appeal to processes that construct or reconstruct temporal order, and could be prone to error. These explanations invoke a wide range of parameters and faculties, and there is no reason to expect that they would all operate the same way across modalities and domains.

²⁶ Views in the vicinity of our Reflection Principle have been endorsed by Evans (373, n18), Mellor *Real Time*, Cambridge: Cambridge University Press, 1985 (144), Phillips (see the papers listed in note 19), and Barry Dainton *Stream of consciousness: Unity and Continuity in Conscious Experience* (London: Routledge, 2000) and “Temporal Consciousness”. Detractors include Daniel Dennett *Consciousness Explained* (London: Allen Lane, 1991), Dennett & Marcel Kinsbourne, “Time and the observer: The where and when of consciousness in the brain,” *Behavioral and Brain Sciences* 15 (2) (1992):183-201. 1992, Rick Grush “Temporal representation and dynamics,” *New Ideas in Psychology* 26 (2008): 146-157, Geoffrey Lee, “Temporal Experience and the Temporal Structure of Experience,” *Philosophers' Imprint* 14 (3). 2014, and Matthen “Active Perception.”

²⁷ N. F. Dixon and L. Spitz, “The detection of auditory visual desynchrony,” *Perception* 9(6) (1980):719-21.

²⁸ Cf. C. R. Scheier, R. Nijhawan, and S. Shimojo, “Sound alters visual temporal resolution,” *Investigative Ophthalmology & Visual Science*, 40(4) (1999):4169; S. Morein-Zamir, S. Soto-Faraco, and A. Kingstone, “Auditory capture of vision: Examining temporal ventriloquism,” *Cognitive Brain Research* 17(1) (2003):154-163, and C. Spence and S. Squire, “Multisensory integration: Maintaining the perception of synchrony,” *Current Biology* 13(13) (2003): R519–21.

Some argue that IRP is threatened even more directly by a class of "postdictive" temporal illusions, in which the experienced simultaneity/succession of two experienced events is mediated by the later experience. One such case is the flash-lag effect: when a moving object and a flash are visually presented simultaneously and in the same location, subjects report the flash as occurring later than the moving object.²⁹ David Eagleman reports an analogous crossmodal postdictive illusion.³⁰ He began by adapting his subjects to a 200ms delay between a keypress and a subsequent flash, so that they experienced the two as simultaneous. When he then removed the delay in the next trial after adaptation, his subjects experienced the flash as preceding (hence, not simultaneous with) the keypress. Prima facie, these are cases in which the subject undergoes two experiences that are simultaneous, but, contrary to IRP, she does not experience them that way.

There are, to be sure, strategies for reconciling these effects with IRP (see, for example, the "Stalinesque" interpretation of Dennett and Kinsbourne, or the temporal smudge view of Phillips ("Temporal Structure," see note 20 above). Without taking any official stand on the plausibility or success of these proposals, we want to make the more general point that answering the temporal MQ will depend on the particular, and potentially modality-specific, psychological mechanisms responsible for temporal integration.³¹

²⁹ R. Nijhawan, "Motion extrapolation in catching," *Nature* 370 (1994): 256-257.

³⁰ Eagleman, "Brain Time," in M. Brockman (ed.) *What's Next? Dispatches on the Future of Science* (New York: Vintage, 2009).

³¹ Of course, there is much more to say about these and many related results, the psychological processes of temporal integration that underpin them, and their significance for the philosophy of perception and the philosophy of time. For further examples and wide-ranging discussion, see Lee ("Temporal Experience," see note 25) and Craig Callender, *What Makes Time Special?* (Oxford, Oxford UP, 2017): ch 9.

These considerations about the temporal version of MQ offer lessons for the spatial MQs as well. Just as there is a non-trivial window of subjective simultaneity such that events picked out in same/different modalities and falling in that temporal region are experienced as temporally simultaneous, we can by analogy ask whether there is a non-trivial spatial window of subjective co-location such that events discerned by same/different modalities and falling in that spatial region are experienced as co-located (cf. the ventriloquist effect, in which subjects perceive a ventriloquist's voice as originating from the location of the visually perceived dummy rather than that of the auditorily perceived ventriloquist.³² This invites us to ask whether visual domination over audition is relevant to MQs (in various spatial and temporal settings).

VII. A space+time, or four-dimensional, version of MQ

We said earlier that MQ raises general issues about integrating information over space and time. And we have gone through various spatial dimensionalities in which these features are arrayed, as well as a temporal version and a version that probes how these features are learned. We conclude with a question about a feature exemplified by individuals at their location at different times. Motion is such a feature, and therefore is of special interest. Here is a version of MQ concerning motion.

³² See H. L. Pick, Jr., David H. Warren, and John C. Hay, John C. "Sensory conflict in judgements of spatial direction," *Attention, Perception, & Psychophysics* 6(4) (1969), 203-205; P. Bertelson, "Ventriloquism: A Case of Crossmodal Perceptual Grouping," *Advances in Psychology* 129 (1999): 347-362; Jean Vroomen and Beatrice de Gelder, "Sound enhances visual perception: crossmodal effects of auditory organization on vision," *Journal of Experimental Psychology: Human Perception and Performance*, 26(5) (2000), 1583-1590; and Jean Vroomen and Beatrice de Gelder, "Ventriloquism and the freezing phenomenon," in G. A. Calvert, C. Spence, and B. E. Stein (eds.), *The Handbook of Multisensory Processes* Cambridge, MA: MIT Press 2004): 141-150.

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Suppose that two objects were shown to a man newly made to see, both moving from left to right, one continuously and the other in jumps. Could he tell by sight alone which is which?

We know that cortical motion blindness is an agnosia. Patients with lesions in the medio-temporal occipital cortex (MT) no longer see motion as continuous, but rather see it as a succession of discontinuous positions.³³ We don't know how soon after restoration of vision this visual area of the brain, which subserves the perception of motion as continuous, kicks in. We also do not know whether and how learning plays a role in the activation of MT. Consequently, the answer to 4D MQ is unobvious, and certainly not a priori.

VII. Conclusion

We take the foregoing to show that there is a variety of fruitful MQs, cast in a number of spatial and temporal regimes, that are about the transferability across modalities of information about spatiotemporal common sensibles, including shape, spatial position, temporal order, and change. We have argued, pace Evans, that these cannot all be reduced to questions about the existence and character of an inter-modally shared representation of space. These questions cannot be answered a priori or by appeal to a single principle. Different MQs have different answers, within different sets of perceptual conditions. We have, however, outlined some organizing principles, based on similarities and differences among the modalities with regard to

³³ J. Zihl, D. Von Cramon, and N. Mai, "Selective disturbance of movement vision after bilateral brain damage," *Brain*, 106 (1983): 313-340.

how they process information in various spatiotemporal dimensions. These organizing principles mark out different obstacles that arise when the perceptual brain transfers information about features it represents in one modality to another modality.³⁴

³⁴ We are grateful to Brian Glenney, Craig Callender, Matthew Fulkerson, Janet Levin, Heather Logue, Alisa Mandrigin, Mike Martin, Farid Masrouf, Louise Richardson, John Schwenkler, Ayoub Shahmoradi, James van Cleve, Aidan Wakely-Mulroney, the Philosophy of Perception Reading Group at UC San Diego, and audiences in Berkeley and York, England for helpful discussion of these matters that has substantially enriched the paper.

Figure 1



Figure 2

