domain. We also argue that Block's interpretation of the neural data in his exemplar mesh is incorrect, and propose an alternative.

What Block calls a "mesh" can also be considered a "model" of the interrelationship between neural and psychological data, and of the relationship of both sources of data to the concepts of phenomenology and accessibility. This kind of model fitting is massively underdetermined, and there is a real danger of overfitting – massaging the data to create meshes that can support any assumption. In a Bayesian framework, competing quantitative models are evaluated by comparing their *marginal likelihoods* – how likely the observed data is under each model. The marginal likelihood incorporates an Occam's razor–like penalty, penalising complex models that have more parameters, and are thus *more* likely to overfit the data (Mackay 2004). The kind of "mesh" at issue here is clearly not yet a quantitative model for which a marginal likelihood can be computed, but the principles of model comparison should still be followed as closely as possible.

Block presents a single mesh whose explanatory power gives us "reason to believe" (target article, sect. 1, para. 2) the assumption embedded in it. We would like to emphasise the necessity of comparing fully developed competing meshes before we can have more reason to believe Block's assumption than its counterpart – a single entrant in a race will always be the winner. We will now use Block's example to demonstrate some of the issues inherent in evaluating whether a particular mesh really does provide the "best explanation" in this domain.

In his example, Block claims that without making the assumption that accessibility is constitutive of phenomenology it is not possible to build a mesh that provides a mechanism for overflow. The starting point is an argument from behavioural data that phenomenology overflows accessibility, which is then taken as a given for the mesh to explain. This conclusion is itself a kind of inference to the best explanation, which ultimately contains an assumption about the answer to the methodological puzzle. The importance of the puzzle is diminished by embedding an assumption about the answer within a larger explanatory structure. However, how much the structure relies upon such assumptions will affect the strength of the evidence it provides, and it is therefore essential to be extremely precise about which assumptions are made, and where.

Another issue that makes model comparison particularly difficult in this domain is the imprecise terminology. In his example, Block uses unitary concepts of accessibility and reportability to refer to different phenomena, in different contexts. This can lead to confusion. For instance, whatever is currently part of access-consciousness is reportable in the sense that it can be reported at any time, without any reorienting of attention or the sense organs. Objects in a Sperling task are reportable only if attended, but no terminological distinction is made between these two types of reportability even though the distinction is critical to Block's disentangling of phenomenology and accessibility. We propose that a more precise taxonomy of the different types of accessibility and reportability would be easy to develop and would resolve much of this confusion.

A significant source of difficulty in building and comparing meshes is how we should describe the neural data, and how it maps to psychological states. Block acknowledges that the neural data he invokes may be "wrong or at least highly incomplete" (sect. 13, para. 3). Therefore, great care should be taken at this stage because an error here can cascade through the mesh, severely limiting the strength of the evidence it provides. In demonstration of this point we suggest an alternative mapping between neural states and phenomenology which, in our opinion, would strengthen the mesh by better accounting for the data, or at least cast doubt over Block's version.

Block proposes that cortico-cortical (CC) recurrent loops from higher to lower areas are the core neural basis for phenomenology – for example, that feedback from V5 to V1 is constitutive of phenomenal motion. We propose that motion phenomenology should instead be viewed as being composed of different component phenomenal characters that correspond to the activity of independent but interacting cortical areas, and that recurrent feedback is then necessary for *binding* these phenomenal characters together. As an illustrative oversimplification, the phenomenal experience of a simple moving grating could be characterised as being composed of a phenomenal experience of a retinotopic array of contrast elements, and a phenomenal experience of motion within a particular retinotopic region. It has been argued elsewhere that the best candidate for the core neural basis of the phenomenal experience of contrast elements is V1 (Pollen 1999) and of motion is V5 (Zeki & Bartels 1999). Under normal conditions the two attributes are bound to each other and one directly experiences the surface qualities of the thing that is moving – a *modal* experience. If the two are not bound, one will have an *amodal* experience of motion.

This hypothesis can be tested by looking at what happens when feedback from V5 to V1 is prevented. Block claims that V5 activity over a certain threshold in the absence of feedback to lower areas is not sufficient for the experience of motion (sect. 13). We would claim that it is in fact sufficient for an *amodal* phenomenal experience, supported by the observation (cited by Block in his Note 10) that patient G.K. can experience fast motion in his "blind field," described as looking like "black moving on black" (Zeki & ffytche 1998), despite having no possibility of recurrent feedback from V5 into V1/V2 in his damaged hemisphere (Semir Zeki, personal communication).

The same logic can be applied to the transcranial magnetic stimulation (TMS) evidence that disrupting feedback from V5 to V1 prevents the perception of a moving phospene (Pascual-Leone & Walsh 2001). Subjects reported that the phosphene was "present but stationary," which is equally consistent with the role of CC feedback in binding phenomenal contents. A true test would be whether subjects can distinguish between sham and real V5 stimulation in the context of disrupted feedback to V1, and whether this is correlated with an experiential report of amodal motion. Adopting this alternative mapping would potentially strengthen Block's mesh by better fitting the neuroscientific evidence.

Block's proposed approach compares meshes as a proxy for a direct comparison of competing hypotheses about the relationship between accessibility and phenomenology. To make this comparison meaningful, we must be very precise about the necessity of the hypothesis to the explanatory power of the mesh. From this perspective the explanatory gap may prove to be more like a crack in the pavement than a gaping hole, but we must still take great care in stepping over it.

Many ways to awareness: A developmental perspective on cognitive access

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Abstract: Block's target article makes a significant contribution toward sorting the neural bases of phenomenal consciousness from the neural systems that underlie cognitive access to it. However, data from developmental science suggest that *cognitive* access may be only one of several ways to access phenomenology. These data may also have implications for the visual-cognitive phenomena that Block uses to support his case.

Prelingual infants perform mental operations that signal levels of awareness beyond phenomenal consciousness and that may be observed or indexed by processes other than those involved in cognitive accessibility. These include: (1) using action selection processes to group stimuli into perceptual categories, thereby laying groundwork for subsequent concept formation; (2) recognizing and responding appropriately to faces and facial expressions of basic emotions and making stable emotion-cognition connections; and (3) exhibiting movements indicative of intentionality, goal-directed behavior, and problem-solving (Slater & Lewis 2007; cf. Merker 2007). These behaviors may reflect the development of different levels or complexities of awareness and offer possibilities of extending current conceptualizations of ways to access phenomenal experience.

Mechanisms of accessibility and levels of awareness. Developmental scientists routinely observe evidence suggesting that prelinguistic infants not only experience objects and events phenomenologically, they respond to them in meaningful ways. They discriminate between animate and inanimate faces (Ellsworth et al. 1993), familiar and strange persons (Bushnell et al. 1989), and among a wide variety of objects sufficiently well to place them in categories (Quinn 2006). As well, they respond differentially to others' emotion expressions (Walker-Andrews 1998), and execute movements to influence persons, objects, and events, and to solve problems (Sommerville & Woodward 2005).

Foundations of concept formation. Through visual tracking and eye movements, young infants have shown that they can parse visual experiences into perceptual groups that subsequently attain conceptual significance. For example, 3-to-4–month-olds presented with visual images of realistic photographs of cats generalize their looking-time responsiveness to subsequently presented novel cats, but use comparison and selection processes to display visual preferences for exemplars from novel categories including birds, dogs, and horses (Eimas & Quinn 1994; Oakes & Ribar 2005; Quinn et al. 1993). Studies demonstrating categorization abilities early in life indicate that infants do not experience objects in the world as undifferentiated, but as separate groups that fall into distinct representations (Quinn & Eimas 1996). These representations may then serve as placeholders for the acquisition of the more abstract and non-obvious information that occurs beyond infancy, through language and more formal learning of semantic categories (Quinn & Eimas 1997; 2000). Thus, over time, the perceptual placeholder representation for cats will come to include the information that cats eat tuna, hunt mice, give birth to kittens, have cat DNA, and are labeled as "cats."

Emotion expression. In mother-infant face-to-face play, young infants display emotion expressions in synchrony with the mother but also periodically take the lead, indicating behavior other than imitation (Stern 1974; Tronick 1989). Their behavior in the "still-face" procedure is typically interpreted as an effort to re-engage the mother (Muir & Lee 2003). 2.5-to-9–month-old infants respond differentially and predictably to the mother's discrete emotion expressions (Izard et al. 1995; Montague & Walker-Andrews 2001). Through their emotion expressions, children without a cerebral cortex also show evidence of access to phenomenal experience (Merker 2007).

Body movement/action. Kinematic data have shown that 10-month-old infants reach more rapidly for a ball that they have been encouraged to throw into a basket than for one they have been encouraged to fit into a plastic tube (Claxton et al. 2003). From ages 9 to 19 months, infants show clear developmental changes in target selection and movements that ultimately lead to problem solving (McCarty et al. 1999).

The three foregoing types of data suggest that prelingual infants have emotion- and action-systems that mediate access to contents of phenomenal experience independently, or largely independently, from those involved in cognitive access. Thus young infants (like hydranencephalic children; cf. Merker 2007) appear to possess forms of accessibility that may lie outside the pale of Block's "cognitive" criteria.

Independence and interdependence of access modes. Evidence suggestive of accessibility via emotion- and action-systems (in the absence of cognitive accessibility) can be found in adults as well as in children. However, due to maturation and resultantly enriched connections among neural systems, examples of functionally independent access pathways may become rarer with age. In adults, observations of such independence might often require artificially constrained manipulations or incidental brain lesions. Milner and Goodale's (1995) work with patient D.F., for example, suggests that dorsal and ventral visual pathways output separately to action and cognitive systems respectively (also see James et al. 2003). When asked to indicate explicitly the orientation of a slot, D.F. (who had a compromised ability to process information via her ventral visual pathway) was unable to do so. However, when asked to insert a card into the slot as if posting a letter, her action was immediate and correct. Examples also abound of situations where emotion processes seem to glean aspects of experience that lie beyond reach of cognitive accessibility. These include emotion's role in decision making (Bechara et al. 2000) and in the power of emotional stimuli to guide attention even when people cannot report them (Jiang et al. 2006).

Recent evidence suggests that contents accessible to the neural systems of emotion can be made available to the systems of cognitive access (e.g., particularly emotional task-irrelevant stimuli appear to gain access to explicit report mechanisms at the expense of non-emotional target stimuli; Arnell et al. 2007; Most et al. 2005a). However, the quality and function of the experience change after the emotion-cognition connection (Izard, in press). For example, when people label emotions, there follows an observable activation decrease in neural areas associated with emotional reactivity (Lieberman et al. 2007). Emotion-cognition-action connections and interactions have played a critical role in the evolution and functioning of consciousness and continue to influence the development of higher levels of awareness in ontogeny.

Implications for visual cognition. Evidence of multiple routes for accessing phenomenology might help reframe findings from the visual cognition literature, several of which Block described in making his argument. Rather than casting phenomena such as the attentional blink (Chun & Potter 1995; Raymond et al. 1992), inattentional blindness (Mack & Rock 1998; Most et al. 2001; 2005b; Simons & Chabris 1999), and object substitution masking (Di Lollo et al. 2000; Reiss & Hoffman 2006; Woodman & Luck 2003) in terms of a conscious versus unconscious divide, it may be more fruitful to regard them as failures of cognitive access but not necessarily as failures of other types of access. The limitations that constrain cognitive accessibility might not generalize to other forms of accessibility. For example, evidence suggests that whereas people often fail to detect neutral targets during an attentional blink, emotion stimuli are much less susceptible to this effect (except in cases of bilateral amygdala damage; Anderson & Phelps 2001).

A different look at accessibility and reportability of levels of awareness. Developmental research potentially allows us to examine a time before connections between cognition-, emotion-, and action-systems are fully formed, thereby providing insights that might not be as readily gleaned from, but which may affect interpretation of, the adult literature (e.g., evidence of separable access systems). The developmental data also have implications for Block's endeavor to pinpoint neural bases of phenomenal experience unadulterated by access mechanisms. His suggestions for ruling out the machinery of cognitive accessibility are important, but ruling out mechanisms involved in accessibility via emotion and action processes may prove even more challenging. Block's ability to construct an empirically based proposition for how phenomenology might overflow cognitive accessibility gives testimony to the burgeoning of cognitive science investigations relevant to this enterprise. Empirical investigations of similar constraints on emotion- and action-accessibility have yet to catch up. We hope that Block's path-making endeavor will kick-start this process.