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18

19 **Abstract**

20 Neuroscientific discourse on consciousness often resorts to ‘collection of elements’,
21 notwithstanding the Gestalt demonstrations against representing conscious experience as a
22 collection of sensory elements. Here I show that defining conscious experience as an object of
23 the category of conscious experiences, instead of as cohesion-less set of structure-less elements,
24 provides the conceptual repertoire—basic shapes, figures and incidence relations—needed to
25 reason about the essence of conscious experiences and the essence-preserving transformations of
26 conscious experiences. Viewed in light of the category of conscious experiences, designers of
27 user experience—in designing pre-conceptualized desired user experiences—are well situated to
28 contribute to the development of the science of consciousness.

29

30 **Keywords:** Category theory, Consciousness, Element, Figure, Gestalt theory, Mind, Object,
31 Perception, Relation, Set, Shape.

What is consciousness? Consciousness, according to Koch, “is everything you experience. It is the tune stuck in your head, the sweetness of chocolate mousse, the throbbing pain of a toothache, the fierce love for your child and the bitter knowledge that eventually all feelings will end” (Koch, 2018, p. S9). This raises two foundational questions:

1. What is the nature of conscious experiences?

2. What is the nature of consciousness?

How are we to think of the totality of conscious experiences i.e., consciousness? How are we to think of the constituents of consciousness i.e., conscious experiences? One obvious answer: Conscious experiences are objects of the category of all conscious experiences and consciousness is the category of conscious experiences. In other words, every conscious experience has the essence of the category of conscious experiences, whatever the essence(s) maybe. This characterization is in the spirit of asserting that a chair is an object of the category of chairs.

Let us consider a visual experience: a face. A first-order approximation would represent the experience as a feature list or as a point in a feature-space or as a set of features i.e., Face = {eyes, nose, mouth} (Fodor, 1998). Sensory features are obviously structured, unlike the structure-less elements of sets (Lawvere and Rosebrugh, 2003, p. 1). Equally importantly, sensory features of a visual object are related to one another in specific ways resulting in a cohesive object, which cannot be modeled by a set with its zero internal cohesion (Lawvere and Schanuel, 2009, p. 146). Elementism, notwithstanding the Gestalt demonstrations (Albright et al., 2000, p. S34), continues to be the default terminology as in analyzing “perceptual experience into a collection of simple sensory elements” (Albright, 2013a, p. 19). Along similar lines, mind

is defined as a set of brain functions (Bunge, 1981, p. 68; Kandel, 2013, p. 546). The claim that ‘mind is a set’ is repeatedly asserted in the textbook *Principles of Neural Science* (Kandel et al., 2013, p. 5, 334, 384), which takes on added significance in light of its pedagogical value in training neuroscientists. Of course, this terminology does not reflect any failure to recognize that, in terms of the above example of face perception, the constituent eyes, nose and mouth, unlike the structure-less elements of a set, are figures of various shapes; these figures constituting a face are related to one another in specific ways (cf. Albright and Stoner, 2002). Nevertheless, it does highlight the absence and the significance of having a conceptual repertoire that fits the reality of conscious experiences. Here I put forward mathematical category (Lawvere and Schanuel, 2009, p. 21, 135-148) as a construct suited for the study of consciousness. In line with the commonplace understanding of the notion of category, a mathematical category consists of objects all of which partake in the essence that is characteristic of the category; since every object of the category partakes in the essence, the transformations of objects preserve the essence (e.g. in the category of dogs, a transformation of an young dog into an old dog preserves the “dogness”).

Theory of Conscious Experiences

What is the essence of conscious experiences? Continuing with our example of face perception, an experience of a face can be said to consist of figures of various shapes: two eye-shaped figures, one nosed-shaped figure and one mouth-shaped figure. Of these shapes, we can say that eye, nose and mouth are the basic shapes, and their incidence relations determine the mutual relations between various basic-shaped figures constituting the face (Lawvere and Schanuel,

2009, pp. 82-83, 250-253). When considering conscious experience in general, we may treat sensory features (e.g. color, shape), modalities (visual, tactile, etc.), and emotion, among others, as basic shapes. For illustration, anger (in conscious experience) can be considered as an emotion-shaped figure (in the experience) just as redness can be thought of as a color-shaped figure. The mutual relations between basic shapes, say, emotion and color, determine the mutual relations between figures of the corresponding shapes (anger and redness).

Basic shapes along with their incidence relations constitute the abstract essence or theory of the category of conscious experiences (Lawvere, 2003, p. 215, 217; Lawvere, 2004, pp. 10-12; Lawvere and Rosebrugh, 2003, pp. 154-155, 235-236; Lawvere and Schanuel, 2009, pp. 149-151, 369-370). First, every experience has the essence [of experiences] given by the basic shapes and their incidence relations. Next, every experience can be represented as a structure formed of basic-shaped figures and their mutual relations induced by the incidences of basic shapes (see Fig. 4 in Posina, Ghista and Roy, 2017). Since every experience has the essence of experiences, transformations of experiences are required to preserve the essence of experiences, and as such are natural transformations (Lawvere and Schanuel, 2009, p. 378). Geometrically speaking, natural transformations ‘do not tear’ the structure transformed (ibid, p. 210). Philosophically, a natural transformation is: Becoming consistent with Being (e.g. biological growth; Posina, 2016).

What are we to make of the totality of all conscious experiences along with their essence-preserving transformations? Objects along with essence-preserving morphisms of objects form a category. With experiences as objects [with a given structural essence] and essence-preserving transformations of experiences as structure-preserving morphisms of objects, consciousness—the totality of conscious experiences—can be construed as a category of experiences (Lawvere and

99 Schanuel, 2009, p. 21, 152-154, 321-322). Note that any experience can remain the same
 100 (identity transformation). If I went from sad to happy and from happy to detached, then I went
 101 from sad to detached (composition of transformations of experiences). Along these lines, other
 102 axioms and laws, which are required to be satisfied in order for us to talk about a category of
 103 experiences, can be verified. Within this categorical framework, the structure of consciousness is
 104 an external reflection of the structural essence of conscious experiences (Lawvere, 1972, p. 10).
 105 More immediately, a category embodies a mode of cohesion (Lawvere and Schanuel, 2009, p.
 106 146), which is the most basic attribute of conscious experience. For example, parts (hands, legs,
 107 etc.) of a body have a mode of cohesion, which is different from the mode of cohesion of parts
 108 (color, shape) of a perceptual object. Note that ‘part’ is both itself and its relationship to the
 109 whole (Lawvere, 1994, p. 53).

110 As an illustration of theory of a category and its basic shapes, I present simple theories
 111 (abstract essences) of conscious experiences (in the spirit of Lawvere, 1999). More explicitly, the
 112 mathematical method, according to F. William Lawvere, “consists of taking the main structure
 113 [of an object] by itself as a first approximation to a theory of the object, i.e. mentally operating as
 114 though all further structure of the object simply did not exist” (Lawvere, 1972, pp. 9-10). With
 115 ‘interpretation of sensation’ (Croner and Albright, 1999) as a theory of conscious experiences,
 116 we obtain a category of two-sequential processes as the category of conscious experiences. Here,
 117 the basic shapes are physical stimuli, neural sensation of stimuli, and conscious interpretation of
 118 sensation. With conscious experience as an object of the category of two sequential functions, we
 119 find that the objective logic intrinsic to consciousness is non-Boolean; for example, it has four
 120 truth values (Posina, Ghista and Roy, 2017, pp. 172-174). Alternatively, we can take ‘action of
 121 memory on sensation’ (Hopfield, 1982; Lawvere and Schanuel, 2009, p. 218) as a theory of

conscious experiences. With empathy and aboutness (or representation; Chalmers, 2006) as the form and essence, respectively, of conscious experiences, we can define conscious experience as a product: Empathy x Aboutness (cf. red circle = Shape x Color, i.e., object as a product of its extensive and intensive qualities; Lawvere, 2007, pp. 44-45). Yet another example of an abstract theory of conscious experiences is ‘particular as an exemplar of a general’ (Albright, 2013b, pp. 628-630), which gives the category of idempotents as the category of conscious experiences (Lawvere and Schanuel, 2009, p. 106).

Given a category of experiences, how do we abstract the theory (essence) of experiences? Theorization begins with measurements of properties of the objects of the given category. Oftentimes, we find that there is small subcategory of properties (and their determinations) within the category of all properties that constitutes the abstract essence shared by all objects of the given category. This abstract essence in which every object of a given category partakes is the theory of the given category (Lawvere, 1994, pp. 44-47; Lawvere and Rosebrugh, 2003, pp. 154-155; Lawvere and Schanuel, 2009, pp. 149-150; see also Fig. 5 in Posina, Ghista and Roy, 2017). In geometric terminology, we consider a subcategory of basic shapes and their incidence relations, and examine if figures with objects in the subcategory as shapes are adequate to completely characterize every object of the category and tell apart transformations between objects (Lawvere, 1994, p. 49; Lawvere and Schanuel, 2009, pp. 370-371).

Designing User Experience

We now view user experience design in light of the category of conscious experiences. Let us say you were to design an artifact that elicits a specific experience, say, religious experience

(Arbib, 2016). You imagine a category of artifacts (along with their mutual relations). Next, you measure the values of their properties and examine their mutual determination. On further examination, you find within this category of properties (and determinations), there is a subcategory of properties, which is essential for the elicitation of the specific experience (cf. raised gaze for religious experience). This essence is the theory of the category of artifacts (eliciting the desired experience). Now that you have the essence ('raising the gaze') of the category of religious buildings, you interpret the essence (theory) into a background category of, say, brick and mortar to obtain a model of the theory of your imagined category of religious buildings (Lawvere, 1994, pp. 44-47). Within this broad categorical framework, we can accommodate distinct experiences elicited by different architectural designs (Albright, 2015, p. 201).

In the context of developing a scientific theory of conscious experience, it is important to recognize change-of-experience as intrinsic to the practice of design. Neuroscientists vary stimuli and examine the corresponding changes in conscious experience. So do user-experience designers. Designers of user experience, by way of changing the basic shapes (e.g. sensory features, modalities) and their incidence relations constituting the essence or theory of desired experiences, are designing experiences ranging from ordinary experiences with the usual subject-object divide and all the way to aesthetic and spiritual experiences variously described as 'figure-sans-background', 'disappearing into appearance' or 'losing oneself' (cf. music; Posina, 2017). Here, material objects are designed to elicit a specific (pre-conceptualized) experience. In designing experience, design subsumes specification of the experience (in terms of figures of various basic shapes and their incidences) and its essence (aboutness)-preserving transformations from and to experiences of the category of experiences. Since theory is the essence of practices

extracted from a conscious participation in the practice (Lawvere, 2003, p. 215), a theory of experience can be abstracted from conscious participation in the practice of designing user experiences. Furthermore, changing theories and the induced changes in experiences are integral to designing user experiences. Equally importantly, the wealth of empirical data accumulated in designing user experiences is a valuable resource to draw upon in testing for the adequacy of theories of consciousness.

Conclusions

I defined conscious experience as an object of the category of conscious experiences, which aligns with the intuitions engendered by our everyday interactions with things (cf. a table is an object of a category of tables). It is fascinating to note that the most advanced scientific understanding of object (as an object of a category of objects; Lawvere, 2015) is in accord with our ordinary experience. The category of conscious experiences provides the conceptual repertoire—basic shapes, figures and incidences—needed to develop an adequately explicit theory of conscious experience. In doing so, it brings into focus the significance of user experience design in the development of a comprehensive theory of consciousness.

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