Quasi-Conscious Multivariate Systems: a counterpoint to IIT

UNIVERSITY OF OXFORD

Dr Jonathan W. D. Mason, masonj@maths.ox.ac.uk

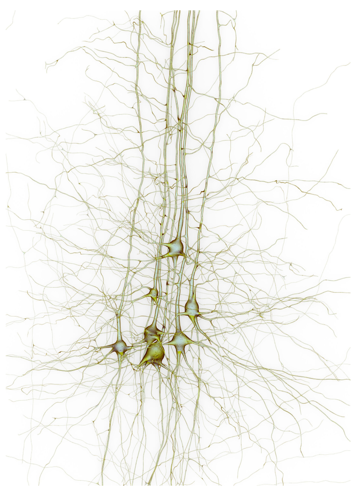
P 041

Introduction

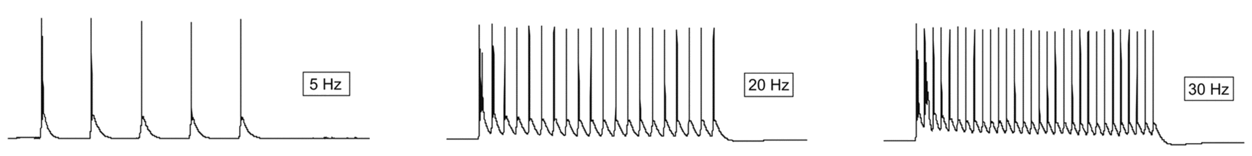
Conscious experience is awash with underlying relationships. Moreover, for various brain regions such as the visual cortex, the system is biased toward some states. Representing this bias using a probability distribution shows that the system can define expected quantities. We can link these facts by using expected float entropy (efe), which is a measure of the expected amount of information needed, to specify the state of the system, beyond what is already known about the system from relationships that appear as parameters. Under the requirement that the relationship parameters minimise efe, the brain defines relationships. It is proposed that when a brain state is interpreted in the context of these relationships the brain state acquires meaning in the form of the relational content of the associated experience. Examples obtained using Monte-Carlo methods (where relationship parameters are chosen uniformly at random) suggest that efe distributions with long left tails are most important.

Definition 1 In this theory, a system is a triple (S, V, P), where:

$S := \{n_1, n_2, n_3, \cdots\}$ is the set of nodes of the system (e.g. where the nodes could be individual neurons or larger mechanisms);



$V := \{v_1, v_2, v_3, \cdots\}$ is the set of node states (e.g. where the node states could be firing frequency or tuples there of);



$P : \Omega_{S,V} \to [0, 1]$ is the inherent probability distribution on the set $\Omega_{S,V}$ of system states. System states have the form

	n_1	n_2	n_3	n_4	$\cdots$
S_i	v_2	v_3	v_1	v_3	$\cdots$

Weighted relations

An observation that is fundamental to this theory is that consciousness is awash with underlying relationships such as those between different points in our field of view (giving geometry), different brightnesses, different colours, different auditory frequencies and volumes, and different tastes/smells etc. By representing relationships with weighted relations, a state of the system S_i and a weighted relation U on V give a canonical choice of weighted relation $R(U, S_i)$ on S. Below is an example.

	n_1	n_2	n_3	$\cdots$
S_i	v_2	v_3	v_1	$\cdots$

U	v_1	v_2	v_3	$\cdots$
v_1	1	0.7	0.3	$\cdots$
v_2	0.7	1	0.6	$\cdots$
v_3	0.3	0.6	1	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$

$\Big\}\, R(U, S_i) :=$

	n_1	n_2	n_3	$\cdots$
n_1	1	0.6	0.7	$\cdots$
n_2	0.6	1	0.3	$\cdots$
n_3	0.7	0.3	1	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$

The set of all reflexive, symmetric weighted-relations on V is denoted Ψ_V and on S is denoted Ψ_S. For $U \in \Psi_V$ we have $R(U, S_i) \in \Psi_S$.

Expected float entropy (efe)

Definition 2 Let (S, V, P) be as in Definition 1, let $U \in \Psi_V$, and let $R \in \Psi_S$. The *float entropy* of a system state $S_i \in \Omega_{S,V}$, relative to U and R, is defined as

$$\mathrm{fe}(R, U, S_i) := \log_2(\#\{S_j \in \Omega_{S,V} : \mathrm{d}(R, R\{U, S_j\}) \leq \mathrm{d}(R, R\{U, S_i\})\}),$$

where d is a suitable metric. Furthermore, the *expected float entropy*, relative to U and R, is defined as

$$\mathrm{efe}(R, U, P) := \sum_{S_i \in \Omega_{S,V}} P(S_i)\mathrm{fe}(R, U, S_i).$$

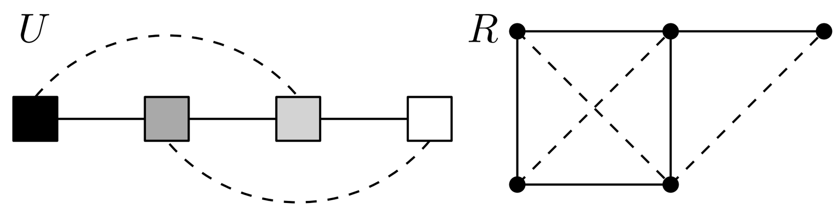
It is proposed that a system (such as the brain and its subregions) will define U and R (up to a certain resolution) under the requirement that the efe is minimised. Hence, for a given system (S, V, P), we attempt to find solutions in U and R to the equation

$$\mathrm{efe}(R, U, P) = \min_{R' \in \Psi_S, U' \in \Psi_V} \mathrm{efe}(R', U', P). \tag{1}$$

Example

With potential relevance to the visual cortex, digital photographs can be sampled to approximate P for systems that are biased toward such states. In this example the photographs have a four shade gray scale, giving $\#V = 4$, and five sampling locations are used giving $\#S = 5$. At higher computational cost, the example could equally well use colour photographs.

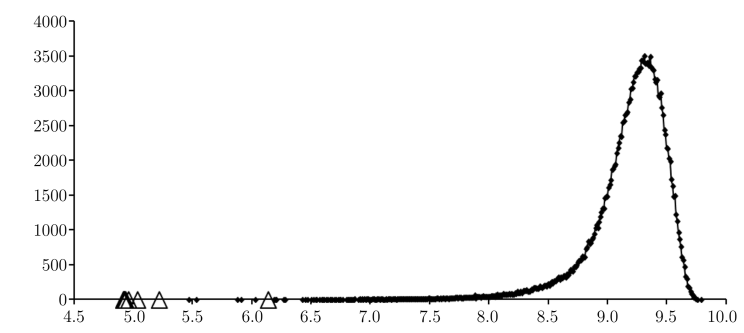
Below is a graph illustration of an approximate solution to (1), showing strongest relationships (solid lines) and intermediate relationships (dash lines).



If relevant to the visual cortex then such examples show that the perceived relationships between different colours, the perceived relationships between different brightnesses, and the perceived relationships between different points in a persons field of view (giving geometry) are all defined by the brain in a mutually dependent way.

efe-histograms obtained from Monte-Carlo methods

For a given system (S, V, P), we can choose weighted relations uniformly at random and compute the efe values to obtain an efe-histograms.



Research suggests that efe-distributions with long left tails are most important; when P is uniformly random the left tail disappears.

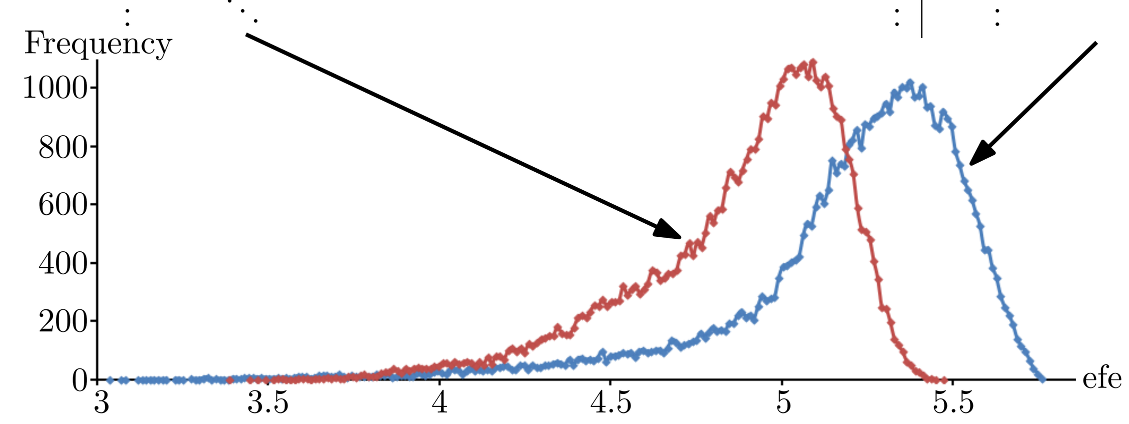
Base branching structure

In this theory, nodes need not be individual neurons. Instead there is a base branching structure given by the different ways to form composite nodes (tuples) that have comparable states. Below is an example.

	n_1	n_2	n_3	n_4	$\cdots$
S_i	v_2	v_3	v_1	v_3	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$

	(n_3, n_1)	(n_2, n_4)	$\cdots$
S'_i	(v_1, v_2)	(v_3, v_3)	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\ddots$

	(n_4, n_1)	(n_3, n_2)	$\cdots$
S''_i	(v_3, v_2)	(v_1, v_3)	$\cdots$
$\vdots$	$\vdots$	$\vdots$	$\ddots$



Some branches give efe-histograms that have much longer left tails than others. Hence, the definition of efe generalises to involve weighted relations on those branches.

References

(1) Jonathan W. D. Mason, *Quasi-Conscious Multivariate Systems*, accepted to appear in Complexity, 2015.

(2) Jonathan W. D. Mason, *Consciousness and the structuring property of typical data*, Complexity, 18(3):2837, 2013.