



# INTEGRATED INFORMATION THEORY

A non-binary systems based code implementation

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PLOS COMPUTATIONAL BIOLOGY

## From the Phenomenology to the Mechanisms of Consciousness: Integrated Information Theory 3.0

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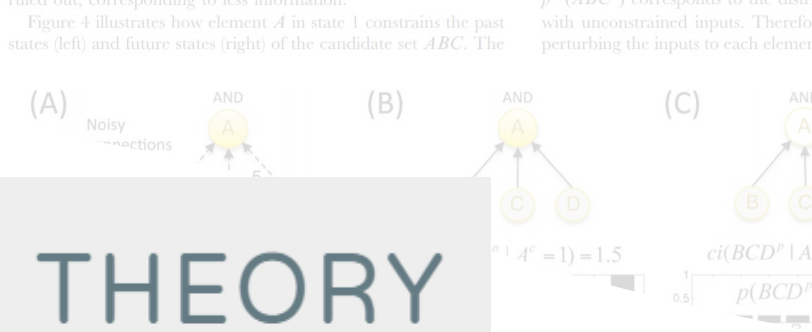


By Juan Gomez, PhD

2019

### Abstract

This paper presents Integrated Information Theory (IIT) of consciousness, which incorporates various previous formulations. IIT starts from phenomenological axioms: information says that what it is by how it differs from alternative experiences; integration says that interdependent components; exclusion says that it has unique borders. These axioms are formalized into postulates that prescribe how physical mechanisms can generate experience (phenomenology). The postulates are: (1) "a difference" within a system, and integration that specified by its mechanism.



## New function to calculate the TPM of a system:

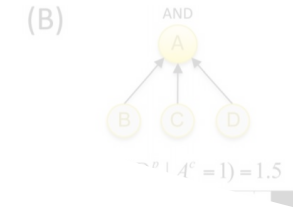
The re-design of the algorithm aimed to calculate a TPM, makes it possible now to work with systems of  $n$  elements, each with  $m$  possible states.

This new flexible method will allow us to analyze non binary systems.

Here is the Phyton code and next, some examples of its performance are shared.



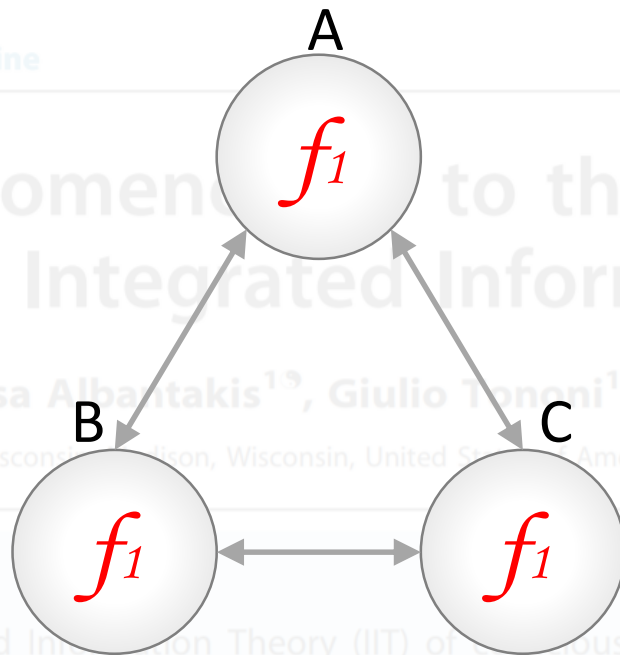
ruled out, corresponding to less information.  
Figure 4 illustrates how element  $A$  in state 1 constrains the past states (left) and future states (right) of the candidate set  $ABC$ . The



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what it is by how it differs from alternative experiences; integration...  
interdependent components; exclusion says that it has unique borders...  
are formalized into postulates that prescribe how physical...  
to generate experience (phenomenology). The postulates...  
a difference" within a system, and integration...  
that specified by its...  
that specified by its...

# System of 3 elements, each element with 3 possible states



$$f_1 = \begin{cases} 1 & \text{if } x_1 + x_2 > 0 \\ 0 & \text{if } x_1 + x_2 = 0 \\ -1 & \text{if } x_1 + x_2 < 0 \end{cases}$$



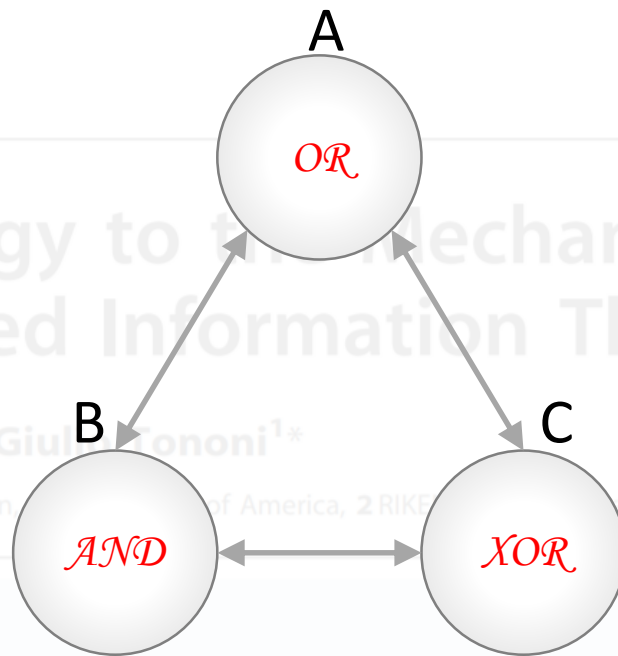
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# TPM

[illegible]

# System of 3 elements, each element with 2 possible states



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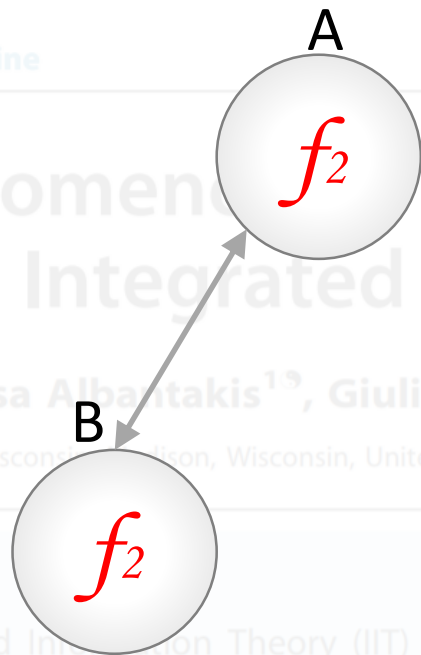
# TPM

A	0	1	0	1	0	1	0	1
B	0	0	1	1	0	0	1	1
C	0	0	0	0	1	1	1	1

A	B	C									
0	0	0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
0	1	0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
1	1	0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	0	1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
0	1	1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
1	1	1	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0



# System of 2 elements, each element with 4 possible states



$$f_2 = \begin{cases} 2 & \text{if } 2 \leq i+v \leq 4 \\ 1 & \text{if } 0 \leq i+v \leq 1 \\ -1 & \text{if } -2 \leq i+v \leq -1 \\ -2 & \text{if } -4 \leq i+v \leq -3 \end{cases}$$

$i$ : input

$v$ : own value





# TPM

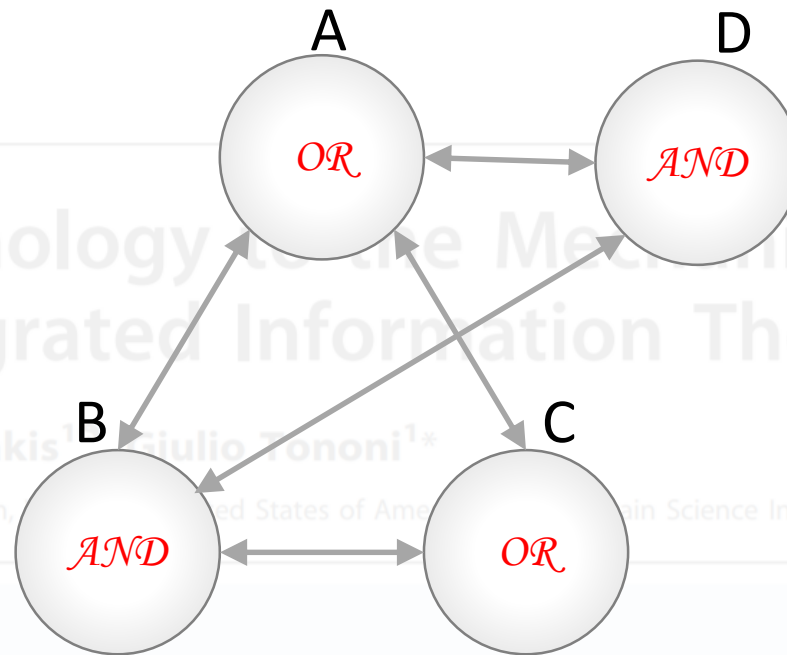
A -2 -1 1 2 -2 -1 1 2 -2 -1 1 2 -2 -1 1 2  
B -2 -2 -2 -2 -1 -1 -1 -1 1 1 1 1 2 2 2 2

A	B																
-2	-2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-1	-2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	-2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
-2	-1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-1	-1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
2	-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
-2	1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
-2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
-1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0





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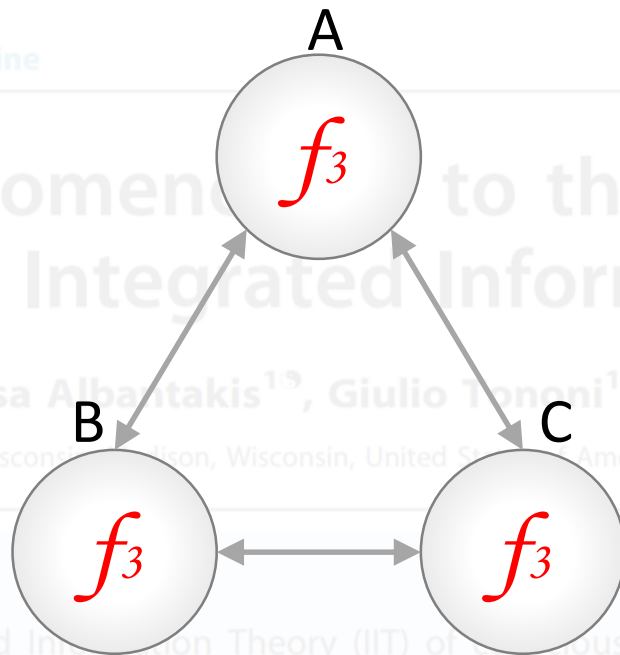
# TPM

A	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
B	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
C	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
D	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

A	B	C	D																	
0	0	0	0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	0	0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	1	0	0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
0	0	1	0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	1	0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	1	1	0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
0	0	0	1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	0	1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	1	0	1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	0	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
0	0	1	1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	1	1	1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0



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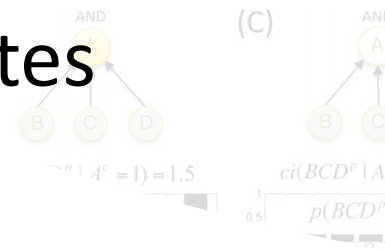


$$f_3 = \begin{cases} 2 & \text{if } 2 \leq x_1 + x_2 \leq 4 \\ 1 & \text{if } 0 \leq x_1 + x_2 \leq 1 \\ -1 & \text{if } -2 \leq x_1 + x_2 \leq -1 \\ -2 & \text{if } -4 \leq x_1 + x_2 \leq -3 \end{cases}$$



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# TPM

[illegible]

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