



# 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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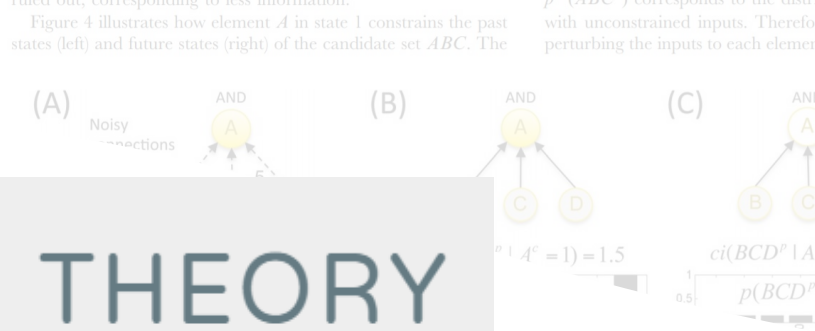


By Juan Gomez, PhD

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 is the process of specifying that difference by its parts.



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

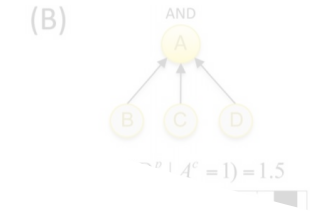
The re-design of the algorithm aimed to calculate a TPM, makes it possible now to work with systems of  $n$  elements, each with  $m$  possible states.

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.



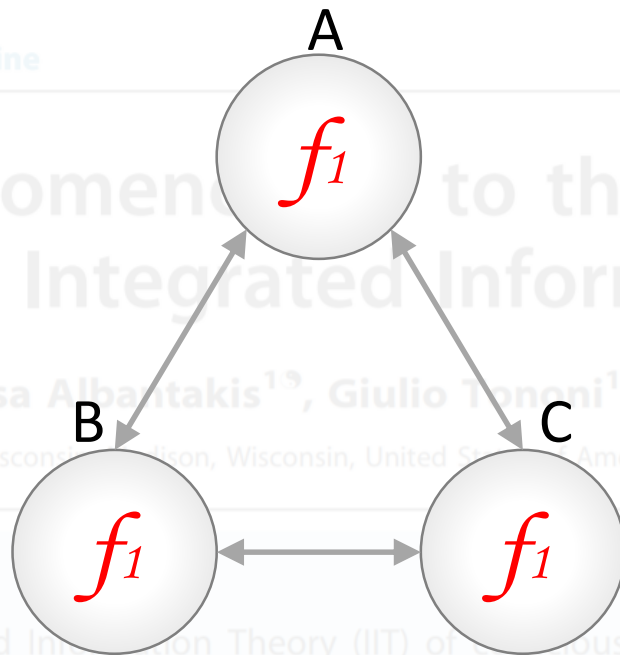
ruled out, corresponding to less information.  
Figure 4 illustrates how element  $A$  in state 1 constrains the past states (left) and future states (right) of the candidate set  $ABC$ . The



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

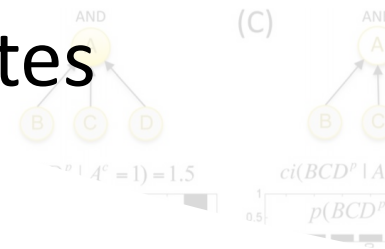


$$f_1 = \begin{cases} 1 & \text{if } x_1 + x_2 > 0 \\ 0 & \text{if } x_1 + x_2 = 0 \\ -1 & \text{if } x_1 + x_2 < 0 \end{cases}$$



## Abstract

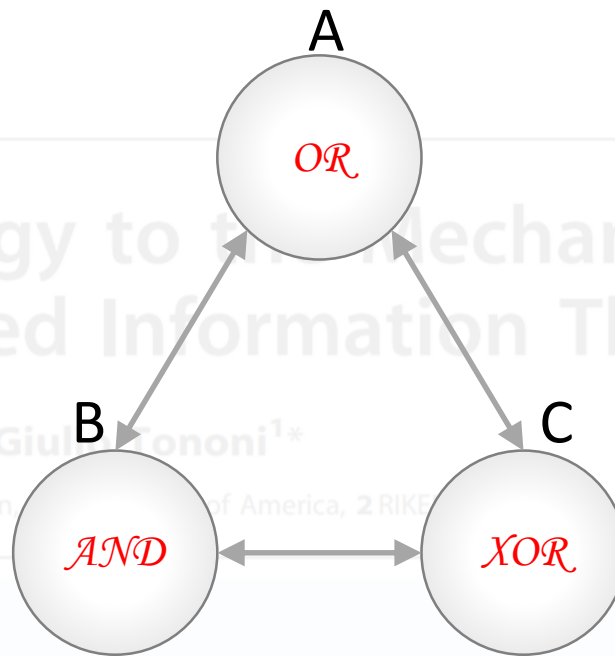
This paper presents Integrated Information Theory (IIT) of consciousness 3.0, which incorporates various previous formulations. IIT starts from phenomenological axioms: information says that what it is by how it differs from alternative experiences; integration says that the system is a unified whole of interdependent components; exclusion says that it has unique borders. These axioms are formalized into postulates that prescribe how physical processes generate experience (phenomenology). The postulates are: "a difference" within a system, and integration is the process that specifies by its



# TPM

[illegible]

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



## Abstract

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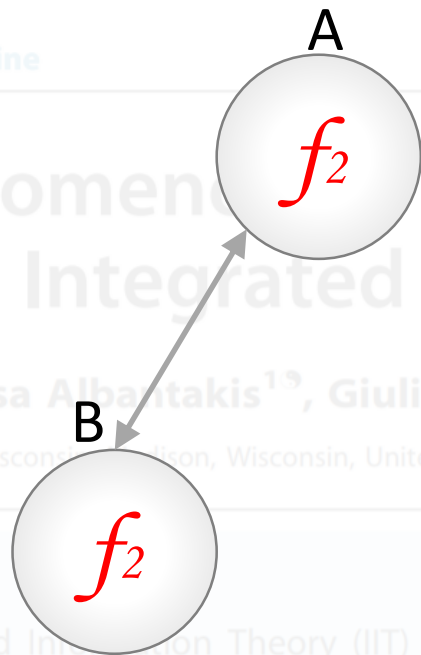
# TPM

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





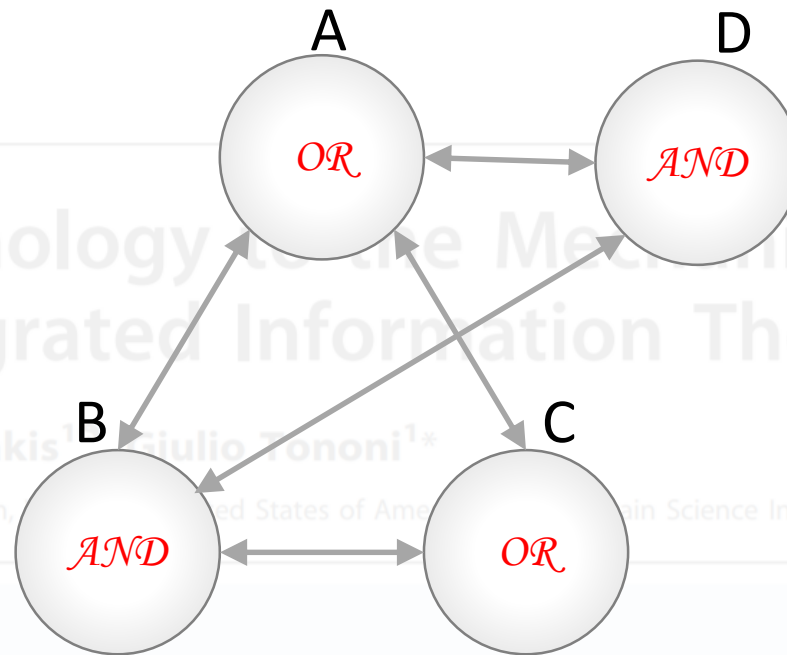
# TPM

		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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	0.0	1.0





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



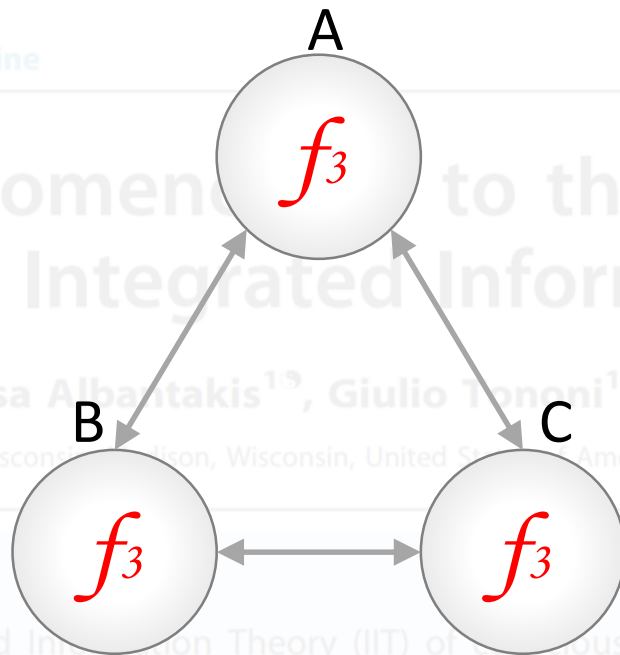
# TPM

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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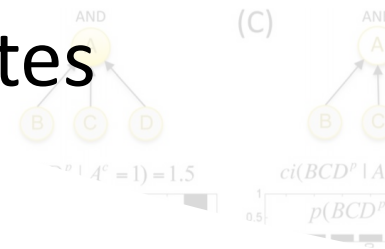


$$f_3 = \begin{cases} 2 & \text{if } 2 \leq x_1 + x_2 \leq 4 \\ 1 & \text{if } 0 \leq x_1 + x_2 \leq 1 \\ -1 & \text{if } -2 \leq x_1 + x_2 \leq -1 \\ -2 & \text{if } -4 \leq x_1 + x_2 \leq -3 \end{cases}$$



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[illegible]

...

