

THE LOGIC OF PSYCHIATRY

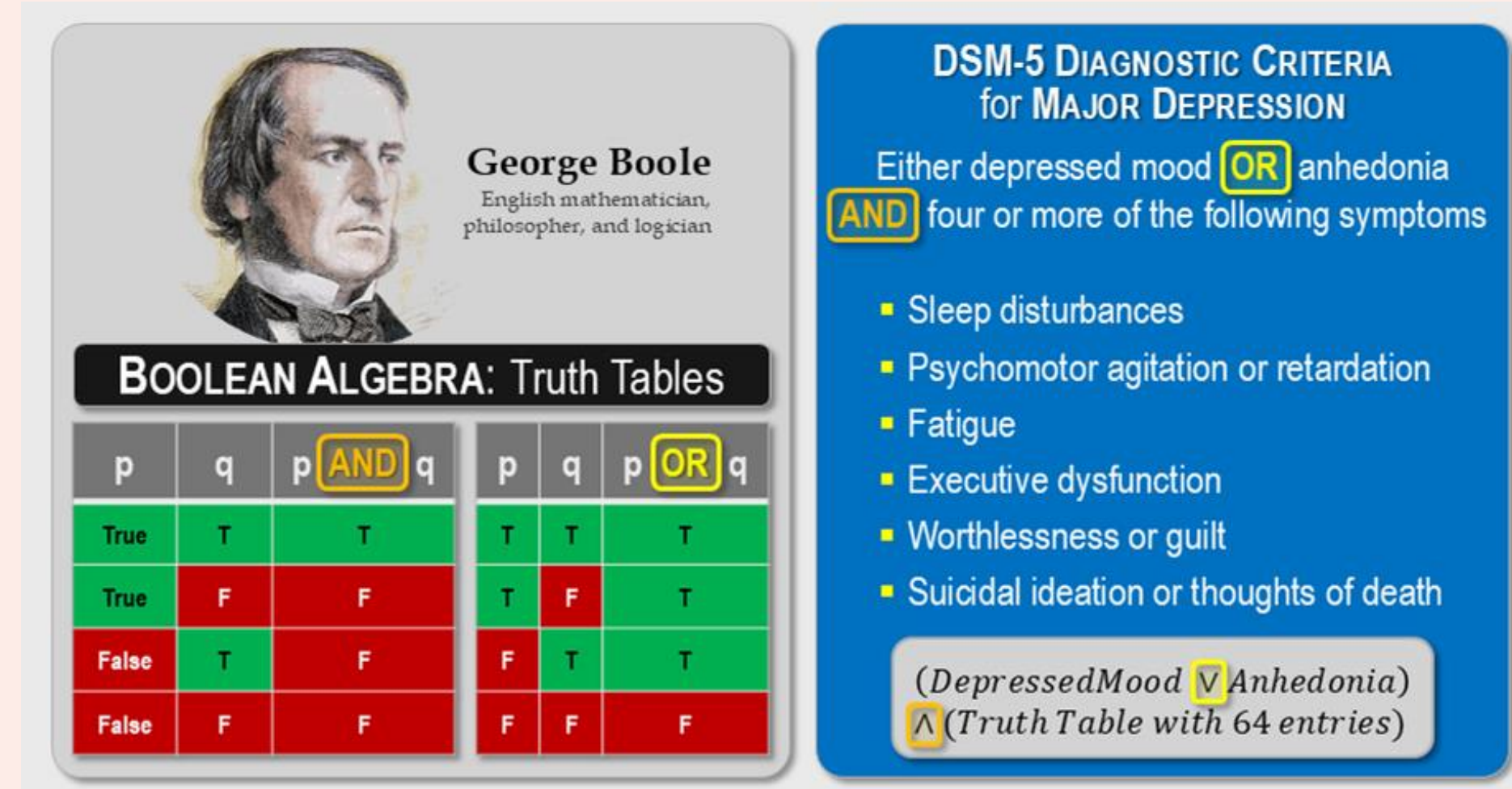
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INTRODUCTION & BACKGROUND

Through logic's gaze, the minds distress is shown,
Where Boole's role diagnosing may be known.
By **OR**, let mood or joy's decline be etched,
Setting the stage for more signs to be sketched.
With **AND**, four trials of grief must bind tight,
Till truth unfolds the diagnosis — right.

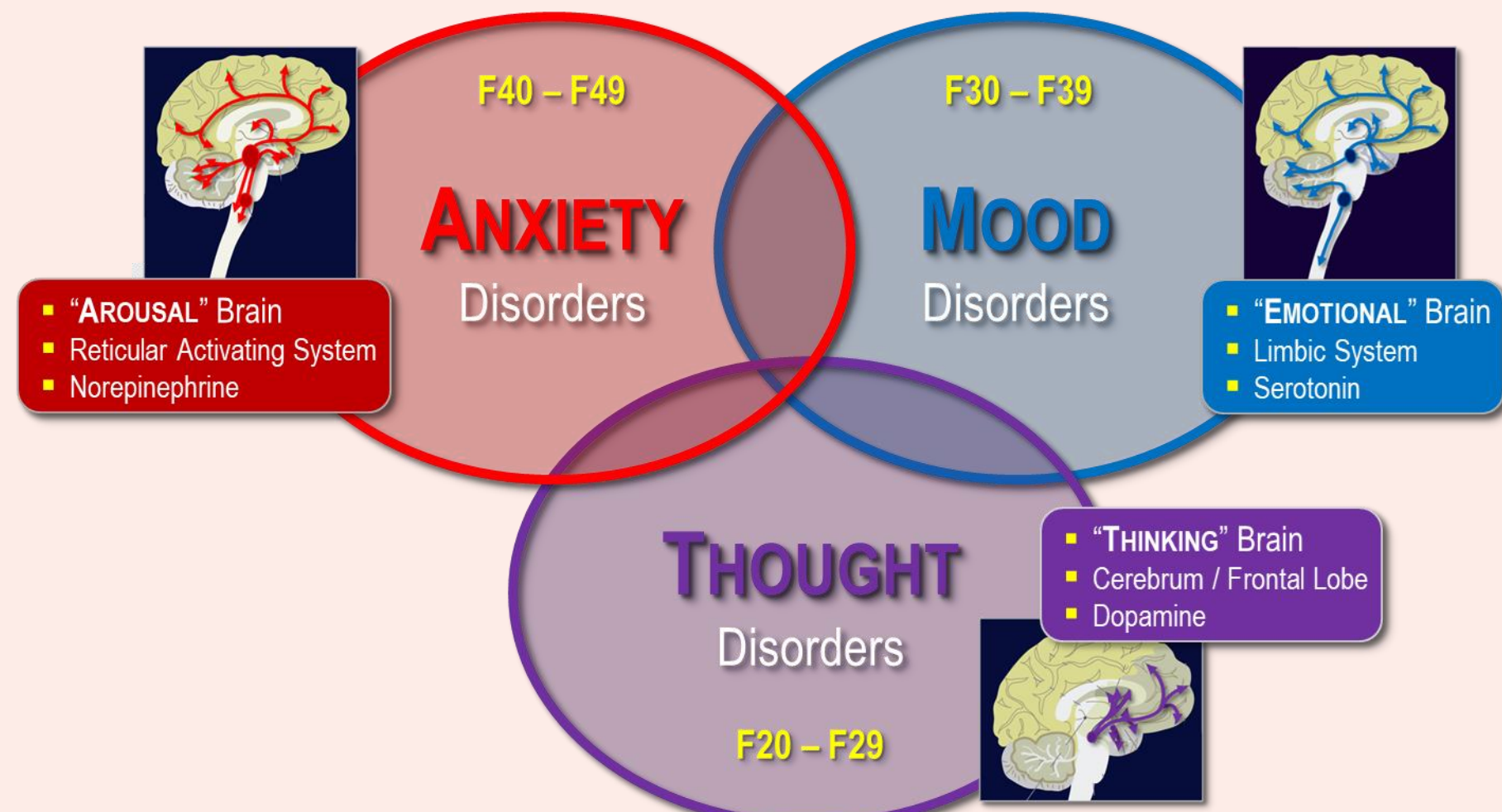
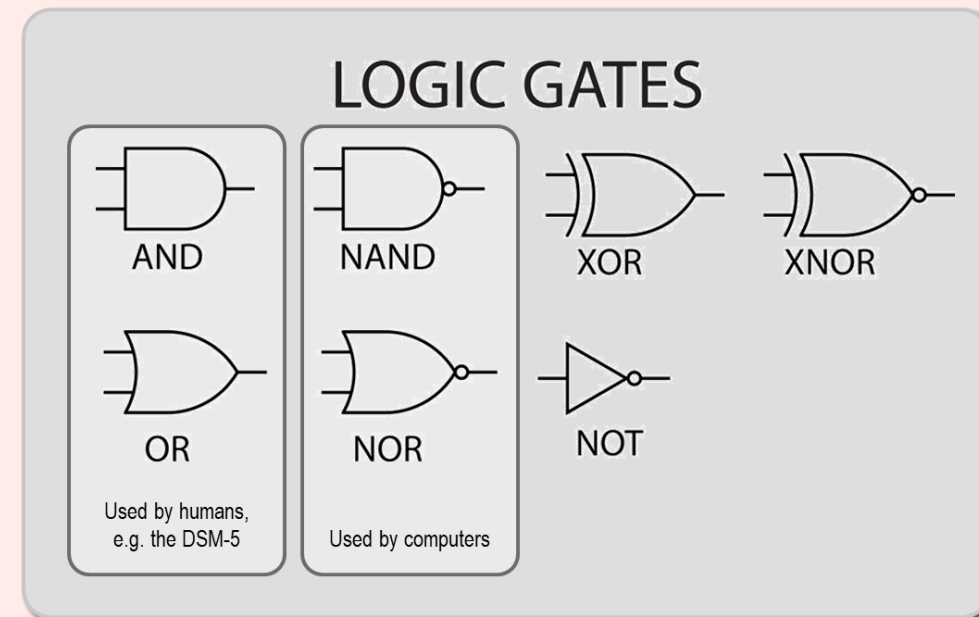


Questions We Wish to Answer

- Is there a logic to psychiatry?
- What patterns and structures become evident?
- How can these logical structures be used to improve patient diagnosis, treatment & prognosis?
- How can these logical structures be used to improve the next incarnation of the Diagnostic Statistical Manual of Mental Disorders (DSM-6)?
- What other new mathematical and computer science concepts may emerge?

Logic Circuits & the DSM-5 as a Logical System

- Boolean Algebra (as introduced above) can be translated into logic circuits
- These circuits are composed of logic gates corresponding to the **AND**, **OR** and **NOT** statements in human language
- For technical reasons, in computers the logic gates are **NAND**, **NOR** and **NOT**.
- Therefore, in principle, the logical constructions of criteria in the DSM-5, the standard reference for psychiatric diagnosis, can be converted to logic circuits.



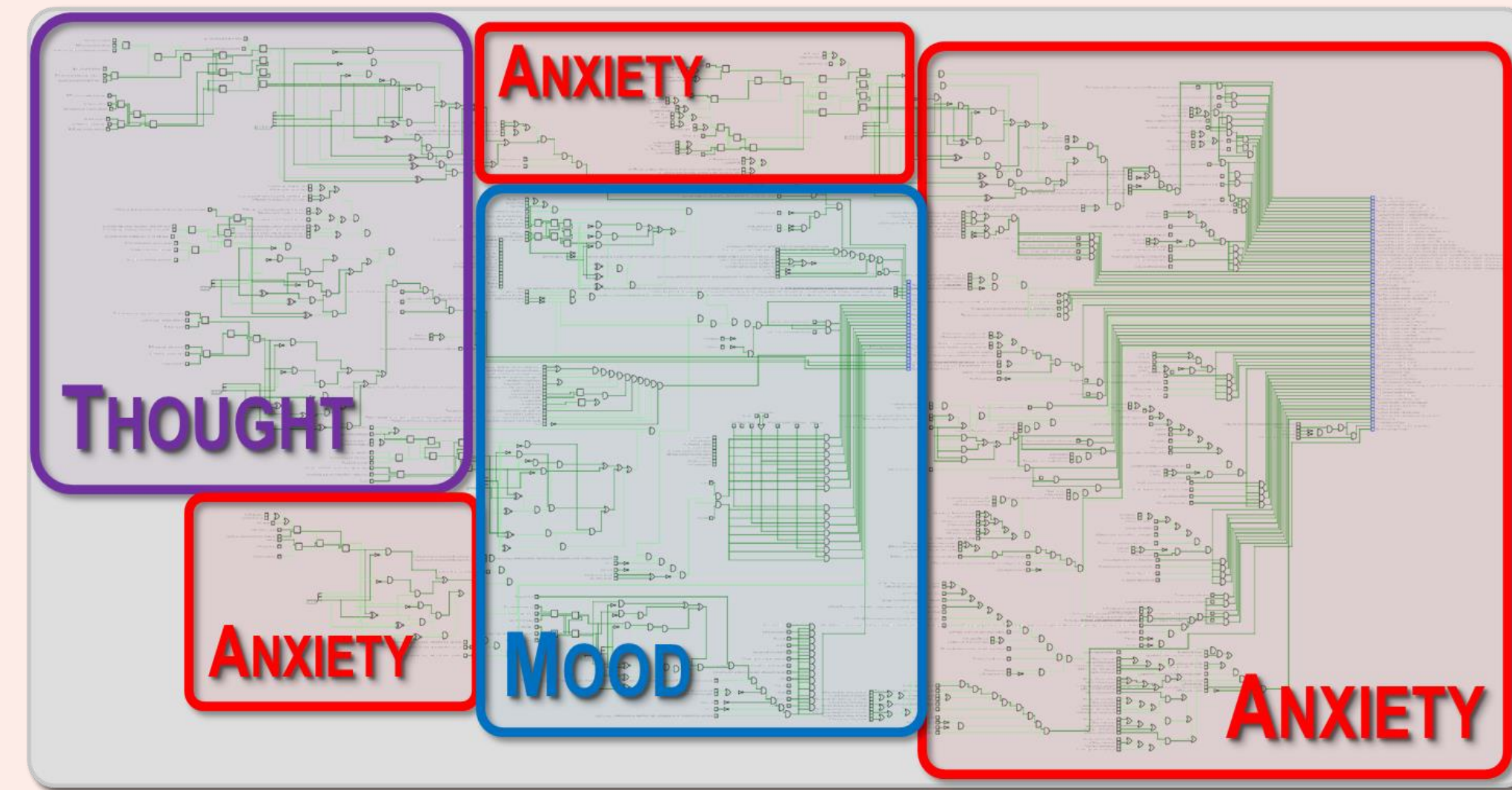
- DSM-5 has 297 conditions, but we focus on the **82 core (Axis I) disorders** as below:
 - Anxiety Disorders**: 40 disorders
 - Thought Disorders**: 21 disorders
 - Mood Disorders**: 21

In this work we both illustrate and compute based on this concept

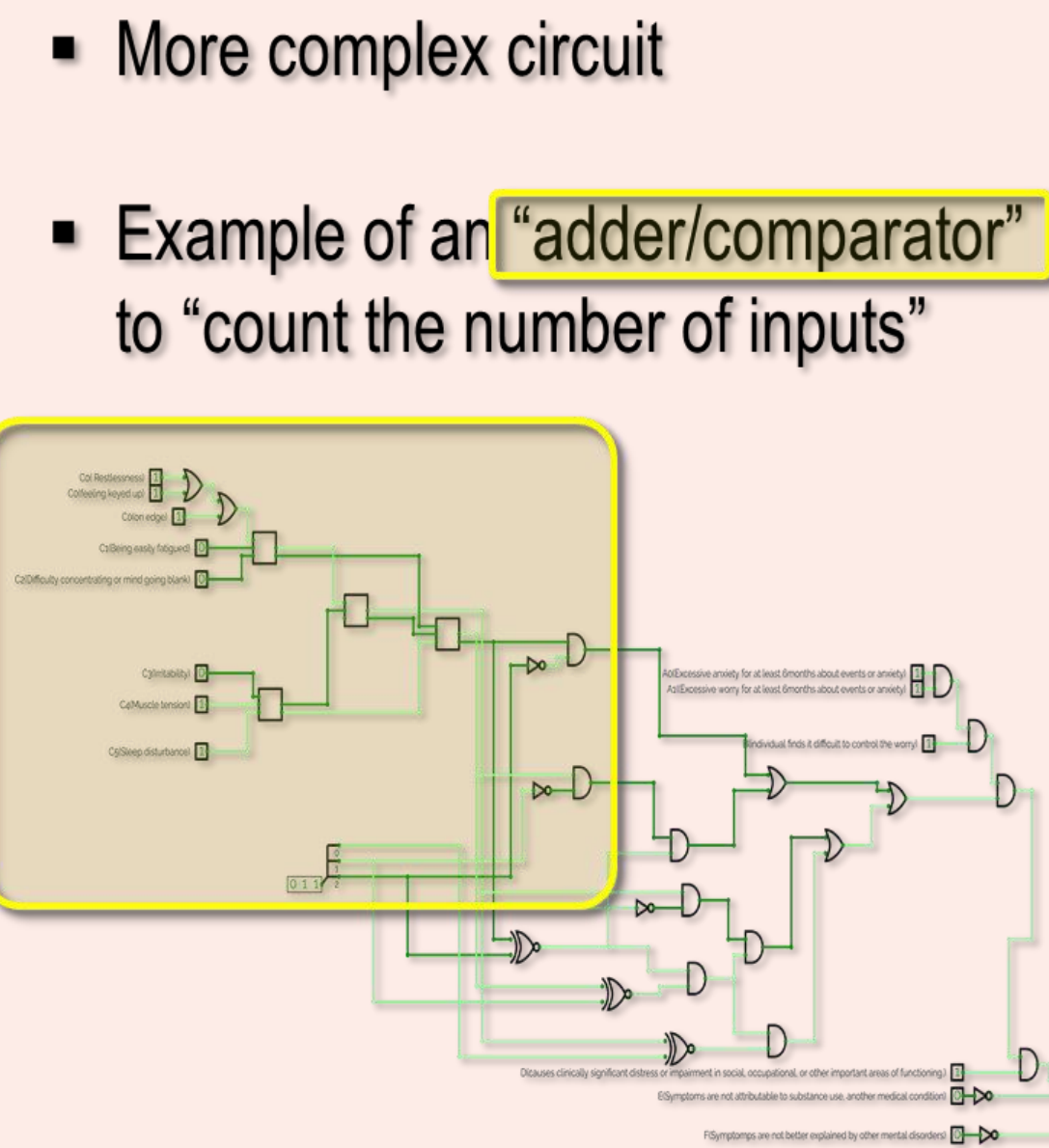
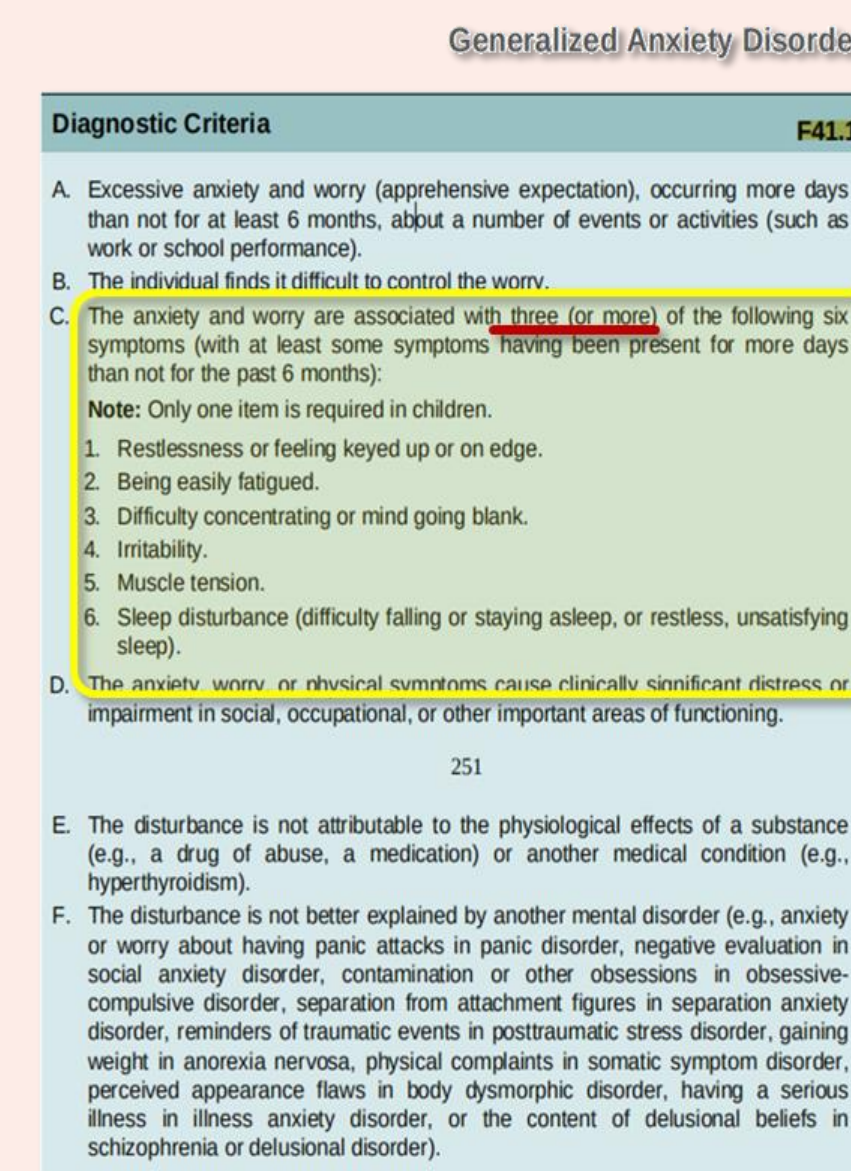
Phase 1 Illustrative

Major Psychiatric Disorders & Proof of Concept

- The DSM-5 Axis I diagnostic criteria for Anxiety, Thought, and Mood disorders were converted into a large-scale logic circuit using Boolean algebra, showcasing symptom-diagnosis relationships with AND, OR, and NOT gates.

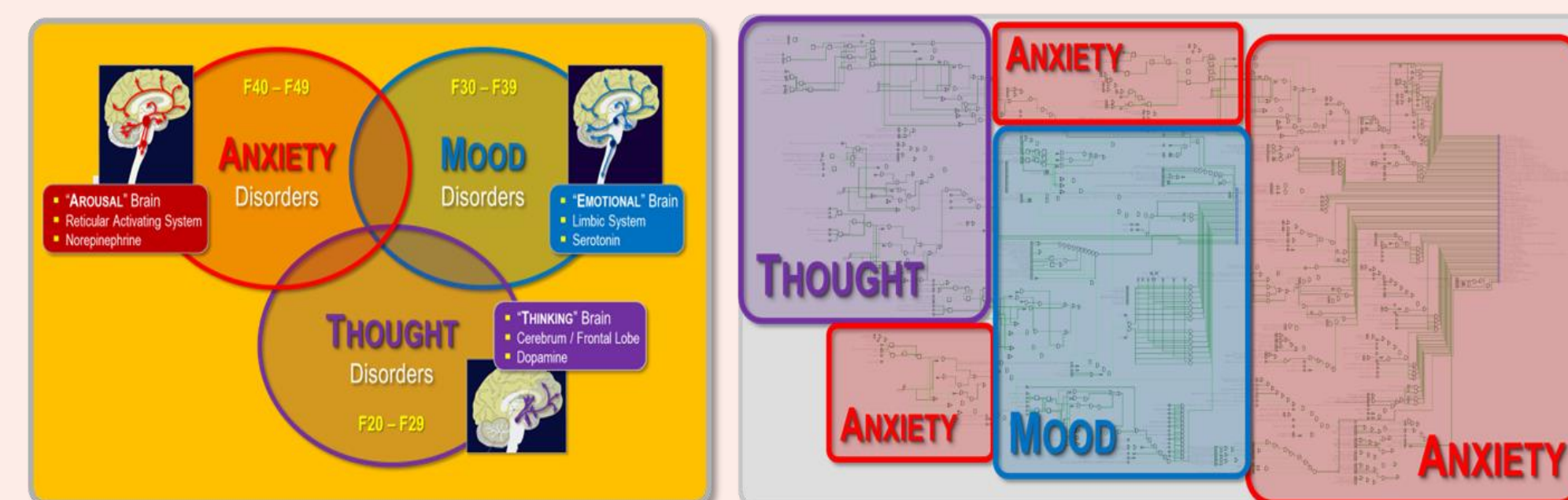


- The logic circuit shows a higher number of logical gates in the Anxiety section due to its greater number of diagnostic variables — covering 50% of the analyzed disorders compared to Thought (25.6%) and Mood (24.4%).



- Generalized Anxiety Disorder (GAD) requires multiple conditions—excessive anxiety (A1), worry (A2), difficulty controlling worry (B), clinically significant impairment (D), and at least 3 of 6 symptoms from C1 – C6 — using multiple AND gates; exclusion criteria (E, F) are incorporated through NOT gates.

- F20 – 29 **“THOUGHT”** disorders → **Few** DSM-5 codes



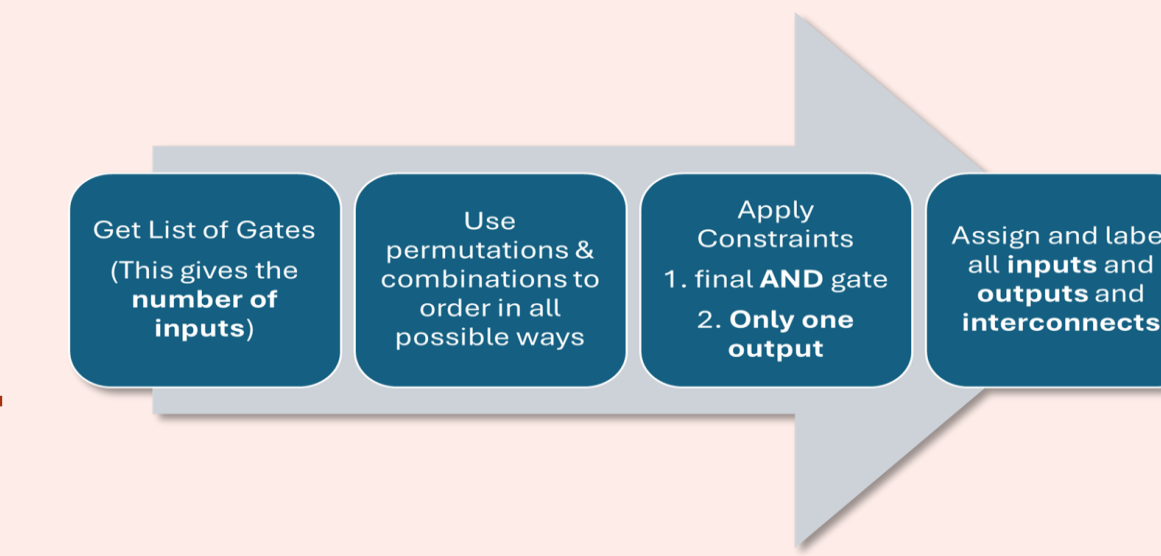
- While F30 – 39 **“MOOD”** & F 40 – 49 **“ANXIETY”** → **Many** codes

- The C1–C6 symptom cluster is evaluated using an adder to sum the inputs and a comparator to verify if the total ≥ 3, increasing the circuit's gate complexity.

RESULTS

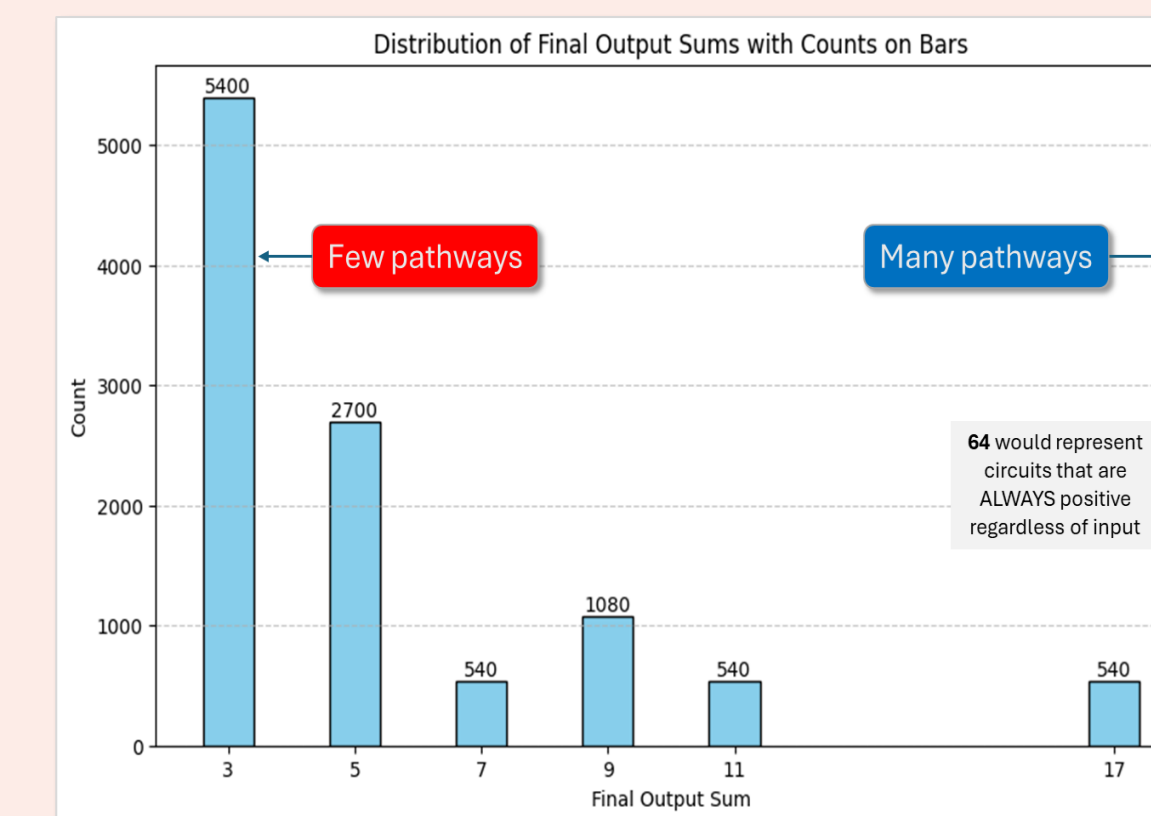
Universal Logic Engine

- The CircuitVerse implementation has limited computational capability and requires each module to be created by hand.
- To enable a **fully computational system**, that can flexibly create any circuit, can also combine all the modules into one, integrated system, and finally, and most importantly, allow us to label and keep track of the pathways, we created a universal logic engine., We call this the "Computational Phase" of the project.

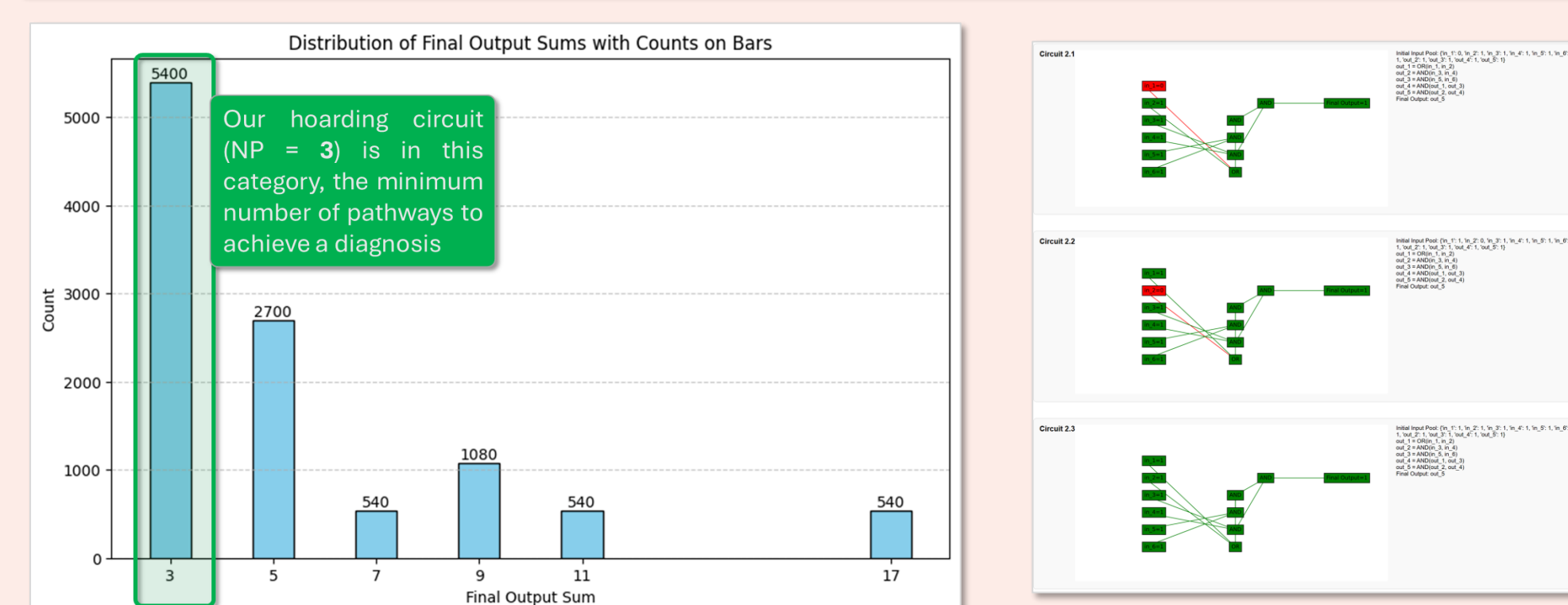
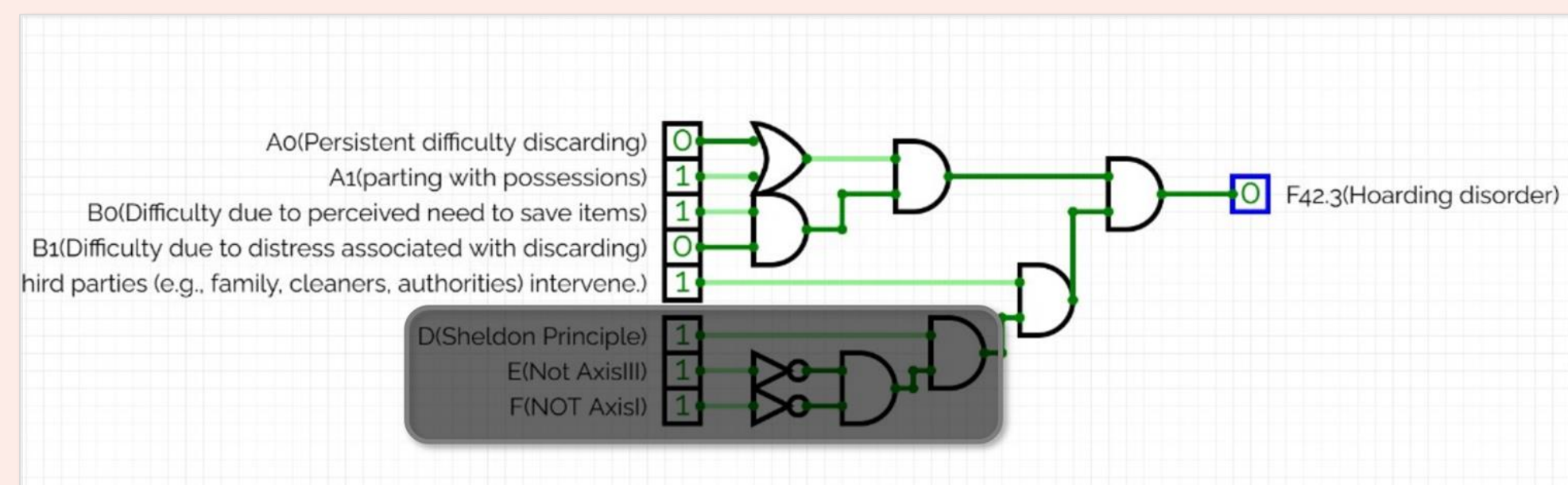


Number of Pathway Analysis

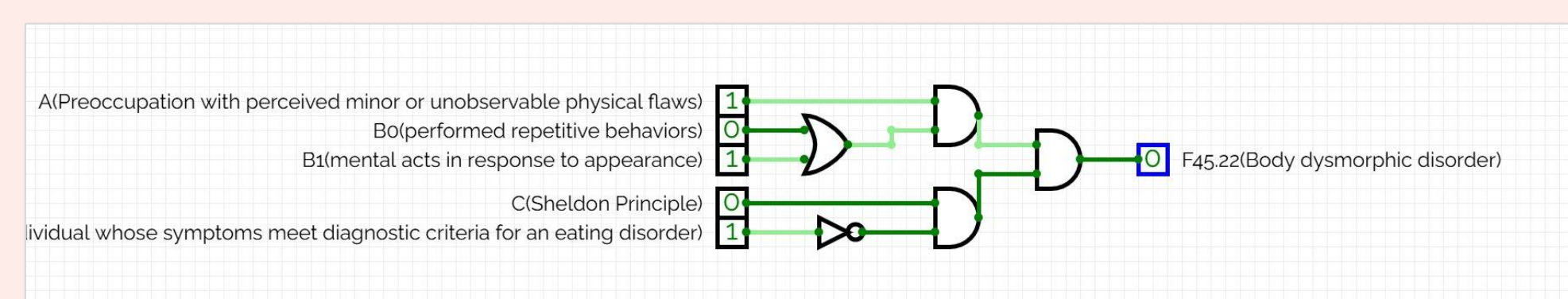
- The graph of an example with 1 OR and 4 AND gates displays the distribution of positive outputs across all 10,800 circuits. The X-axis represents the number of input combinations (For 6 inputs, we have 64 combination) that yield a diagnosis, while the Y-axis shows how many circuits fall into each category.
- The graph distribution is asymmetric and skewed toward circuits with fewer positive outputs because AND gates are more restrictive, requiring inputs to be true. As a result, 5400 circuits produce a positive diagnosis for only 3 out of 64 possible input combinations. We use this example to generate one of the DSM modules below (Hoarding Disorder) as outlined below.



Hoarding Disorder (F42.3)



Body Dysmorphic Disorder (F45.22)



- The Body Dysmorphic Disorder circuit uses 1 OR gate and 2 AND gates to model DSM-5 criteria with 3 diagnostic pathways (NoP = 3), while Specific Phobia has more restrictive circuit, with a single-pathway circuit (NoP = 1) requiring all six inputs to be true.

These results lead to a wide range of conclusions

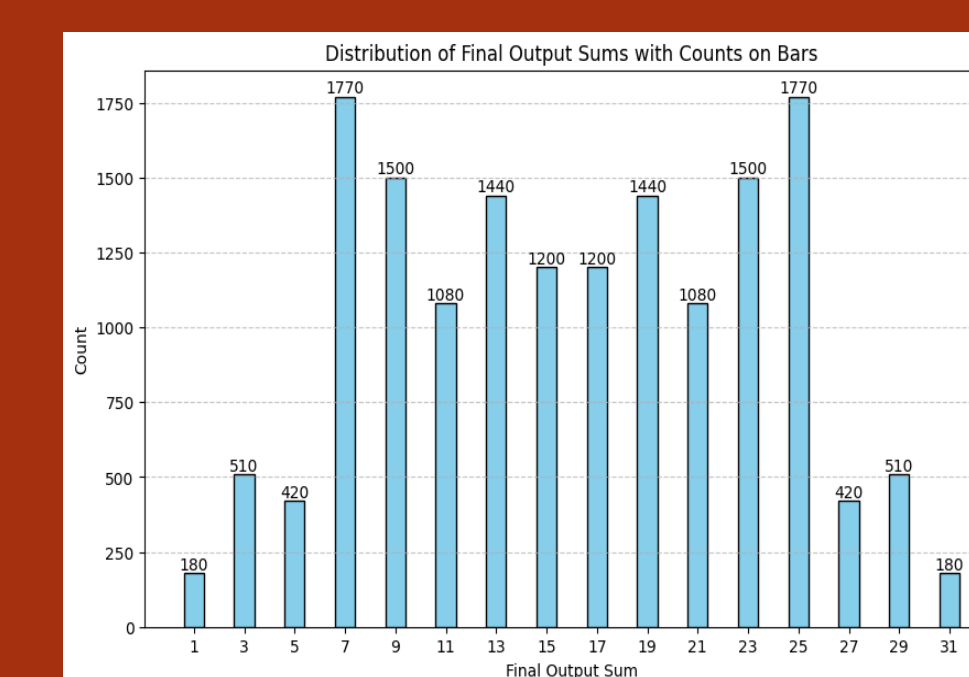
CONCLUSIONS & IMPLICATIONS

Implications for Psychiatry

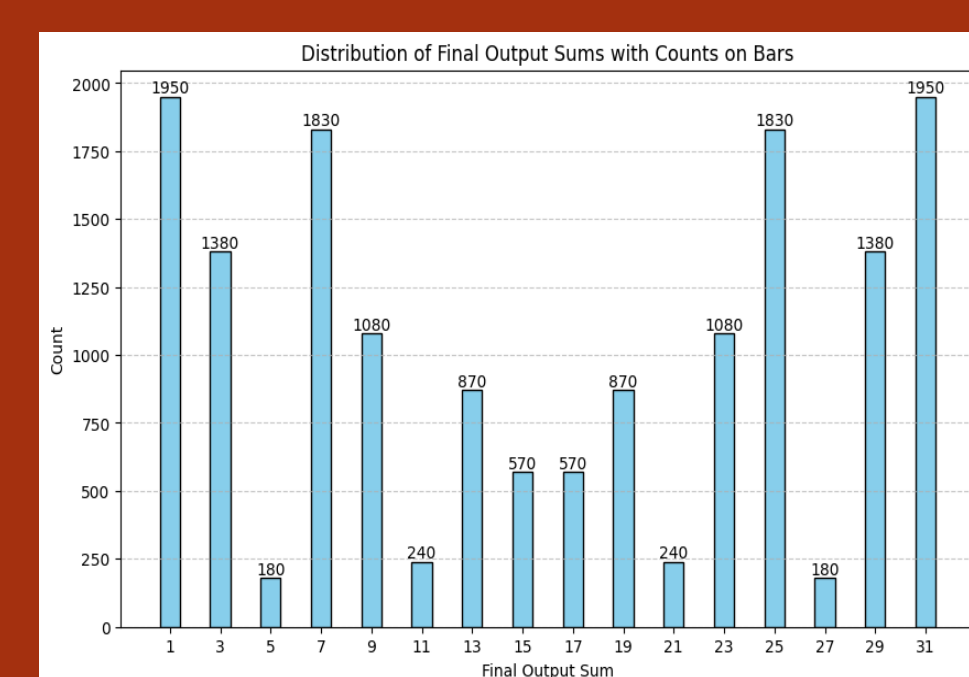
- Pathway analysis offers a novel approach to further refine diagnosis and align with treatment modalities and differing prognosis (such as predicting suicide risk with depression)
- Treatment-resistant depression, for example, may be represented by specific pathways to diagnosis (symptom complexes) which can be predicted in advance
- Monitoring of disease and tracking of improvement can be further assessed by tracking changing symptom complexes and pathways in the diagnosis

Implications for Computer Science & Philosophy

- Wittgenstein in his *Tractatus-Logico-Philosophicus* proposed a "Logical Space." Our ability to generate all possible logic circuits and accompanying NoP analysis facilitates a more rigorous framing of this concept.
- We see, for example, that the NoP analysis for circuits based on human logic (AND, OR & NOT) is entirely different than that of circuits based on computer logic (NAND, NOR & NOT).



Human Logic



Computer Logic

Future Work

- Preparing for publication of the DSM-related work in a major Psychology / Psychiatric journal.
- Developing a website and mobile app for business applications (MavPitch entry).
- Two papers: Preparing for publication of the computational / combinatorial logic system and accompanying NoP analysis in the computer science and mathematics literature.
- Working with leading psychiatrists (Key Opinion Leaders) and the American Psychiatric Association (after the first, main publication) to provide advisory for DSM-6.

Acknowledgements & Key References

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- Spinney, O.T. (2022). Logical form and logical space in Wittgenstein's *Tractatus*. *Synthese*, 200(16).
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