



A Primer for Critical Thinking

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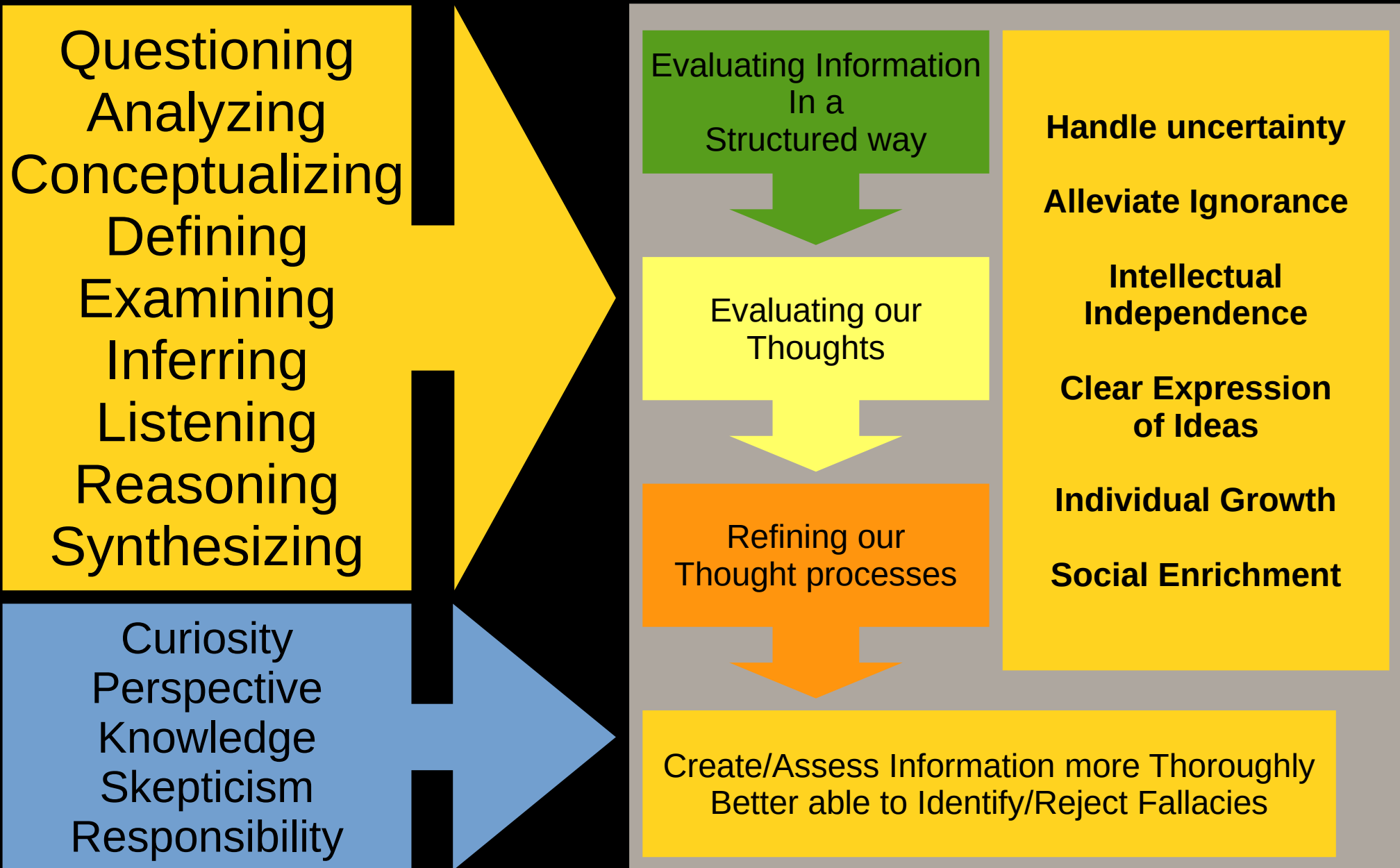
Agenda

Basic Concepts
Considerations
Structured Thinking
Analytic Tools

<https://github.com/joeblankenship1>



Why Critical Thinking





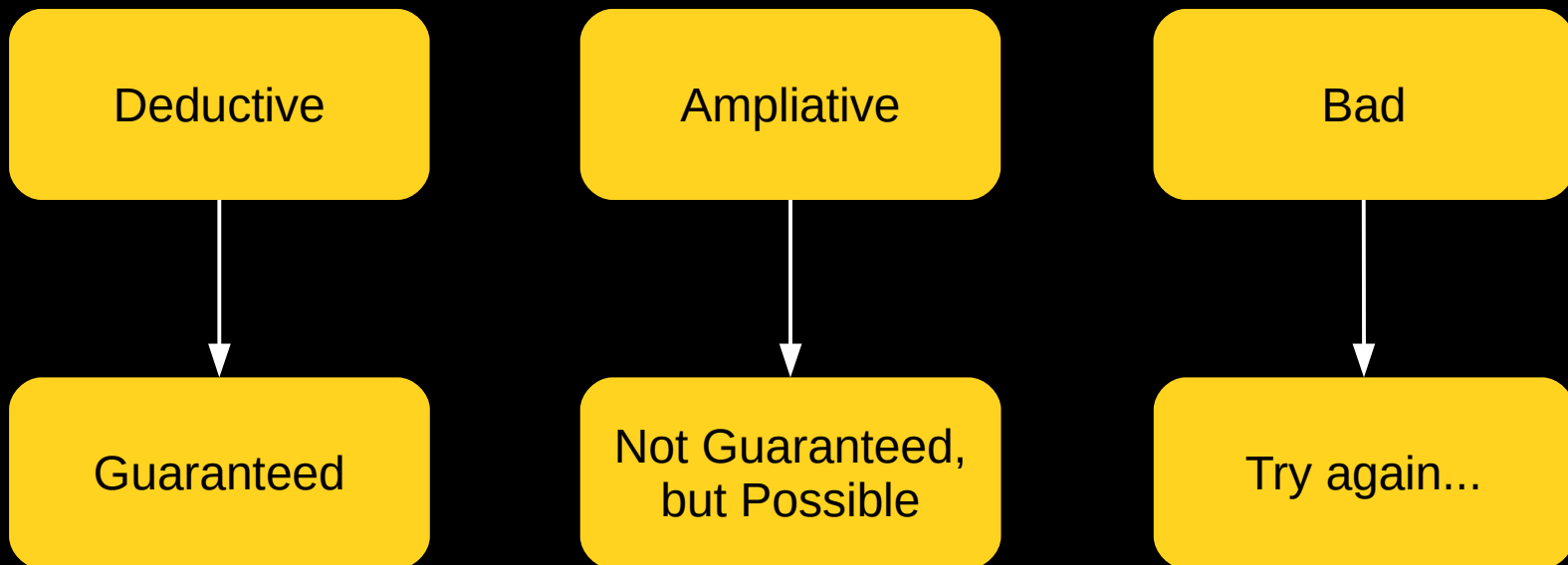
Why Critical Thinking?

- Critical thinking **belongs to the world**
 - Gives you praxis in everything
 - Taking time to “think critically” saves you time
- **Curiosity and skepticism are good**
- Make it a game
 - You **brain wants an adventure**
- **Falsification and Fallacy**
 - Being proven wrong is an opportunity
 - Being able to see how others are wrong
 - Helps you better see the
 - “who, what, when, where, why, and how”



Basics

- **Solid reasoning** behind your conclusion
- **Premises** (statements) form your argument
- **Good argument** supports the **conclusion**



Deductive arguments can still be **False!**



Basics

- Is it **Valid**?
 - Premises can't be true if Conclusion is False
 - Invalid if conclusion is false with all premise as True
- Is it **Sound**?
 - A Valid argument has Premises that are True
 - Anything else is unsound
- **Falsification**?
 - If there is something wrong; try again and make it better!
- **Research**?
 - Logic is not enough, you need Knowledge!

This is deductive reasoning



Basics

- Premises...
 - Don't guarantee a correct Conclusion (ampliative!)
- Conclusions..
 - Inferences to best explanation
- Is the explanation “good”?
 - Fit? Is it Simple?
- Is there a better explanation?
 - Is there more evidence for reevaluation?

This is “every day” abductive reasoning



Basics

- **Necessary Conditions**
 - If “A” is necessary for “B”, “A” has to be True for “B” to be True
- **Sufficient Conditions**
 - If “A” is sufficient for “B”, “A” being True is good enough for “B” to be True
- **Our assessments** of these conditions...
 - Generally rely on your assumptions surrounding the condition (or “**take things for granted**”)
- Can **use these concepts**
 - To break down the elements of the condition to create definition



Basics

- **Implicit Premises**
 - Required to make the argument, but not stated
 - Usually not controversial and obvious to audience
- Ergo...
 - **Need to examine justification!**
 - **Need to provide explanation!**
- This is **Complicated!**
 - Embedded in culture, regional, other geographies



Basics

- **Descriptive Claims**
 - Expressing an understanding or describing
 - Without a following evaluation
- **Normative Claims**
 - Statement of an evaluation
 - Without presentation of the rational (usually implicit)
- **Being aware of this distinction**
 - Allows one to better scrutinize the problem
 - within a contextual space and time



Basics

- Must be aware of **Fallacy!**
 - ...the use of **poor reasoning** in order to **build an argument**
 - Does not necessarily mean the conclusion is false!
- **Many types**
 - Formal or informal (poor form or content in systemic logic)
 - Presumptive (conclusion is the proof)
 - Ambiguity (vague support)
 - And on and on...



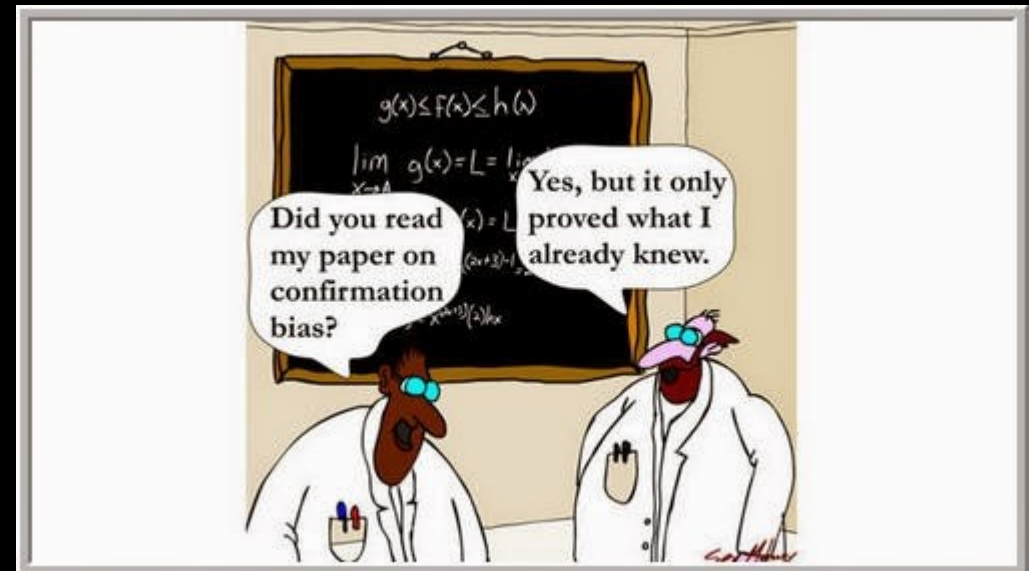
Basics

Questions?



Considerations

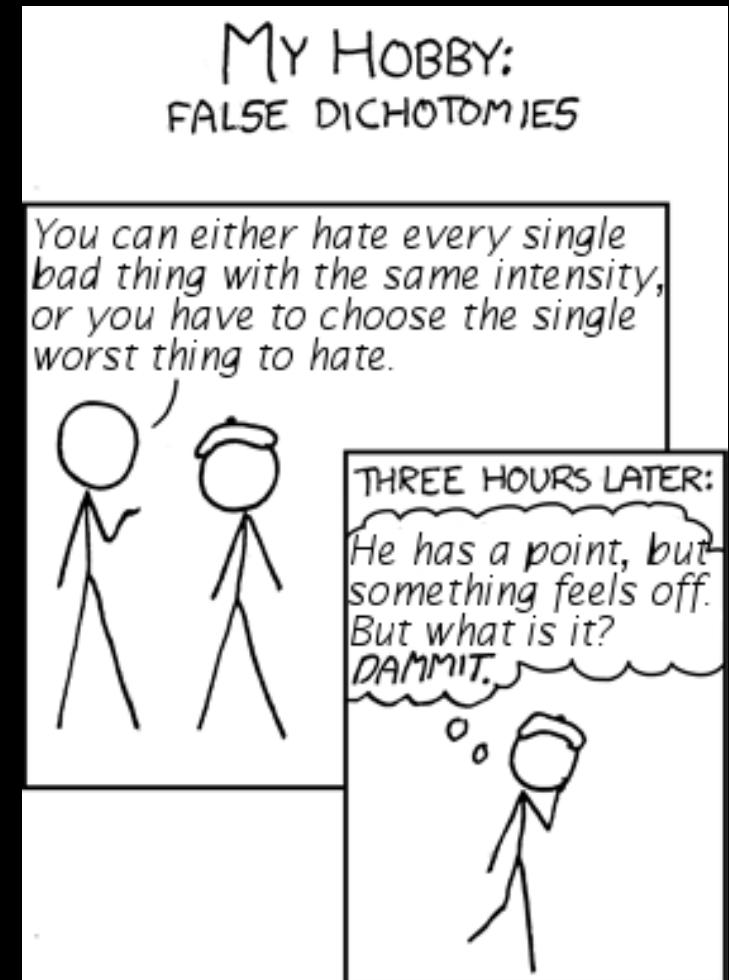
- **Cognitive Bias!**
 - Illogical inferences and deviations in judgment
 - Subjective and created within social spaces
 - Can be useful in matters of timeliness (heuristics)
 - Symptom of human processing limitation
 - Cognitive dissonance
 - Emotions
- Look to **knowledge and evidence**
 - To see what is there
 - To see what is not there (gaps)
 - Helps you to see your flaws
 - Helps you challenge theirs





Considerations

- **Reasoning**
 - Consciously make sense of things
 - Apply logic, Verify facts
 - Change or Sustain in light of new information
- **Assumptions**
 - Taking something(s) for granted
 - Can be dangerous
- **Avoid False Dichotomy**
 - An informal fallacy in which
 - limited alternatives are used to
 - force a choice





Considerations

- **Embodied Metaphor**

- Your mental processes are unique to you
- You experience (sense) the world differently
- Ergo the manner in which you think is slightly or greatly different than those around you
 - Matter of biology
 - Matter of scale
 - Matter of space
 - Matter of time





Considerations

Most Importantly...
Ask Questions!

Any Questions?

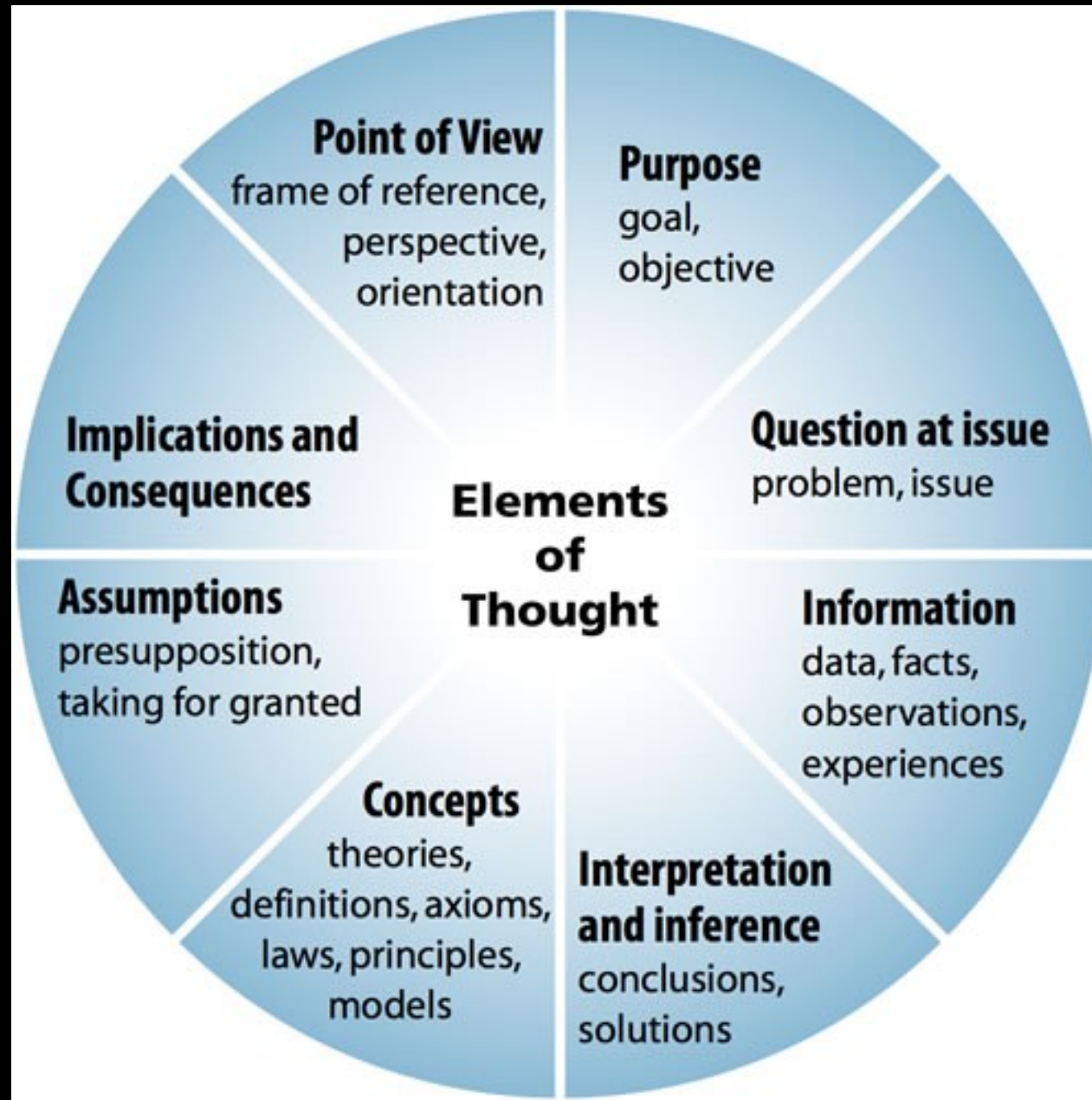


Structured Thinking

- Quality of Life == Quality of Thought
- Deciding to think critically is the beginning
 - In order to make that process better
 - We have to find ways to analyze our thoughts
 - While eliminating/observing biases
- In order to analyze thought
 - We have to look at what composes thought
 - Understand the processes behind our reasoning
 - Establish ways by which to test and reassess thought
 - Find and Include newer data with each iteration
 - Question everything



Structured Thinking





Structured Thinking

Intellectual Standards Are Used to Assess Thinking

Clarity

Could you elaborate further?
Could you give me an example?
Could you illustrate what you mean?

Accuracy

How could we check on that?
How could we find out if that is true?
How could we verify or test that?

Precision

Could you be more specific?
Could you give me more details?
Could you be more exact?

Relevance

How does that relate to the problem?
How does that bear on the question?
How does that help us with the issue?

Depth

What factors make this a difficult problem?
What are some of the complexities of this question?
What are some of the difficulties we need to deal with?

Breadth

Do we need to look at this from another perspective?
Do we need to consider another point of view?
Do we need to look at this in other ways?

Logic

Does all this make sense together?
Does your first paragraph fit in with your last?
Does what you say follow from the evidence?

Significance

Is this the most important problem to consider?
Is this the central idea to focus on?
Which of these facts are most important?

Fairness

Do I have any vested interest in this issue?
Am I sympathetically representing the viewpoints of others?



The Foundation for Critical Thinking
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Critical Thinkers Routinely Apply Intellectual Standards To The Elements Of Reasoning In Order To Develop Intellectual Traits

THE STANDARDS

Clarity	Precision
Accuracy	Significance
Relevance	Completeness
Logicalness	Fairness
Breadth	Depth

Must be applied to

THE ELEMENTS

Purposes	Inferences
Questions	Concepts
Points of view	Implications
Information	Assumptions

As we learn to develop

INTELLECTUAL TRAITS

Intellectual Humility	Intellectual Perseverance
Intellectual Autonomy	Confidence in Reason
Intellectual Integrity	Intellectual Empathy
Intellectual Courage	Fairmindedness

What **others** can you think of?

How do they **vary** depending on “where”, “when”, “how”, and “who” you are?

Questions!



Structured Thinking

- We do this to
 - Overcome **subconscious processes**
 - Biases, perception, memory, processing
 - Prepare for **paradigm shifts**
 - The most knowledgeable of us have the most to unlearn
 - **Keep you fresh**
 - Over time, we become entrenched in daily activity
 - Need to keep fighting against that
 - **Memory changes** over time
 - Long term
 - Short term



Structured Thinking

- We do this to
 - Ensure **delivery of best Information**
 - To seniors
 - To peers
 - **Fill the gaps**
 - When lacking adequate information
 - Backed by strong logic and empirical data
 - **Structure the problem**
 - Break it down into smaller part
 - Put it into a form that is easily and holistically understood



Structured Thinking

Questions?



Analytic Tools

- **Caution!**
 - Don't start with your conclusion; end with it
 - Look at alternate solutions
 - Let the analysis favor the solution; not you
 - Thinking is not analysis
 - Focus on the process of analysis
 - Not the substance
 - When in doubt, ask and ask again
 - Work hard to prove yourself wrong
 - Allow others to do the same
 - Your argument will become stronger



Analytic Tools

- Problem Restatement
- Pros/Cons/Fixes
- Divergent/Convergent
- Sorting & Time Lines
- Causal Flow Diagram
- Matrix
- Decision Tree
- Weighted Ranking
- Hypothesis Testing
- Devil's Advocate
- Probability Tree
- Utility Tree
- Utility Matrix
- Advanced Utility Analysis



Analytic Tools

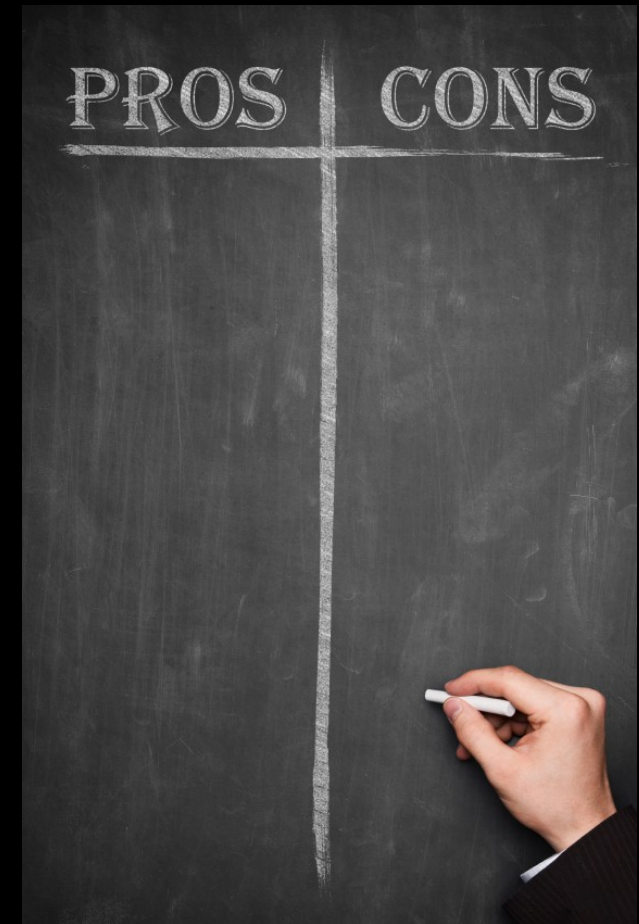
- **Problem Restatement**
 - Paraphrase
 - Use different word; maintain original meaning
 - 180 degree turn around
 - Turn the problem around
 - Broaden the focus
 - Restate in a large context
 - Redirect the focus
 - Change to a tangent
 - Ask why and why again
 - Repeat until the core issue emerges



Analytic Tools

- **Pros/Cons/Fixes**

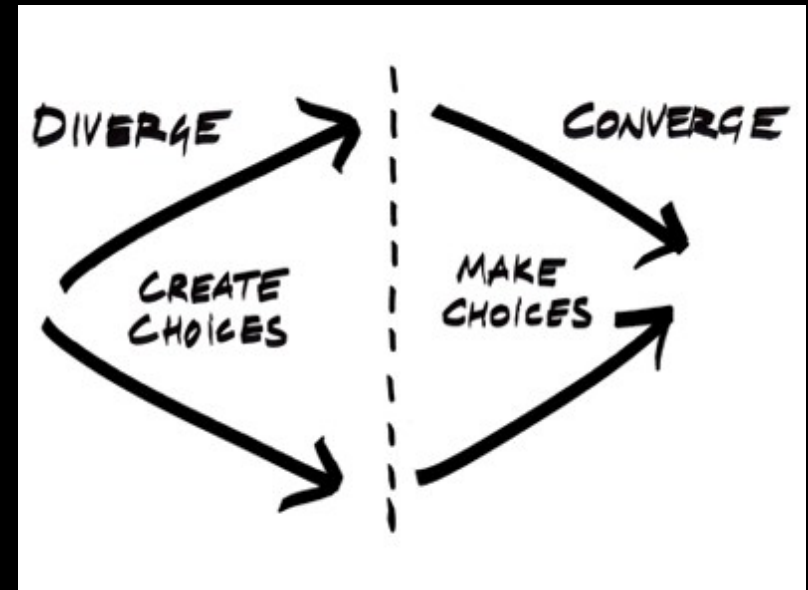
- List the Pros
- List the Cons
- Consolidate the Cons
 - Merge similar
 - Delete redundant
- Neutralize the Cons
 - Or convert Cons to Pros (semi fix)
 - Divergent lists may occur
- Compare Pros and Cons for all options
- Pick one option





Analytic Tools

- **Divergent/Convergent Thinking**
 - Brainstorm
 - Divergent
 - Winnow (cut) and cluster (group) ideas
 - Convergent
 - Select Practical/Promising Ideas
 - Convergent





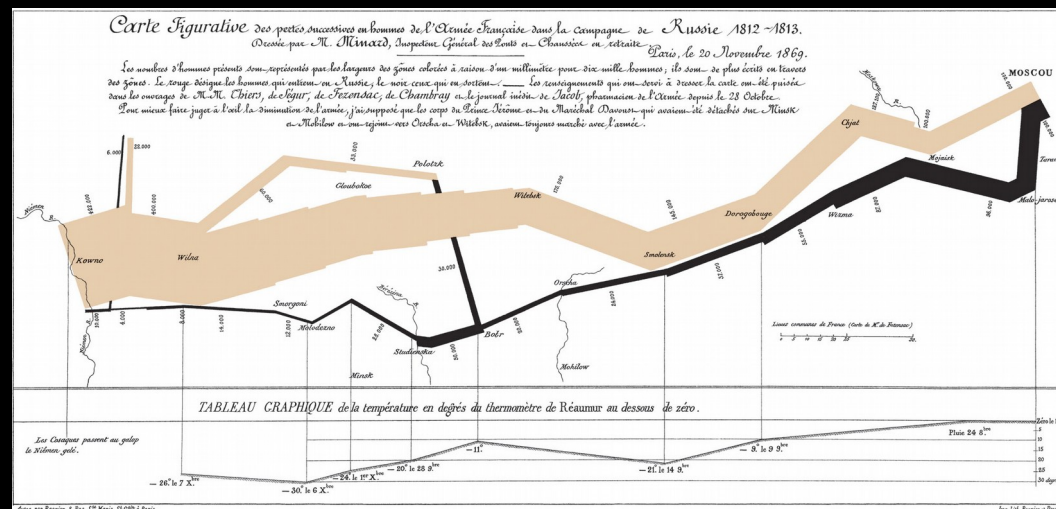
Analytic Tools

- **Sorting**

- Sorting a problem into its parts
- Analysis can benefit from basic sorting

- **Chronology and Time Lines**

- Shows timing and sequence
- Draws attention to key events
- Easier to identify patterns and correlations

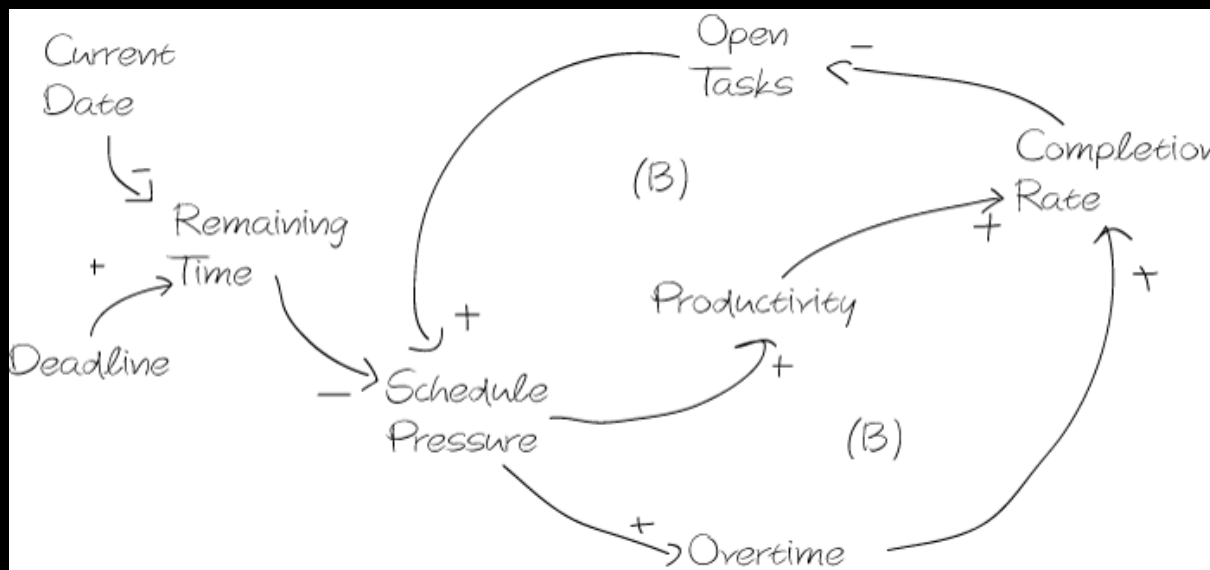




Analytic Tools

- **Causal Flow Diagram**

- Identify major factors (drivers)
- Identify cause & effect relationships
- Characterize relationships as direct or inverse
- Diagram the relationships
- Analyze behavior of relationships as integrated system



Watch for:

- **Feedback loops**
 - Unstable
 - All direct
 - Even # inverse
 - Stable
 - Odd # inverse



Analytic Tools

- **The Matrix**

- Simply, a grid with as many cells as needed to address the problem
 - Separate the problem's elements
 - Categorize information
 - Compare types of information
 - Compare pieces of information within types
 - Spot correlations, patterns, and potentially trends



Customer Requirements/ Functions	Importance	Mechanisms				
		Lead	Eraser	Body	Paint	Band
Make Marks	30	50				
Remove Marks	20		30			
Prevent Smudges	5	45		45		
Support Lead	5			25		
Improve Appearance	10			30	30	10
Accommodate Grip	20			100	20	
Column weight	555	195	100	200	50	10
Mech. weight	1.0	.351	.180	.360	.090	.018
Mech. target cost	2.80	.98	.51	1.01	.25	.05
Mech. actual cost	2.92	1.20	.43	.94	.10	.25

YES

○ Strong correlation weight factor = 5

○ Moderate correlation weight factor = 3

△ Weak correlation weight factor = 1



Should you use a Matrix or a Tree?



Analytic Tools

- **Weighted Ranking**

- List all major criteria for ranking
- Pair-rank them (pair-wise comparison)
 - Which is more important? 1 or 2, 1 or 3, etc.
 - Results in a list of most important to least
- Take top “several” and weight them in percentiles
 - Total must equal 1.0 (or 100%)
- Construct a weighted rank matrix
 - Contains
 - Items to be ranked
 - Selected criteria
 - Criteria weights

Criterion	Pair-rank Votes	Final Rank
Color	3	3
Wheels	2	4
Engine	5	1
Make	1	5
Model	4	2



Analytic Tools

- **Weighted Ranking (cont.)**
 - Pair-rank all items by each criterion
 - “Is this (item) more important than this (item) based on this (criteria)? Yes/No
 - Multiply number of votes by criterion weight
 - Add the weighted values for Total Votes
 - Determine Final Ranking
 - Sanity Check

	Criteria				
Items	Engine 0.5	Model 0.3	Color 0.2	Total Votes	Final Rank
2014 GTO	1	1	3	1.4	3
1969 GTO	3	2	2	2.5	1
1964 GTO	2	3	1	2.1	2



Analytic Tools

- **Hypothesis Testing**

- Generate hypotheses and narrow them down
- Construct a matrix
 - Column for Evidence
 - Column for each hypothesis
- List significant (and absent) evidence
 - Alexander's question (What evidence NOT included would refute any hypothesis?)
- Test evidence for consistency with each hypothesis
 - C (consistent), I (inconsistent), ? (ambiguous)
 - Optional degree
 - - (“in part”), + (“in many respects”), * (“absolutely”)



Analytic Tools

- **Hypothesis Testing**
 - Refine Matrix
 - Reword hypotheses
 - Add significant evidence
 - Delete (but record) evidence consistent with all hypotheses
 - Evaluate each hypothesis
 - Evaluate underlying assumptions and validity
 - Remove hypotheses with significant inconsistent evidence
 - Rank hypotheses by weakness of inconsistent evidence
 - Hypothesis with weakest inconsistent evidence is most likely
 - Sanity Check



Analytic Tools

Question: How did the bread at the bakery become over-baked?

Evidence	Hypotheses		
	Sabotage by Employees	Fluctuation in Gas Pressure	New flour is defective
Only two oven overcooked bread	C	I	C
Three batches over-baked	C	C	C
Maintenance found nothing wrong with ovens	C	C	C
Only batches with new flour were over-baked	I	I	C



Evidence	Hypotheses		
	Sabotage by Employees	Fluctuation in Gas Pressure	New flour is defective
Only two oven overcooked bread	C	I	C
Only batches with new flour were over-baked	I	I	C

Does this conclusion make sense?



Analytic Tools

- **Devil's Advocate**

- Closely related to Hypothesis Testing
- Challenges validity and encourages focus
 - Via defense of opposing viewpoint
 - Seeking new evidence to support opposing viewpoint
 - In attempt to encourage objectivity
- This helps bolster primary viewpoint





Analytic Tools

- **Probability Tree**

- Like a decision tree, but with probability!
- 3 rules
 - Events must be mutually exclusive
 - Events must be collectively exhaustive
 - Probabilities of branches at each node must equal 1.0
- Follow the steps for a decision tree, then...
 - Assign probability to each event/decision
 - Calculate conditional probability of each scenario
 - Multiply probabilities of all nodes in a scenario
 - Calculate the answer to probability questions related to tree



Analytic Tools

Car location:		Host opens:	Total probability:	Stay:	Switch:
$\frac{1}{3}$	Door 1	$\frac{1}{2}$ Door 2	$\frac{1}{6}$	Car	Goat
		$\frac{1}{2}$ Door 3	$\frac{1}{6}$	Car	Goat
	$\frac{1}{3}$ Door 2	1 Door 3	$\frac{1}{3}$	Goat	Car
$\frac{1}{3}$	Door 3	1 Door 2	$\frac{1}{3}$	Goat	Car

Monty Hall Problem: Which door to choose?



Analytic Tools

- **Utility Analysis**

- Rank n options according to how they serve the self-interests of the decision maker
- Utility analysis has 3 basic elements
 - Options (alternative courses of action)
 - Must be mutually exclusive
 - Outcomes (result of selecting an option)
 - Must be collectively exhaustive
 - Perspectives (point of view with respect to an outcome)
 - Role-play or “red team” perspectives



Analytic Tools

- **Utility Tree**

- Identify options and all possible outcomes
 - Options are mutual exclusive, not collectively exhaustive
 - Outcomes must be both
- Identify the perspective of the analysis
- Construct a set of decision trees
 - For the options and outcomes
- Assign a utility value to each scenario in each tree
 - Utility Question: “If this scenario occurs, what is the utility from the perspective of...?”
 - **Utility determines what we want**
 - **Probability determines what we get**



Analytic Tools

- **Utility Tree**

- Probability Question
 - “If this option is selected, what is the probability of the outcome?”
- Expected Value (EV)
 - Product of Utility and Probability
 - Utility is conditioned by its probability of occurring
- Total Expected Value (Total EV)
 - Add all expected values for an option
- Rank the expected values from first to last
- Sanity Check!



Analytic Tools

- **Utility Matrix**

- Two advantages over Utility Tree
 - Relative differences in utility outcome values are easier to perceive
 - Math is easier to perform
- Focus is on alternative outcomes
 - Utility tree portrays whole scenarios in which outcomes are a single part
- Essentially same process as Utility tree
 - Utility value is 0 to 100 unless money is value
 - Has to be at least 1 “100” unless using money



Analytic Tools

Scenario: You are planning to invest \$5000 and want to know which investment is safest.

Perspective: My \$ Profit		Outcome: National and Political Outcome				Total EV	Rank
			War	Prosperity	Depression		
Options	Speculative Stock	Utility	100	20	0	17.2	3
		Probability	0.1	0.36	0.54		
		EV	10	7.2	0		
	Blue-chip Stock	Utility	80	70	10	38.6	2
		Probability	0.1	0.36	0.54		
		EV	8	25.2	5.4		
	Govt. Bonds	Utility	40	40	40	40.0	1
		Probability	0.1	0.36	0.54		
		EV	4	14.4	21.6		

* This is purely hypothetical and for demonstration of the concept's functionality only.



Analytic Tools

- **Advanced Utility Analysis**
 - Multiple options, outcomes, AND perspectives
 - Create a utility matrix for multiple perspective
 - ~ 13 step process
 - Matrices have identical structure
 - Same options
 - Same outcomes
 - Same outcome probabilities
 - Utility value will vary based on perspective
 - Also accounts for multiple classes of outcomes
 - ~14 step process
 - More likely to be examined with advanced utility analysis



Analytic Tools

- **Advanced Utility Analysis (multiple perspectives)**
 - Identify options and outcomes
 - Identify and weight the perspectives
 - Create identical utility matrices for each perspective
- For each utility matrix
 - Assign utility values (values 0 – 100; has to be at least one 100)
 - Assign probabilities
 - Calculate EV
 - Calculate Total EV
- Then...



Analytic Tools

- **Advanced Utility Analysis (multiple perspectives)**
 - Construct a single “merged” matrix with the same options vs. perspectives
 - Take the Total EV from the utility matrices and place them in the corresponding new options vs. perspective matrix
 - Multiply Total EV by the perspective weight
 - Add the products for the “Total Weighted EV”
 - Rank your options
 - Sanity Check!



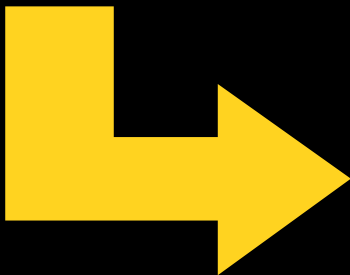
Analytic Tools

Scenario: You are planning to invest \$5000 and want to know who thinks which investment is best.

Utility Matrices

Scenario: You are planning to invest \$5000 and want to know which investment is safest.

Outcome: National and Political Outcome						
Perspective: My \$ Profit	War	Prosperity	Depression	Total EV	Rank	
Options						
Speculative Stock	Utility: 100	20	0			
	Probability: 0.1	0.36	0.54	17.2	3	
	EV: 10	7.2	0			
Blue-chip Stock	Utility: 80	70	10			
	Probability: 0.1	0.36	0.54	38.6	2	
	EV: 8	25.2	5.4			
Govt. Bonds	Utility: 40	40	40			
	Probability: 0.1	0.36	0.54	40.0	1	
	EV: 4	14.4	21.6			



Does this conclusion make sense?

Perspective: Merged	Perspectives				Total Weighted EV	Rank
		You 0.3	Financial Advisor 0.4	Friend 0.3		
Speculative Stock	UM Total EV	17.2	40.0	25.0	28.66	2
	Weight	0.3	0.4	0.3		
	New Total EV	5.16	16	7.5		
Blue-chip Stock	UM Total EV	38.6	35	40.0	37.58	1
	Weight	0.3	0.4	0.3		
	New Total EV	11.58	14	12		
Govt. Bonds	UM Total EV	40	15.0	35.0	28.5	3
	Weight	0.3	0.4	0.3		
	New Total EV	12	6	10.5		

* This is purely hypothetical and for demonstration of the concept's functionality only.



Analytic Tools

- **Advanced Utility Analysis** (multiple classes of outcomes)
 - Identify options
 - Identify outcome classes
 - Identify each classes' range
 - Weight each class by importance
 - Identify perspective of analysis
 - Create utility matrices for each outcome class
 - Identical options and perspective
- For each utility matrix
 - Assign utility values (values 0 – 100; has to be at least one 100)
 - Assign probabilities
 - Calculate EV
 - Calculate Total EV
- Then...



Analytic Tools

- **Advanced Utility Analysis (multiple classes of outcomes)**
 - Construct a single “merged” matrix with the same options vs. outcome classes
 - Take the Total EV from the utility matrices and place them in the corresponding new options vs. outcome classes
 - Multiply Total EV by the perspective weight
 - Add the products for the “Total Weighted EV”
 - Rank your options
 - Sanity Check!



Analytic Tools

Scenario: You are planning to invest \$5000 and want to know which outcome is most likely.

Utility Matrices

Scenario: You are planning to invest \$5000 and want to know which investment is safest.

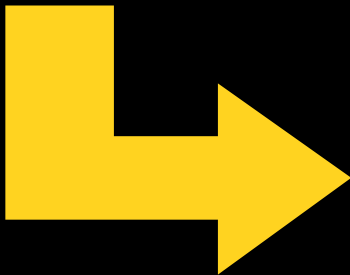
Outcome: National and Political Outcome		Total	Rank
Perspective: My \$ Profit	War	100	1
Perspective: My \$ Profit	Prosperity	20	2
Perspective: My \$ Profit	Depression	0	3
Perspective: My \$ Profit	Total EV	17.2	

Scenario: You are planning to invest \$5000 and want to know which investment is safest.

Outcome: National and Political Outcome		Total	Rank
Perspective: My \$ Profit	War	100	1
Perspective: My \$ Profit	Prosperity	20	2
Perspective: My \$ Profit	Depression	0	3
Perspective: My \$ Profit	Total EV	17.2	

Scenario: You are planning to invest \$5000 and want to know which investment is safest.

Outcome: National and Political Outcome		Total	Rank
Perspective: My \$ Profit	War	100	1
Perspective: My \$ Profit	Prosperity	20	2
Perspective: My \$ Profit	Depression	0	3
Perspective: My \$ Profit	Total EV	17.2	



Does this conclusion make sense?

Perspective: You	Classes of Outcomes				TW EV	Rank
		Political Instability 0.3	Better Opportunity 0.4	Market Depression 0.3		
Invest Now	UM Total EV	17.2	40.0	25.0	28.66	2
	Weight	0.3	0.4	0.3		
	New Total EV	5.16	16	7.5		
Wait until Next FQ	UM Total EV	38.6	35	40.0	37.58	1
	Weight	0.3	0.4	0.3		
	New Total EV	11.58	14	12		
Wait until Next FY	UM Total EV	40	15.0	35.0	28.5	3
	Weight	0.3	0.4	0.3		
	New Total EV	12	6	10.5		

* This is purely hypothetical and for demonstration of the concept's functionality only.



Resources

- The Foundation for Critical Thinking
 - <http://www.criticalthinking.org/>
- The Thinker's Toolkit by Morgan D. Jones
- Structured Analytic Techniques by Heuer & Pherson
- Kahn Academy has a good basic course
 - <https://www.khanacademy.org/partner-content/wi-phi/critical-thinking/v/intro-to-critical-thinking>
- Your peers (Practice the concepts; find new ones)
- Academia (we have numerous schools in the area)
- Anyone with an open mind
 - After building confidence, even some without



That's all folks!

Thanks!

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