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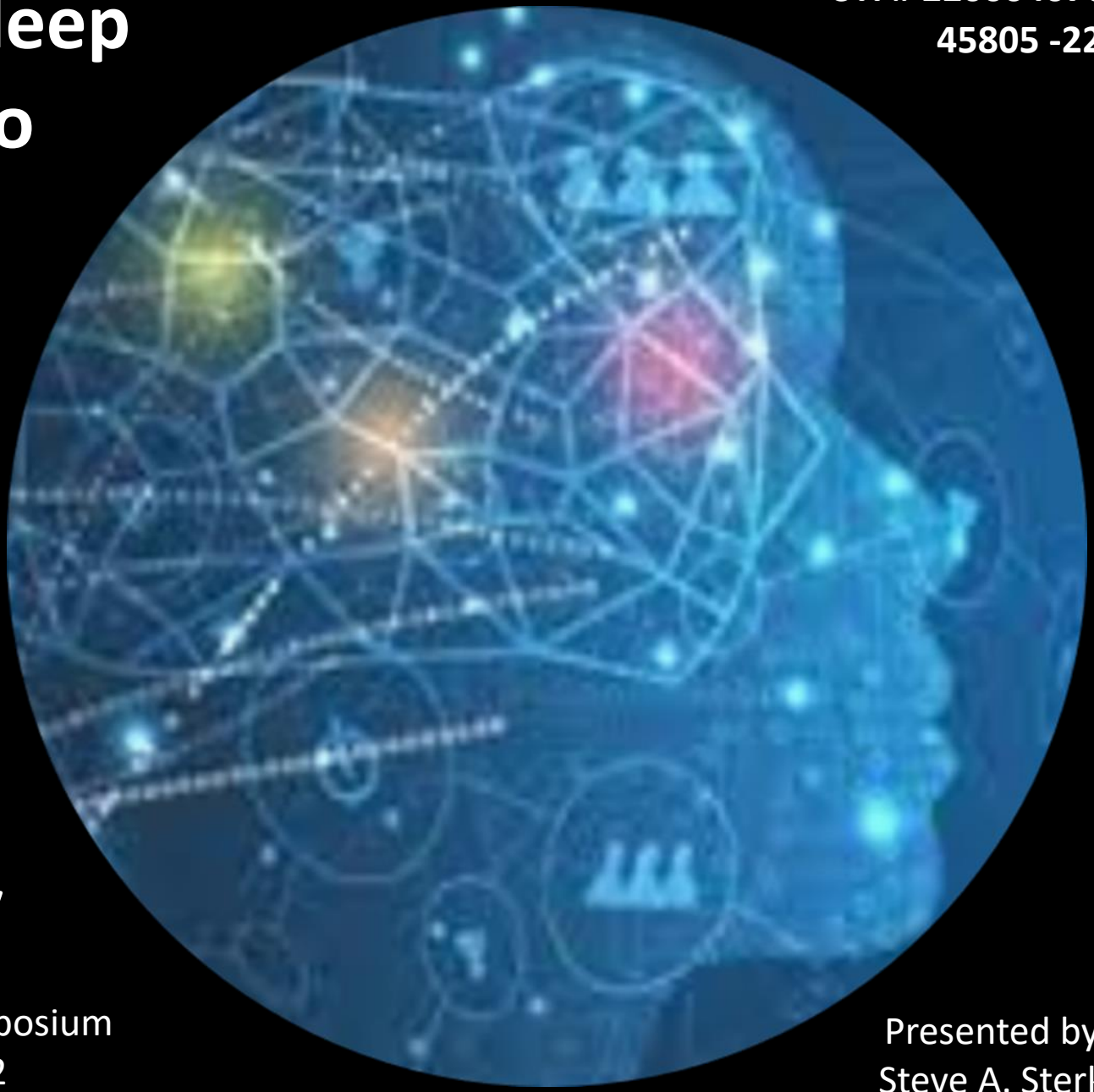
A deep look into Optimistic Cognitive Bias based on a NASA STEAM Activity



NASA 2022 Cost Symposium
April 28th, 2022

Presented by
Steve A. Sterk

About the Author

Background

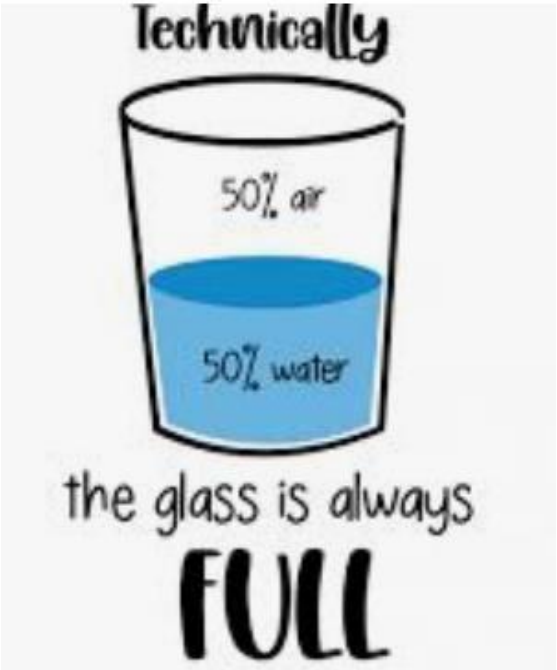
- This Project began as a 4th Grade NASA STEM activity found on NASA's Web site, then was re-engineered into an independent research study, in attempting to understand optimistic cognitive bias and thus digging into human behavioral, neural networks on how we think and interact with other people.
- By using a methodical approach to understand "*why*" Projects and Programs overrun their baseline cost and schedule estimates, data was captured from a gamification activity comparing the baseline to the finished product.
- The future vision is to ultimately generate machine learning, iBOTs, facial recognition and artificial intelligence for future cost and schedule estimates by simply turning your camera "on" while working virtually from the home office.
- An initial road map has been drafted where the I believe the research is headed, from thinking both fast and slow.

Presentation Agenda

1. Is your glass half full or half empty ?
2. Background on NASA's STEM Project.
3. Adapted to an Independent Research Project.
4. Human Factors and Definition of Heuristic.
5. Using a Heuristic Approach.
6. Using Analytics from First Data received.
7. How the Brain Thinks from Fast to Slow.
8. Can Artificial Intelligence help the Cost Engineer ?
9. Road Map
10. Summary

Optimistic people see the glass half full

- NASA seems to only hire optimistic people with exceptional knowledge with additional skills sets.



As a Cost Estimator – one may have to dig-in and ask hard questions to determine ~ that Cognitive Bias is real and it can be found in the Basis of Estimate in every work package !

NASA STEM Project

- This activity was found on NASA's JPL STEM website for elementary school kids K thru 12. This training event has been tailored to a STE**A**M activity as explained by a 4th Grade Teacher because collaboration and teamwork is considered an "***A**rt*" form.

- 4th Grade Students (Future Design Engineers) had to design and build their model for the new 5G Tower Network.
- As every student became engaged in the activity to build the tallest 5G Tower, it was noted that none of them wanted to fail. However during the integration phase several teams had to overcome anomalies. The same situations we see on NASA Projects and Programs.

Independent Cognitive Bias Research

- The NASA's STEM exercise was re-engineered by adding the following heuristic approach:
  1) A five-minute design activity,
  2) Followed by baselining a simple cost estimate, based on per determined CERs,
  3) The schedule estimate was also pre determined; given only 20 minutes to build their 5G Tower model (made from spaghetti noodles and marshmallows),
  4) A feedback learning loop was inserted to talk about what was observed (by an independent observer), with deep conversations back and forth between the Participants and the Instructor.
     - Variance reports were logged into a data base from the baseline cost and schedule to the completed projects.

Scenario

- Participants were asked to be a Project Manager for a new Urban Air Mobility (UAM) Electric vertical Take-Off and Landing (EVTOL) Project.
- The UAM envisions a safe and efficient aviation transportation system that will use highly automated aircraft that will operate and transport passengers or cargo at lower altitudes within urban and suburban areas.
- The requirement is to prepare a cost estimate for the tower that will support the new Radar / 5G network for collision avoidance, terrain following, and precision flying pathways.
- To simulate this task, participants will need to build a tower. The tower will hold specialized ADS-B receivers for the FAA.

New UAM EVTOL Project

To collect Optimistic Bias Data – Participants were asked to be part of a research study. Participants were given the requirements to build a model of the 5G Network Tower

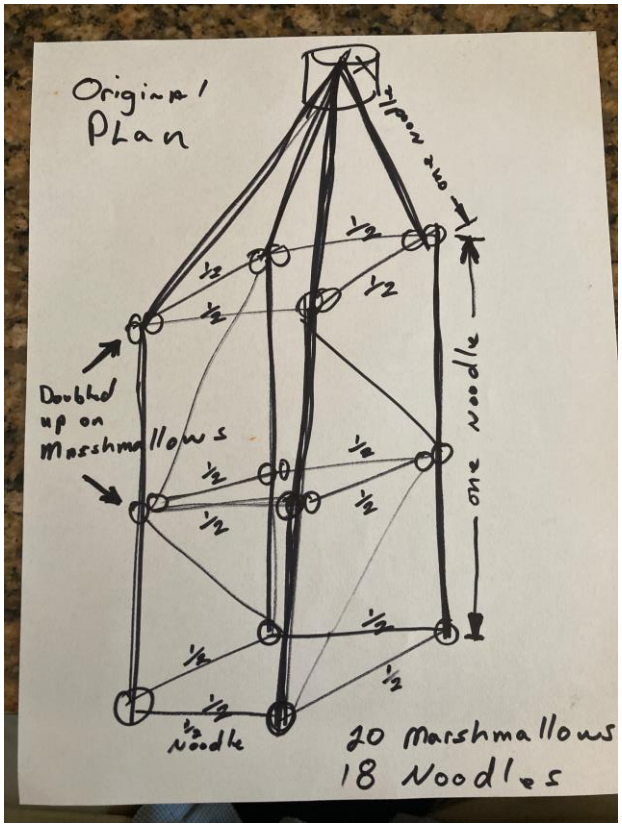
Thinking like a Neuroscientist using the Heuristics Technique

Thinking like a neuroscientist, the activity was broken down into four (4) phases.

1) A Plan was developed. Participants had to scribe their plan onto paper from the Requirements, that were shared to everyone, plus questions and answers.
2) The Participants knew they were being timed and constrained to a predetermined schedule.
3) Observations were being collected during the entire course of the exercise but most notably during the “construction” phase.
4) At the end of the study, the facilitator drew from the Participants as to the results from the activity, either positively or negatively thus fulfilling a feed back loop.

Planning Exercise

- The Plan within 5 minutes is to sketch out a tower to determine how many marshmallows and noodles will be used in preparation for the cost estimate.



Cost Estimate Worksheet (CEW)

$ in DRS

Description	Rate	Unit	Cost
Labor			
FTE (per minute)	$ 2.00	20	$ 40.00
WYE Extra Help	$ 3.00	0	$ -
Procurement			
Small Marshmallow	$ 0.25	20	$ 5.00
Large Marshmallow	$ 5.00	1	$ 5.00
Spaghetti Noodles	$ 1.00	18	$ 18.00
Specialized Tooling	$ 5.00	0	$ -
Sub-Total			$ 68.00
Overhead / CMO	0%		$ -
Baseline Cost Estimate at ABC			$ 68.00

A good plan always starts with a vision, then annotated with pen and onto paper.

Human Factors

The top 7 mistakes are:

1. Over optimism in developing the work packages and tasks down at the WBS 2 and WBS 3 levels. (Tech, Schedule & Cost).
2. Starting a project ~ even before all the Engineering inputs have been received by the PM or PI. Ref. The Engineering "V".
3. Quoting in a hurry ~ without having complete knowledge of the project details/requirements or Basis of Estimate (BOE). WAG, ROM, SME, or from a formal Quote.
4. Lack of Planning and poor discipline. (Note: GAO's 12 Step process).
5. Scope Creep to enhance the project during the integration and test phase.
6. Software bugs are often found during the testing.
7. The change in Leadership either from the Stakeholder or from the Vendor.

A Heuristic (/hjʊˈrɪstɪk/; from Ancient Greek εὑρίσκω (heurískō) 'I find, discover'), or heuristic technique, is any approach to problem solving or self-discovery that employs a practical method that is not guaranteed to be optimal, perfect, or rational,

but is nevertheless sufficient for reaching an immediate, short-term goal or approximation. Where finding an optimal solution is impossible or impractical, heuristic methods can be used to speed up the process of finding a satisfactory solution. Heuristics can be mental shortcuts that ease the cognitive load of making a decision.

Analytics at Work using EVM

- At the end of 20 minutes; time was called.
- Each Participant or Team took a picture of their tower and annotated the final cost estimate, known as "**anchoring**".
- The final cost was then compared to their baseline cost estimate. If a Team needed more time, it was also recorded.
- All the data and the variance was recorded into a data base.

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Baseline Cost Estimate at ABC			$ 68.00

Final Cost of Construction	Qnty	Unit	Final Cost
Labor	**Qnty**	**Unit Cost**	**Total Cost**
Workforce Equivalent	1	$20.00	$20.00
Workforce Equivalent	1	$20.00	$20.00
Procurement			
1 Small Marshmallow	21	$0.25	$5.25
1 Large Marshmallow	1	$5.00	$5.00
1 Spaghetti Noodle (per Kitted)	18	$1.00	$18.00
Tooling		$5.00	
Final Cost			$68.25
Percent Increase or Decrease from Baseline			0.37%

Who	Time	SPI	BCE	Act.	+ or -	CPI
ICEAA i3	20	1.00	48.00	49.00	$1	0.98
ICEAA i4	15	0.75	48.00	48.00	$0	1.00
ICEAA i5	20	1.00	48.00	49.00	$1	0.98
ICEAA i6	22	1.10	68.00	68.00	$0	1.00
Composite		0.98				0.99
NASA i1	25	1.25	48.00	62.00	$14	0.77
NASA T1	20	1.00	68.00	84.00	$16	0.81
NASA T2	20	1.00	78.25	78.25	$0	1.00
NASA T3	20	1.00	73.00	93.00	$20	0.78
NASA T4	20	1.00	81.00	91.00	$10	0.89
NASA T5	20	1.00	68.00	66.25	-$2	1.03
NASA T6	24	1.25	68.00	73.50	$6	0.93
NASA T7	20	1.00	68.25	68.25	$0	1.00
NASA T8	20	1.00	68.00	73.25	$5	0.93
NASA T9	20	1.00	68.00	72.00	$4	0.91
Composite		1.05				0.90

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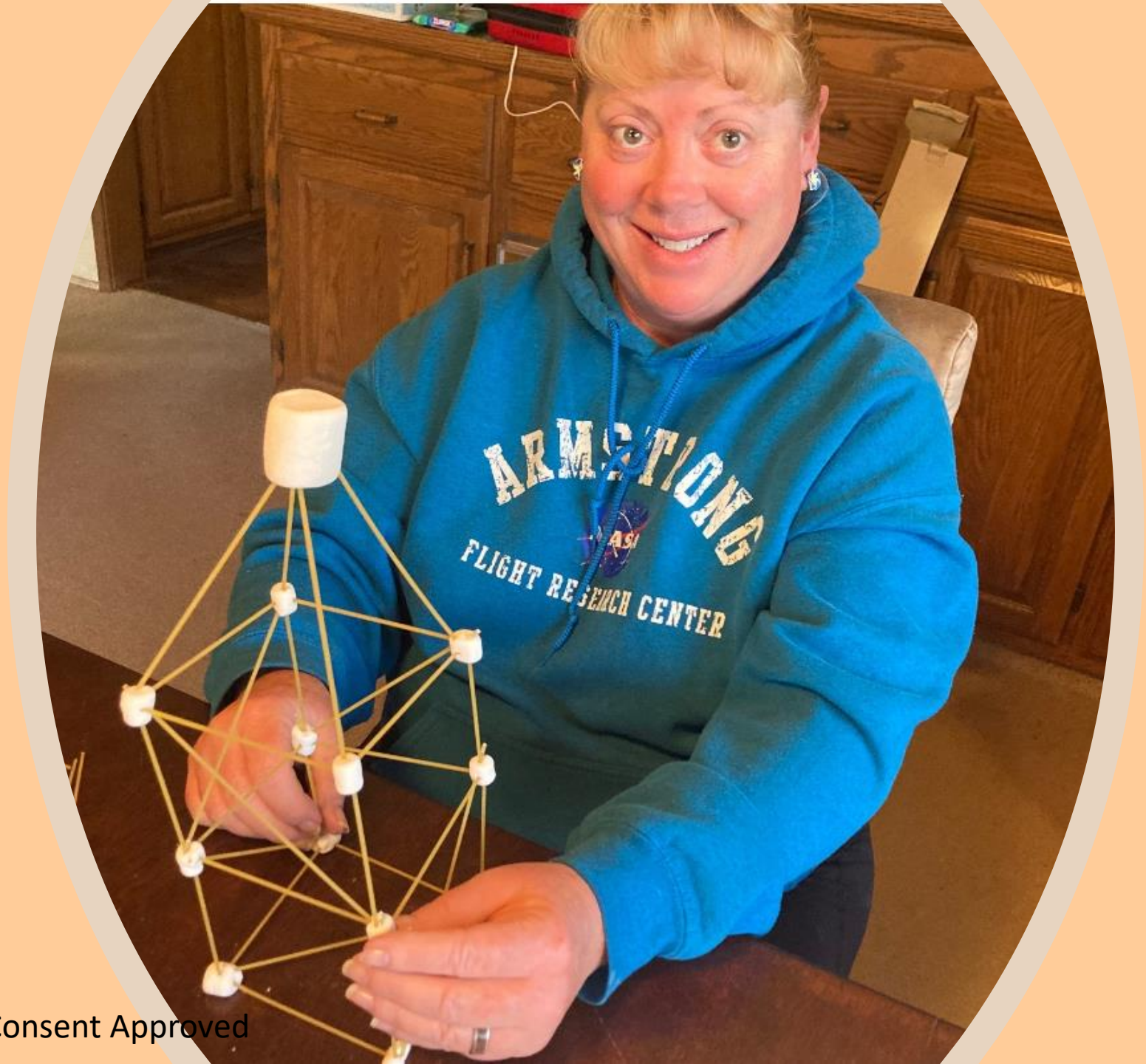

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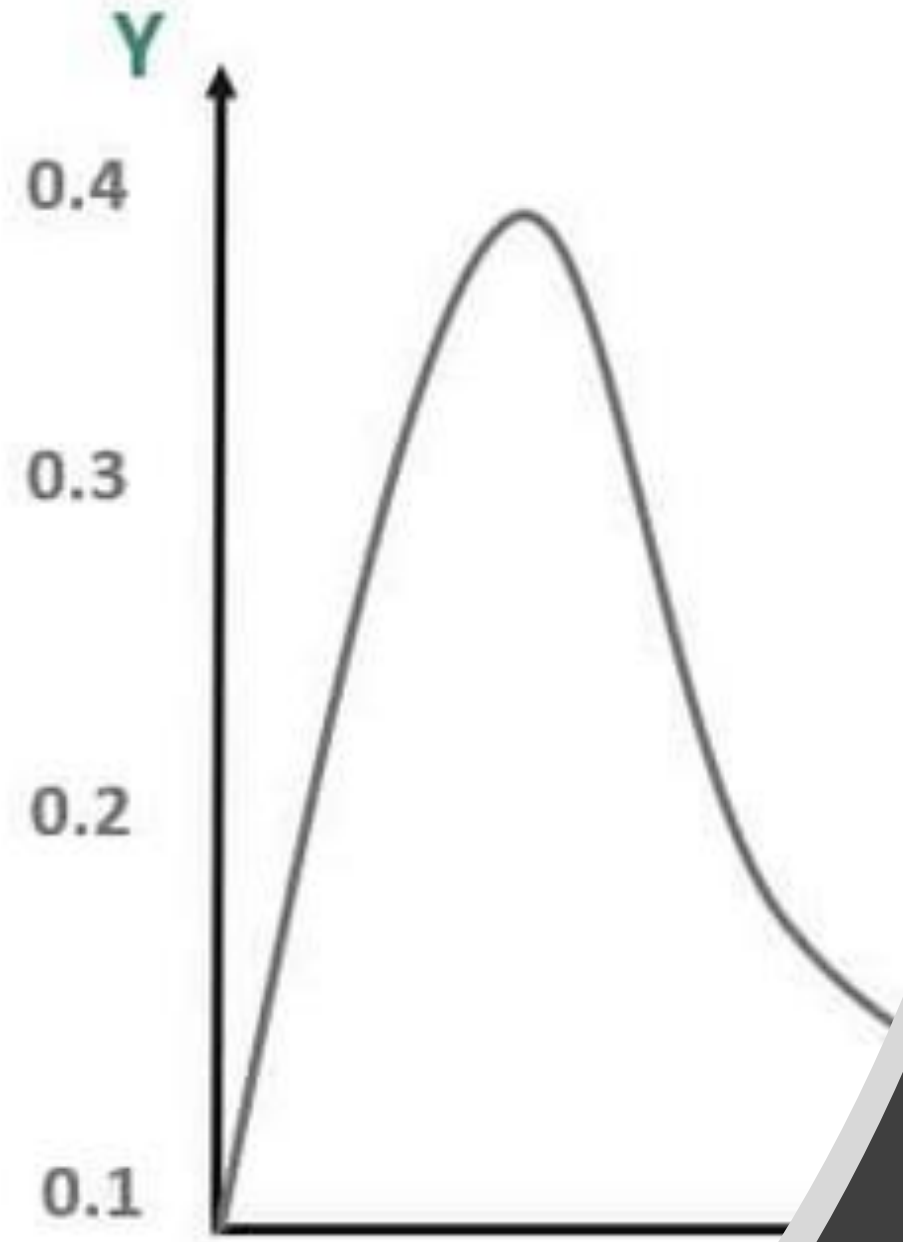


How much Optimistic Bias do we naturally possess ?

First Data from the STEAM Activity reflects a Log Normal Distribution.

Only one person completed the task 5 minutes early scored 0.75 SPI and on Cost at 1.0 CPI.

Log Normal range on the X-Axis from the Data Base

2 Control Groups ~ Comparison

$$SPI = \frac{EV}{PV}$$

EV: Earned Value — 20.9 Minute Avg.

PV: Planned Value — 20 Minutes Avg.

Schedule Performance Index

NASA

- Composite SPI = 1.05
- Composite CPI = .90

ICEAA

- Composite SPI = 0.98
- Composite CPI = 0.99

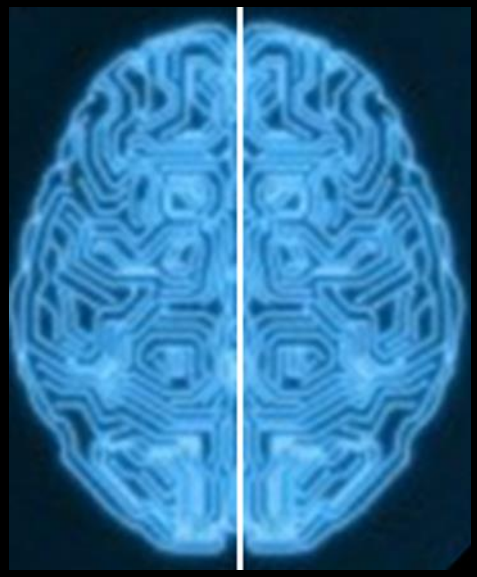
1.) My conclusion… members of the ICEAA Professional Society scored higher.
2.) Core Reason – 1st Control Group; 2 of the 10 completely skipped the planning activity and went right to the build. Another 2 Groups had incomplete planning documents resulting in a 40% combined in accuracy planning activity, which in-turn busted their Schedule Performance Index and contributed to a cost overrun.

Thinking like a Neuroscientist

- By analyzing the variance or datasets between the two control groups, I discovered 10 out of 16 of the Participants exceeded their baseline cost estimate. CPI = .90 vs CPI = .99
- Only a handful came in “on-time” but during the construction phase or integration phase, several participants either accidently broke their spaghetti noodles or needed additional marshmallows thus needing more material and at the end overran their estimate.
- Only one person (an outlier) built the tower to the specification on cost and completed five minutes early.
- Thinking like a Neuroscientist we can conclude that humans are wired to think optimistically. We “*think*” we can achieve tasks sooner than expected. Digging deeper into the neurons, we know there are two halves of the brain.

A Deeper look into Neuroscientist

- The instructions were each Participant or Team had “five minutes” to design the Tower thus **anchoring their thoughts onto paper**.
- 87.5% of the participants had sketched out some sort of design onto paper. Two people ignored the “design phase” and went immediately into the build phase.



Thinking Fast **Thinking Slow**

- One can only image when there was no diagram found on the paper provided which brings me to how we think both fast and slow.
- According to Dr. Daniel Kahneman’s research, he covers 3 themes: cognitive biases, prospect theory, and happiness.

Left and Right Brain (2 Systems)

#1 Thinking Fast	#2 Thinking Slow

Continuous scans our surroundings

Fast but prone to error

Works automatically & effortlessly, shortcuts intuition & impulse

Slow but reliable

Used for specific problems

Takes effort to analysis reason, solve complex problems, exercise self-control

Source: Kahneman

Understanding how our Minds Thinks

- System 1: operates automatically and quickly, with little or no effort, and no sense of voluntary control.
- System 2: allocates attention to the effortful mental activities that demand it, including complex computations. Often associated with the subjective experience of the agency, culture and style.
- A lazy System 2 accepts what the faulty System 1 gives it, without questioning. This leads to cognitive biases. Even worse, cognitive strain taxes System 2, making it more willing to accept System 1. Therefore, we're more vulnerable to cognitive biases when we're stressed.

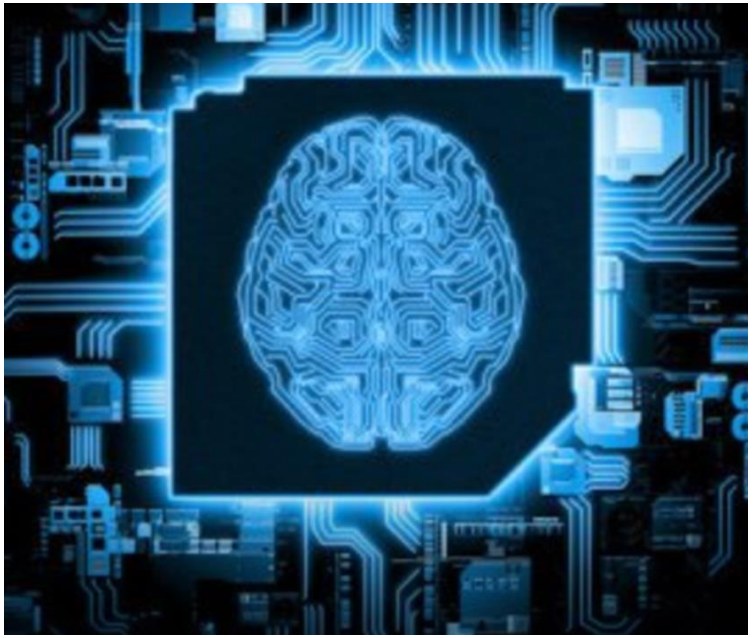
Source: Kahneman

Cognitive Bias and Heuristics

- To block System 1 errors, recognize the signs especially in the home office environment and ask System 2 for reinforcement.
- Observing errors in others is easier than in yourself. So, ask others for a Peer Review. Other organizations “future of work” and virtual forums can be better than individuals at decision-making.
- To better regulate behavior, make critical choices in times of low duress, so that System 2 is not taxed. As an example, to order food in the morning, not when you’re tired. In other words, go grocery shopping after you haver already eaten.
- Optimistic people will likely find themselves in high anxiety and duress. Notice our Leadership Teams often put off big decisions until later as they have learned to switch from thinking fast to thinking slow.
- Never make an instantaneous decision, set the cost estimate aside (*if possible*). Schedule a “peer review”, go over the estimate prior to signing it or sending the package up to the Decision Makers.

Can Artificial Intelligence Help ?

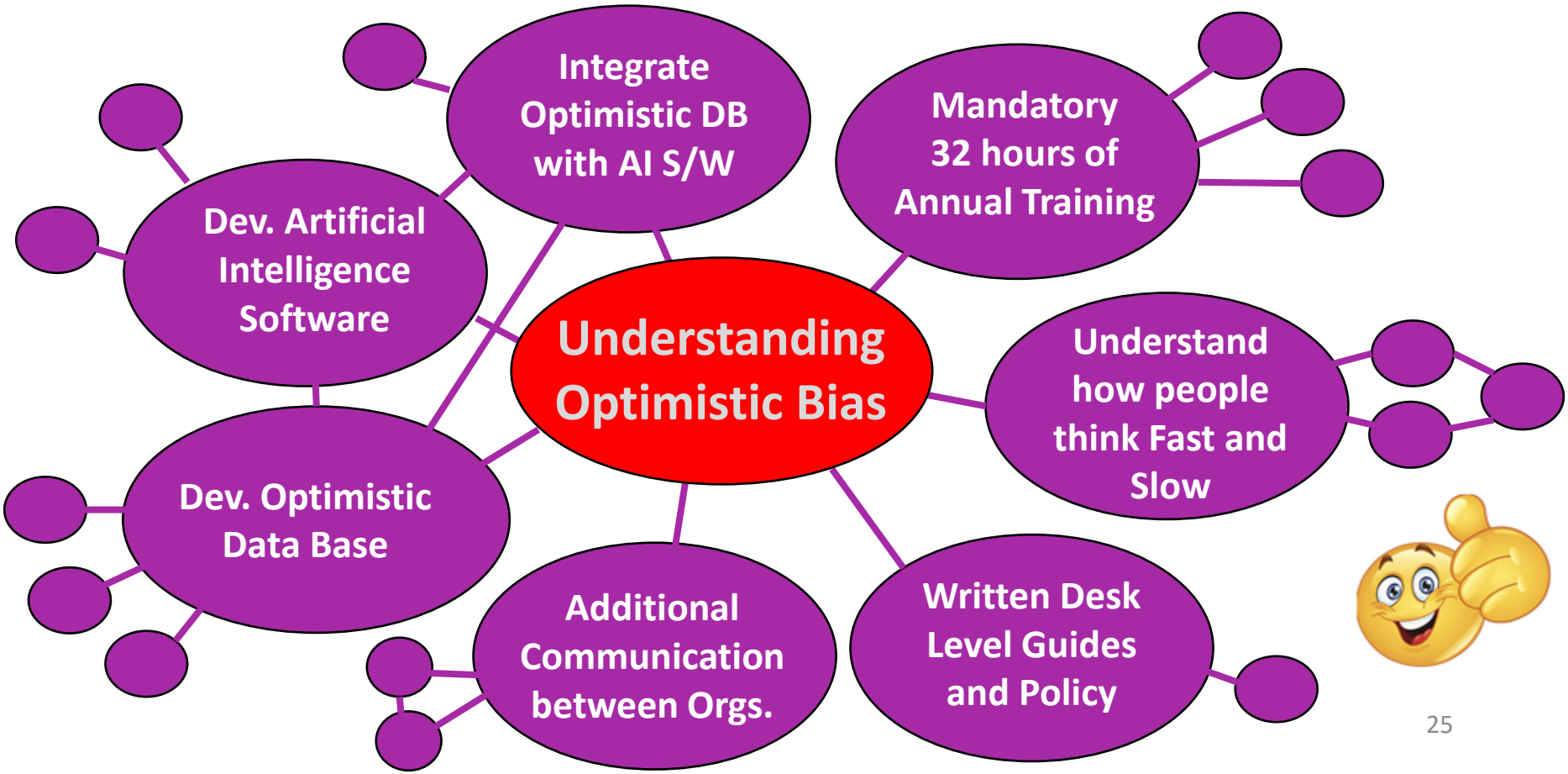
- iBots, Power Bi, Fit Bit Apps, Machine Learning and Mathematical Algorithms are all around us and they are in development – as of today !
- Can we take our Data Bases and mold them into AI?
- What would it look like and what are the first steps?
- Dr. Joe Hamaker, has stated, "***We don't have to count all the trees to know how big the forest is ?"***



- New research from MIT, Feb. 2022, states they can detect facial recognition towards bias.

Roadmap to Combat Optimistic Bias

I don't believe it's a traditional waterfall approach rather than a neuroscience approach using an agile decision tree style to over come Optimistic Bias.



In Summary

- Artificial Intelligence (AI) systems may be able to recognize cost and schedule bias at the beginning of a project, but that doesn't mean AI will always do it fairly. If the datasets within the database used to train machine-learning models contain biased data, it is likely the system could exhibit that same bias.

- By developing a new database with datasets containing the age of the person along with facial-recognition in conjunction with some sort of "**gamification statistics**", (by simply turning your camera (on) while working from home), could identify an Optimistic Bias while working on your schedule SPI and cost model's CPI Index's.

- Software Programmers are capable in designing a machine-learning Apps, very similar to the  ancestry leaf icon "Leaf Hints" used by Ancestry.com to recognize subtle variances in datasets to reduce the Optimistic Bias.

- A neural network machine-learning module that mimics the human brain eventfully would contain layers of interconnected nodes, or "neurons," that process data.

- I believe we are on the doorstep in eliminating cost and schedule bias ~ if we expand on the roadmap and the methods listed above.

Conclusion

Optimistic Bias is the number one problem to the Cost and Schedule Community.

I have created an optimistic data base, from tailoring a 4th, Grade STEM project into a Science Technology Engineering Art and Mathematics (STEAM) project and thus developed a “Road Map” to one day integrate common software tools with artificial intelligence to reduce the bias from cost and schedule estimates thus increasing accuracy and efficiently.

Questions

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