The Future of Work
in the
Digital Economy

Brian Armstrong
September 2023

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Wits Business School
Sculpting global leaders

Goldman Sachs

"...generative AI could expose the equivalent of **300mn full-time jobs** to automation."

The Potentially Large Effects of Artificial Intelligence on Economic Growth
March 2023

OECD

27% of jobs are in occupations at high-risk of automation

WORLD ECONOMIC FORUM

"**Task automation** in 2027 is expected to vary from 35% of reasoning and decision-making to 65% of information and data processing."

"50% of organizations expecting (AI) to **create job growth** and 25% expecting it to create job losses."

f workers' skills will upted in the next five and "**6 in 10 workers quire training** before

he Future of Jobs Report 2023

McKinsey & Company

The economic potential of generative AI: The next productivity frontier
June 2023

"... **half of today's work activities could be automated** between 2030 and 2060, with a midpoint in 2045, or roughly a decade earlier than in our previous estimates."

"...the most important impact of the technology is likely to be of **augmenting work** ... as opposed to fully automating occupations."

"In low-income countries, **only 0.4 per cent of total employment is potentially exposed** to automation effects, whereas in high-income countries the share rises to 5.5 percent."

Generative AI and Jobs: A global analysis of potential effects on job quantity and quality
August 2023

LinkedIn

Globally, AI skilled people* comprise **~1.5% to 2% of the workforce.**

* members who have added AI skills to their profiles

Future of Work Report: AI at Work, August 2023

The broad messages are:

- ✓ AI will replace “only” 2 – 20% of jobs
- ✓ The economic growth it creates will possibly create **net job growth**
- ✓ The primary role of AI will be human **augmentatio**n, not human substitution
- ⚠ But at a **task-level the impact**s will be widespread and profound

But we need to be careful...

- ⚠ Most of the research is based on views of current managers and employees
- ⚠ Generally the impact of tech is underestimated in the long term
- ⚠ Many of these studies focus narrowly on Gen-AI, not other forms of AI and digitalisation
- ⚠ Even 10% job displacement is severe
- ⚠ And 50% – 60% of tasks will be impacted, requiring major staff re-skilling
- ⚠ Pessimism doesn’t sell

Outline

AI, people and the future of work

- Will AI take over the world?
- Accelerating AI capability
- AI and cognitive intelligence
- AI and emotional intelligence
- The result: the revolution of work

A skills framework for the Digital era

- What the popular literature reveals
- A skills framework
- Zooming in to some human-biased skills

What's to be done?

- Institutionally & organisationally
- Individually
- Where to start

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AI *is* a game-changer

OpenAI
Chat GPT-4

Bard

Pause Giant AI Experiments: An Open Letter

We call on all AI labs to immediately pause for at least 6 months the training of AI systems more powerful than GPT-4.

AI systems with human-competitive intelligence can pose profound risks to society and humanity, as shown by extensive research[1] and acknowledged by top AI labs.[2] As stated in the widely-endorsed Asilomar AI Principles, Advanced AI could represent a profound change in the history of life on Earth, and should be planned for and managed with commensurate care and resources. Unfortunately, this level of planning and management is not happening, even though recent months have seen AI labs locked in an out-of-control race to develop and deploy ever more powerful digital minds that no one – not even their creators – can understand, predict, or reliably control.

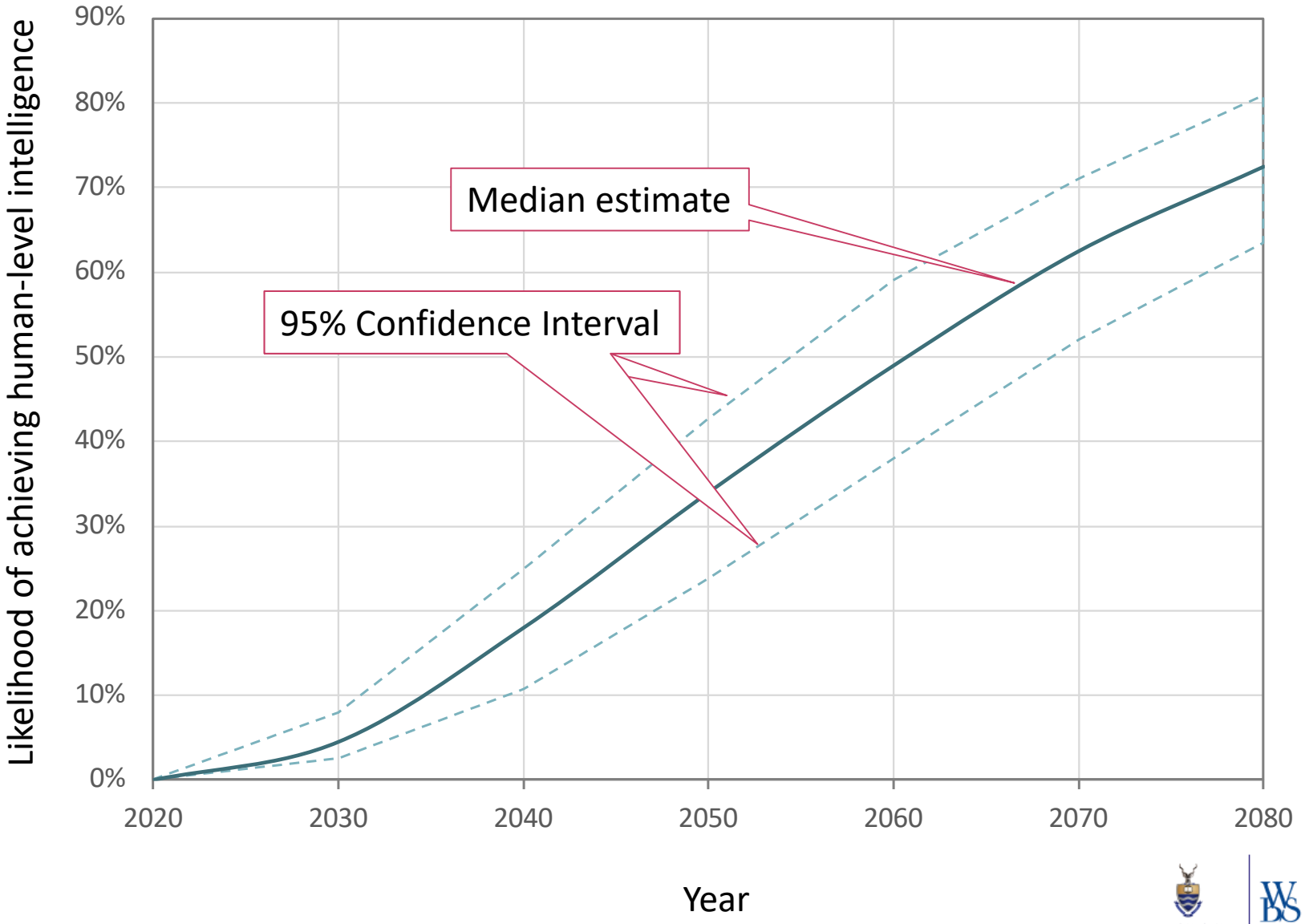
Signed:

Yoshua Bengio, Turing Prize winner and professor at University of Montreal
Stuart Russell, Berkeley, Professor of Computer Science, director of the Center for Intelligent Systems
Bart Selman, Cornell, Professor of Computer Science, past president of AAAI
Elon Musk, CEO of SpaceX, Tesla & Twitter
Steve Wozniak, Co-founder, Apple
Yuval Noah Harari, Author and Professor, Hebrew University of Jerusalem
Emad Mostaque, CEO, Stability AI
John J Hopfield, Princeton University, Professor Emeritus, inventor of associative neural networks
Valerie Pisano, President & CEO, MILA
Connor Leahy, CEO, Conjecture
Jaan Tallinn, Co-Founder of Skype
Evan Sharp, Co-Founder, Pinterest
Chris Larsen, Co-Founder, Ripple
Tom Gruber, Apple (led the team that designed Siri), Co-founder and CTO of Humanistic.AI
...
and > **30 000 others**

When is AI likely to equal and surpass human intelligence?

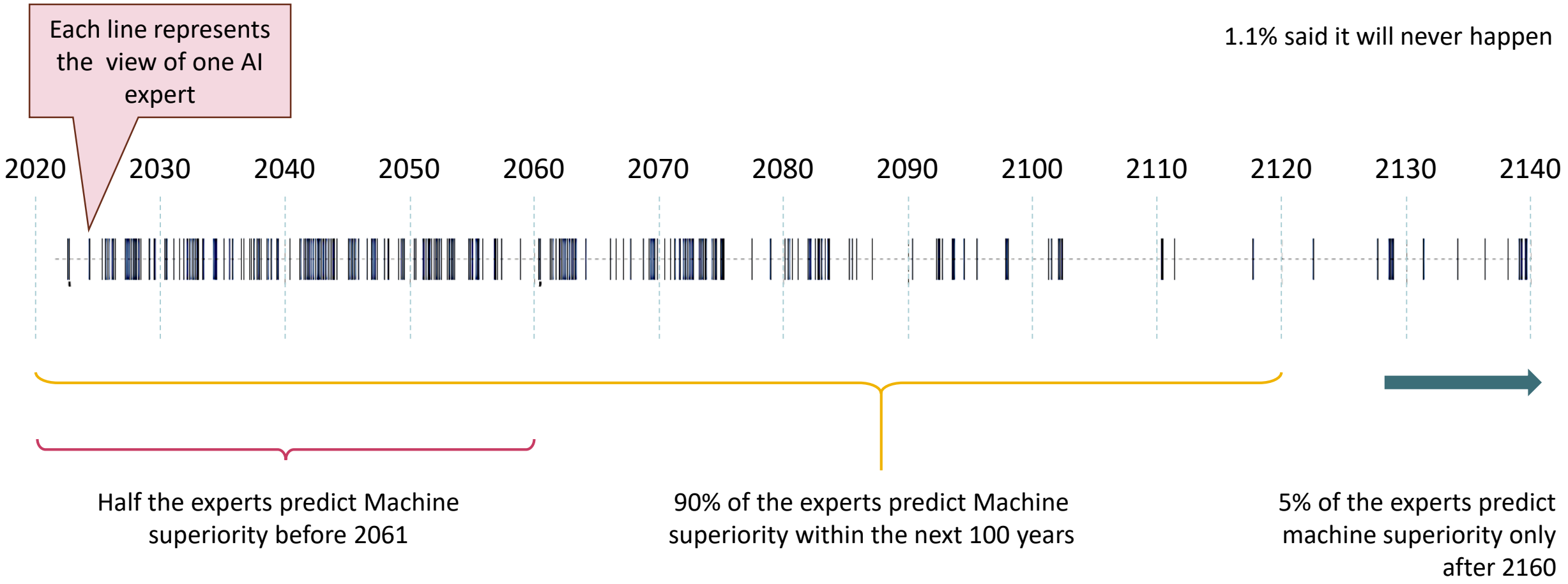
Responses of 296 AI Experts in a Survey conducted in 2019

Source:
Zhang et al (2022), *Forecasting AI progress: evidence from a survey of machine learning researchers,*
https://arxiv.org/abs/2206.04132

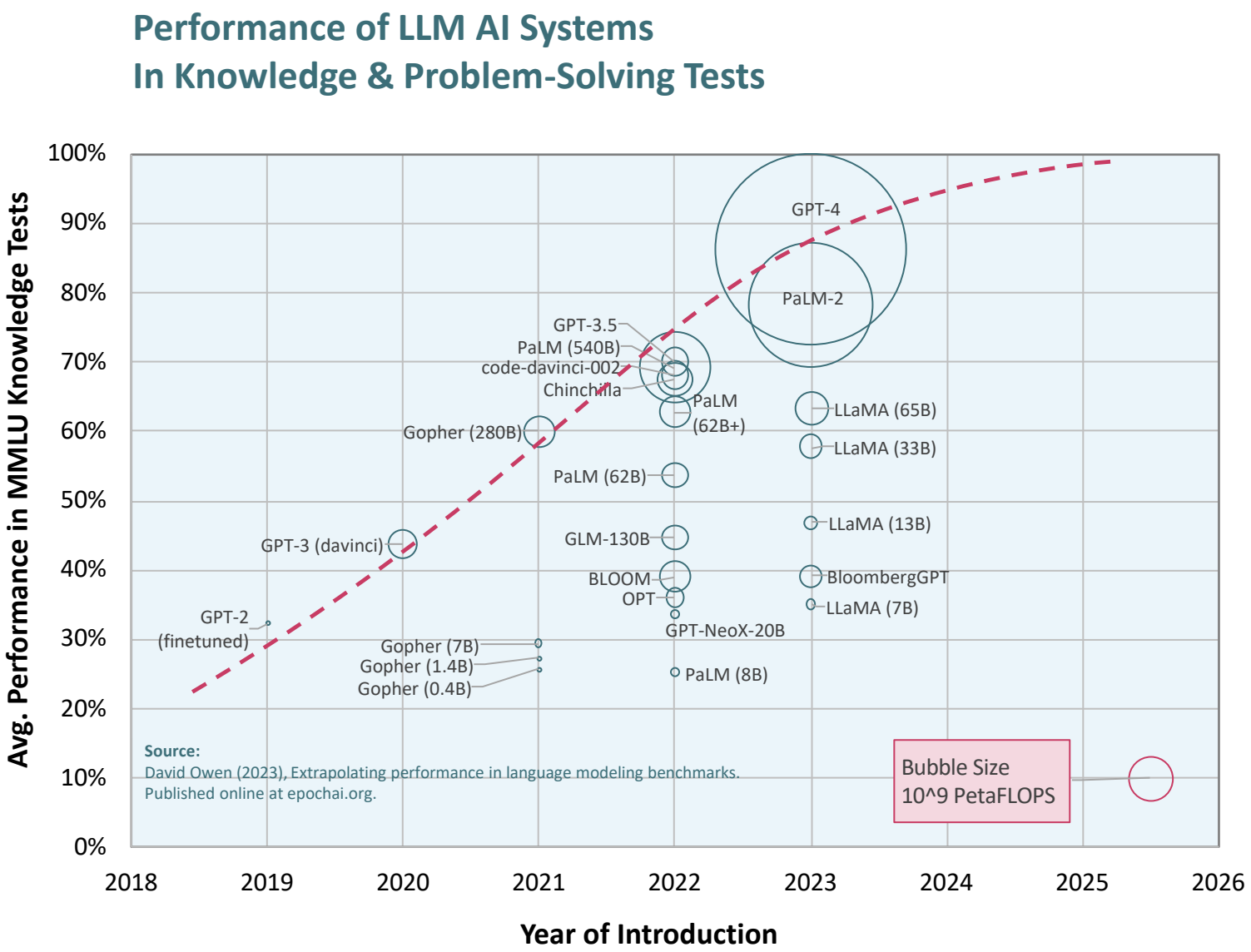


When will **unaided** Machines be able to accomplish **every task** better and more cheaply than human workers?

Survey of 356 AI Experts, 2022



AI already performs better than many people in knowledge tests

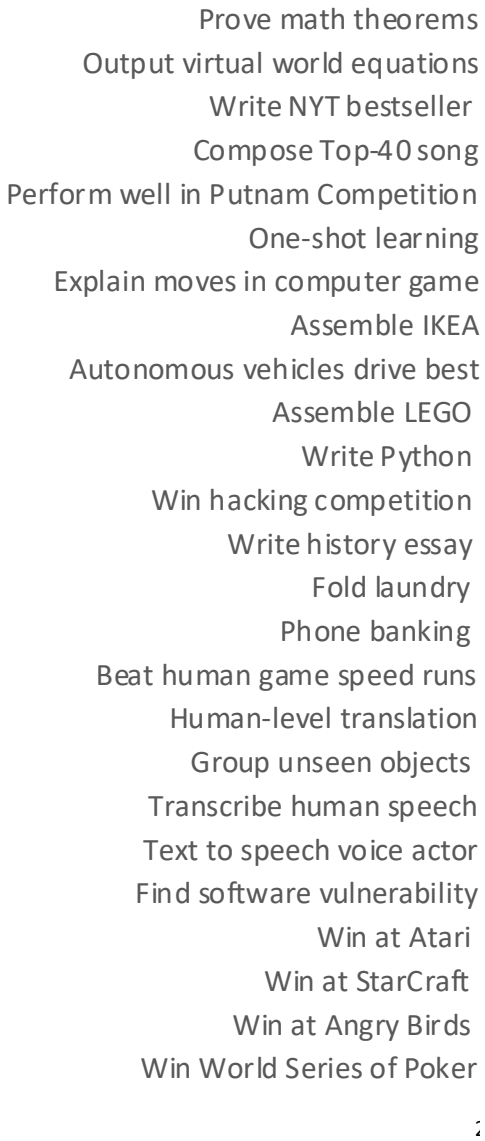


MMLU (Massive Multitask Language Understanding) is a new benchmark designed to measure knowledge acquired by evaluating models exclusively in zero-shot and few-shot settings. This makes the benchmark more challenging and more similar to how we evaluate humans.

It comprises

- 57 subjects
- Includes STEM, humanities, social sciences, and more.
- Subjects range from traditional areas, such as mathematics and history, to more specialized areas like law and ethics
- Encompasses subjects of varying difficulty levels, spanning from elementary concepts to advanced professional topics.
- Assesses not only world knowledge but also problem-solving abilities.

AI capability growth is accelerating



Experts now believe AI will attain many capabilities earlier than previously predicted

This is most dramatically evident for tasks which require higher levels of generalization

Source: Zhang et al (2022), *Forecasting AI progress: evidence from a survey of machine learning researchers,* https://arxiv.org/abs/2206.04132

Generalizing "General" (Cognitive) Intelligence

What is "Intelligence"

"…a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience."

Gottfredson, 1994

Gottfredson, L. S. (1997). Mainstream science on intelligence: An editorial with 52 signatories, history and bibliography [Editorial]. *Intelligence, 24*(1)

It has (at least) 3 "levels"

Depth
(Includes both volume of knowledge on a particular topic; as well as speed and accuracy of doing a task)

Machines have superior capacity

Breadth
The number of topics on which capability exists

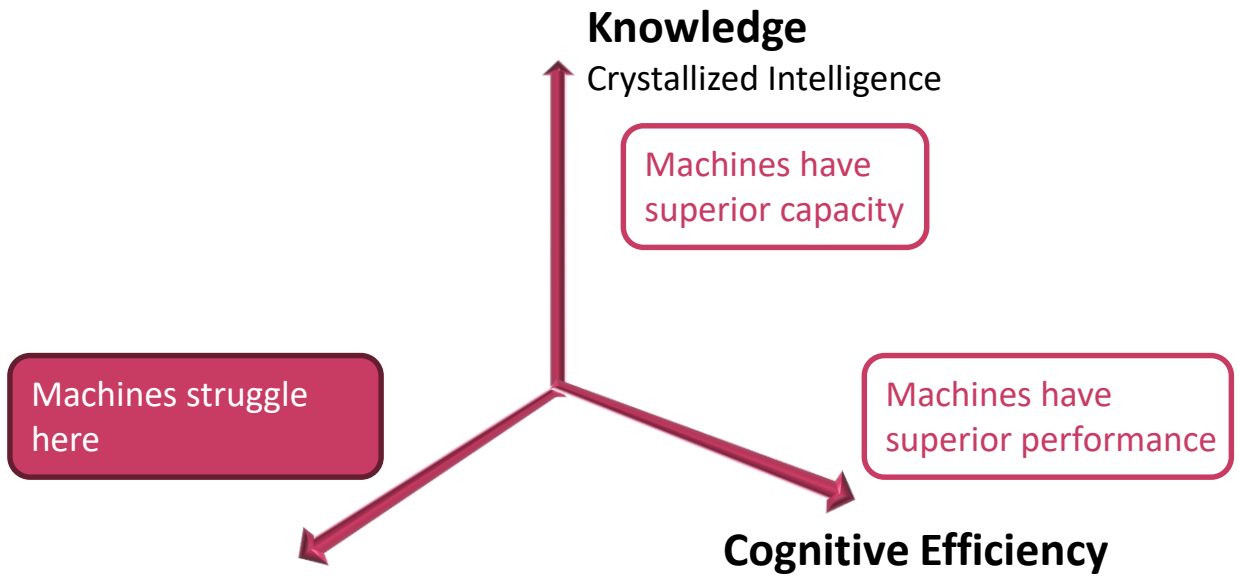
Machines (currently) are more task-specific

Integration & extrapolation

- The ability to apply knowledge and skills from one topic to a different topic
- The ability to extend insights/skills beyond previously learned tasks and contexts

Machines struggle here

Source: Author



The ability to represent and manipulate mental (visual) images to solve problems

The ability to:

- make inferences and reason
- solve problems
- think abstractly
- understand complex ideas, analogies & relationships
- learn efficiently from experience

Source: Mindspace and Author, based on McGrew, K. S. (2009). CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research. Intelligence, 37(1), 1–10.

Emotional Intelligence & Machines

Gulewitz & Higgs (2000)8)

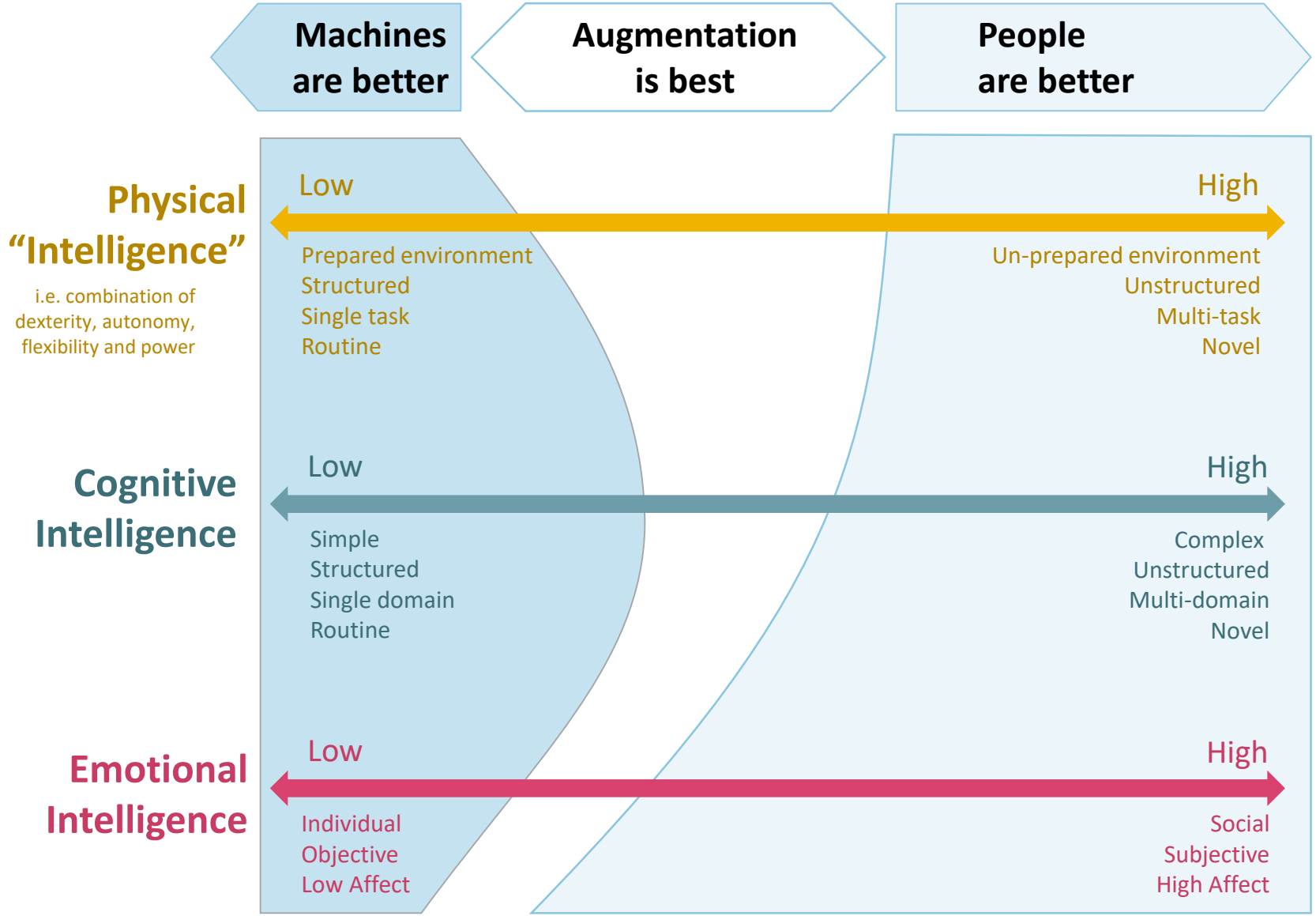
Goleman (1998)

	Machine Possible?[1]
1. Self-awareness The awareness of your own feelings and the ability to recognise and manage these. Comprises emotional consciousness, accurate self-esteem, and self-confidence.	 No emotional consciousness
2. Self-regulation The ability to perform well and consistently in a range of situations and when under pressure. Comprises: (1) emotional self-control; (2) integrity; (3) innovation & creativity; (4) initiative & bias to action; (5) resilience; (6) achievement guide; (7) stress management; (8) realistic optimism and (9) intentionality	 Inherent to Machines?
3. Motivation The drive and energy which you have to achieve results, balance short and long-term goals and pursue your goals in the face of challenge and rejection.	 Not applicable to Machines?
4. Empathy / Interpersonal Sensitivity The ability to be aware of the needs and feelings of others and to use this awareness effectively in interacting with them and arriving at decisions impacting on them. Based on visual, tonal and content cues	 Current limitation is I/O
5. Social Skills / Influence The ability to persuade others to change their viewpoint on a problem, issue or decision. Includes: rapport-building, communication, collaboration, negotiation, conflict management/de-escalation	
6. Intuitiveness The ability to use insight and interaction to arrive at and implement decisions when faced with ambiguous or incomplete information.	
7. Conscientiousness & Integrity The ability to display commitment to a course of action in the face of challenge, to act consistently and in line with understood ethical requirements.	 Ethics can be programmed/trained in

Sources:
Dulewicz, V., & Higgs, M. (2000). Emotional Intelligence. A review and evaluation study. *Journal of Managerial Psychology*, 15(4), 341–372.
Goleman D. (1998), Working with Emotional Intelligence. Bantam; New York.
[1] Author's assessment

People or Machines?

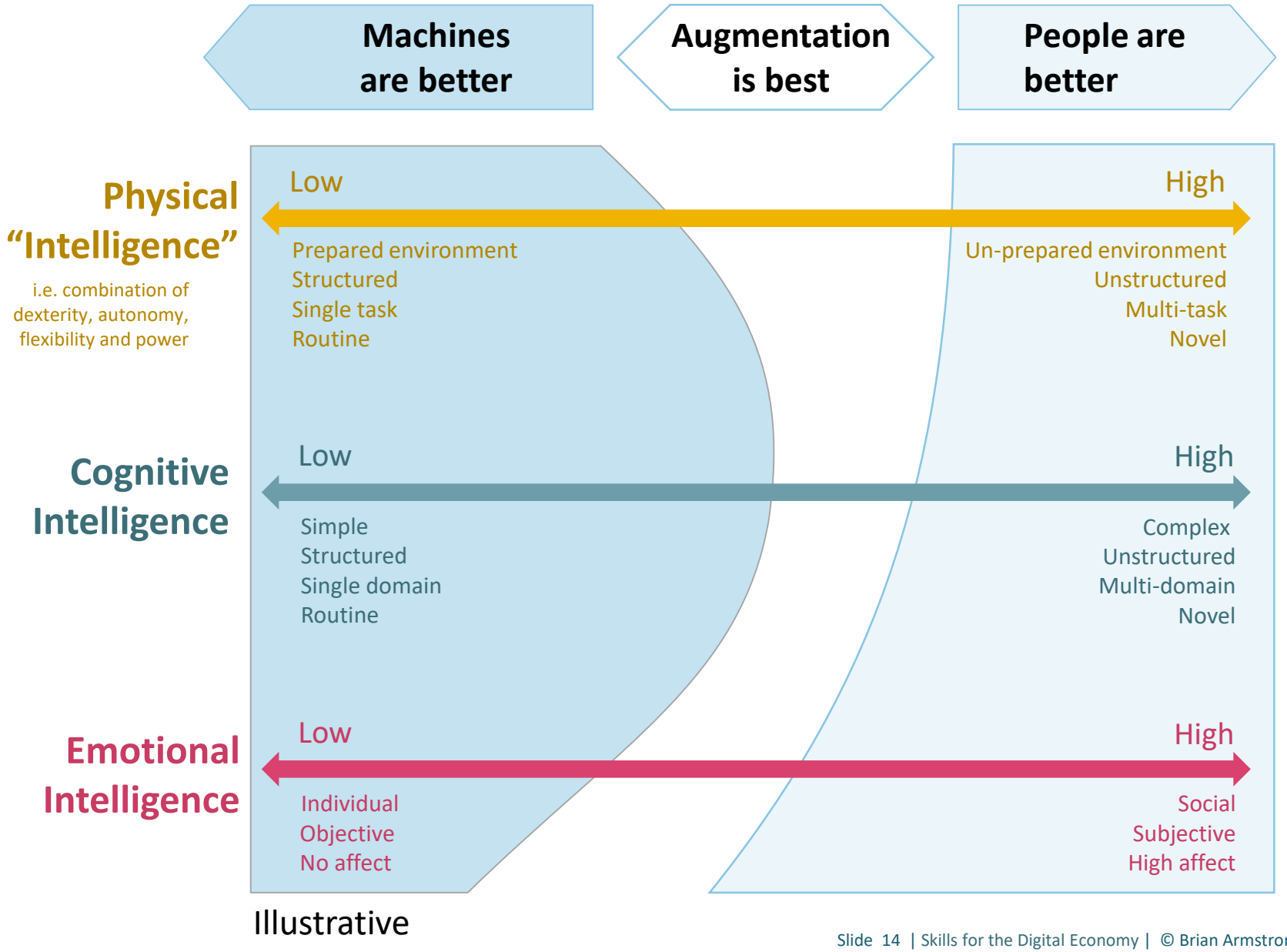
It depends on the types and level of intelligence required for a particular ***task***



Illustrative

People or Machines?

+ 3 years



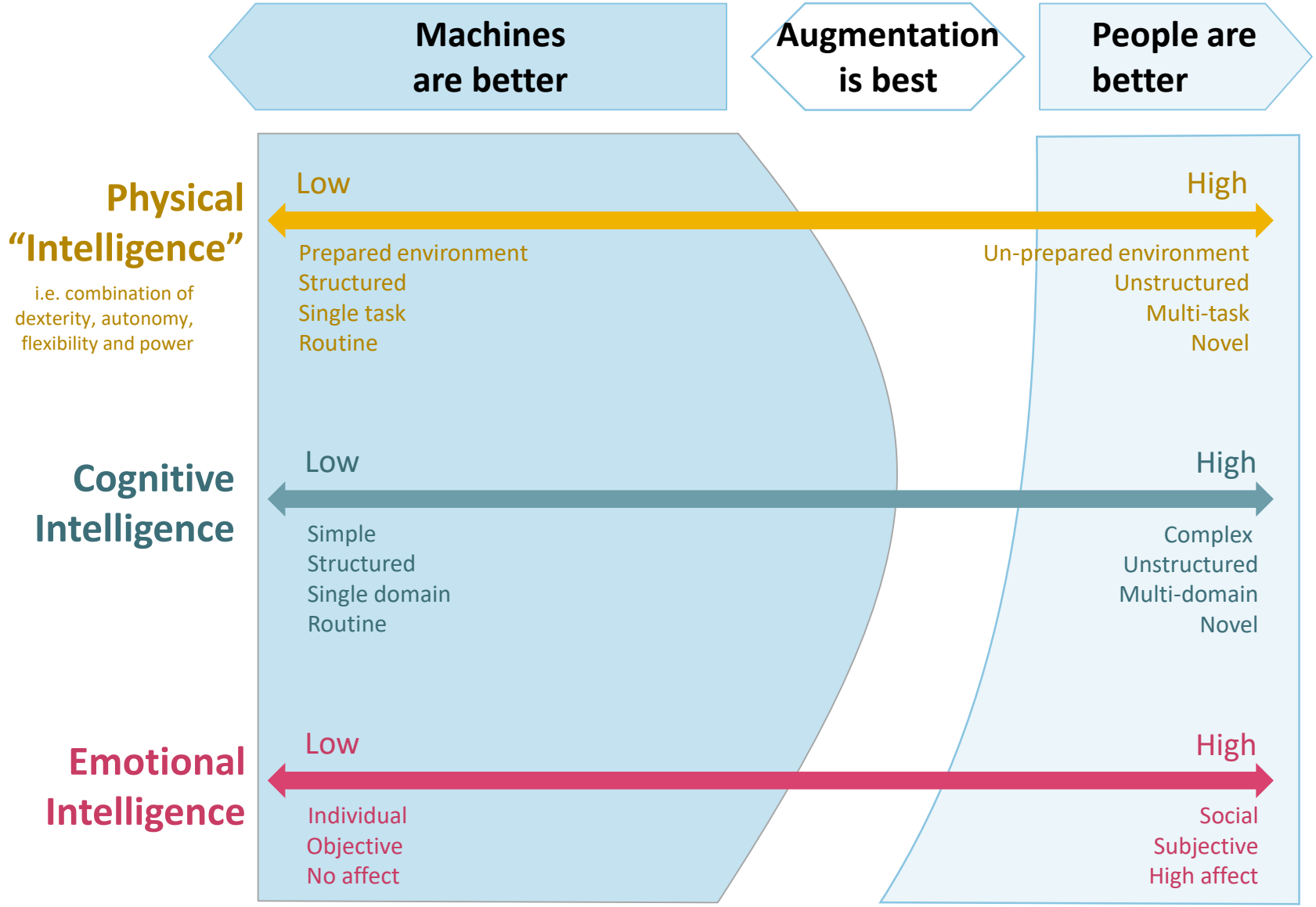
Illustrative

People or Machines?

We need to plan for the reality that machines are advancing faster than we anticipated

Skills strategic horizon typically 10 years

Skills planning needs to reflect this

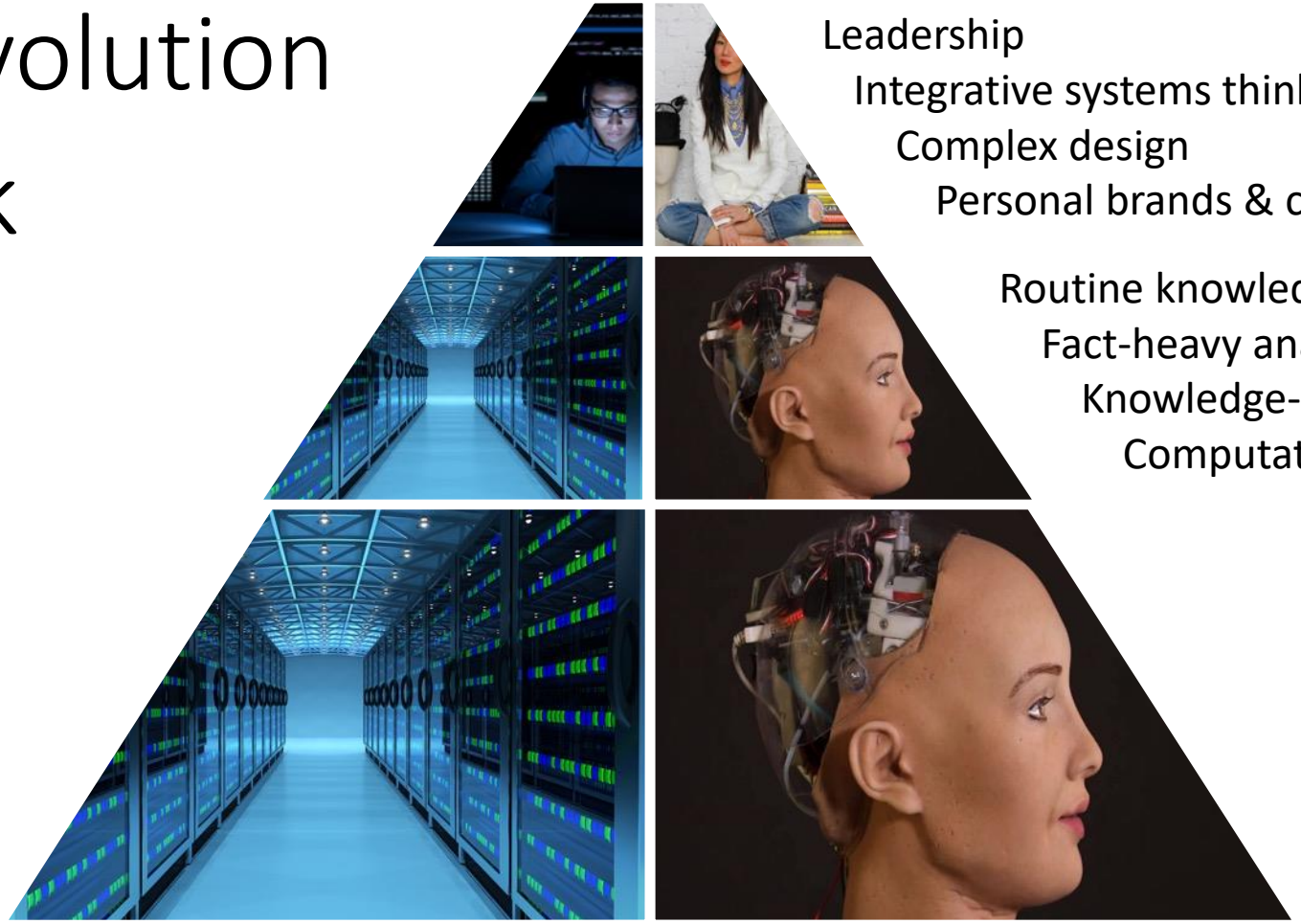


Illustrative

The Revolution of Work

Leadership
Integrative systems thinking
Complex design
Personal brands & celebrity

The Revolution of Work



Leadership
Integrative systems thinking
Complex design
Personal brands & celebrity

Routine knowledge work
Fact-heavy analysis & diagnosis
Knowledge-work production
Computation

The Revolution of Work

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Creatively intensive
Emotionally intensive
Unstructured dexterity
Artisanal work

The Revolution of Work

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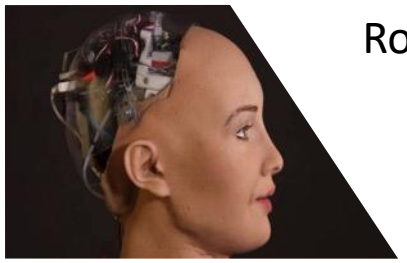


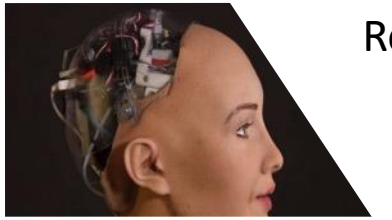
Routine knowledge work
Fact-heavy analysis & diagnosis
Knowledge-work production
Computation

Creatively intensive
Emotionally intensive
Unstructured dexterity
Artisanal work

Production
Structured physical work

The Revolution of Work



Leadership

Integrative & complex problem solving: **People**

Complex design

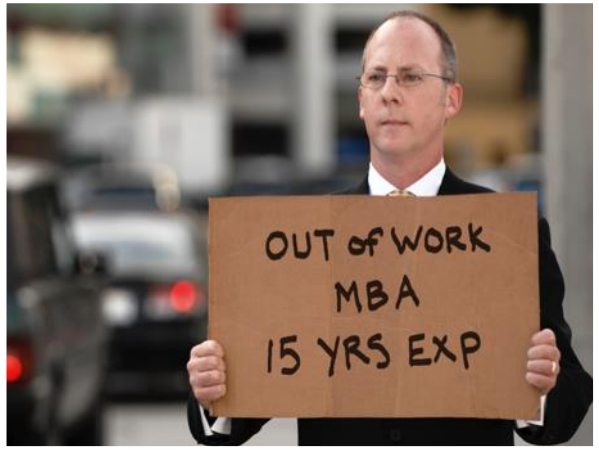
Personal brands & celebrity

Routine knowledge work

Routine and/or structured cognitive tasks: **Computers**

Knowledge-work production

Computation


Unstructured cognitive tasks: **People**

Routine and/or structured physical tasks: **Machines**

Structured physical work







Unstructured physical work

Unstructured physical work: **People**

Sub-economic labour

Semi-skilled services

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Various opinions of critical skills for the digital age

A selection of recent material

Increasing rigour and scholarly substance

Digital Marketing Institute

6 Digital Skills that will Future-Proof a Workforce

1. Expert data analysis
2. Advanced social selling
3. Mobile expertise
4. Multi-platform UX design
5. Network & Information security
6. Creative thinking

https://digitalmarketinginstitute.com/blog/15-05-18-6-digital-skills-that-will-future-proof-a-workforce

Accessed 30 August 2019

LinkedIn

The 4 key skills you need in today's digital world

1. Research Aptitude and Information synthesis
2. Oral and Written Communication skills
3. Coding skills (or at least an appreciation of coding)
4. Having an independent opinion and world view

https://www.linkedin.com/pulse/4-key-skills-you-need-todays-digital-world-ramachandran-t-r-/

Accessed 30 August 2019

PWC

Your workforce needs reskilling

1. Business and science skills—including domain specialties such as marketing, organizational design and finance.
2. Human or soft skills—including communication, critical thinking, adaptability, problem-solving, leadership, creativity and innovation.
3. Technology skills—from basic data literacy to applying artificial intelligence to real-world problems..

https://www.pwc.com/us/en/services/hr-management/library/workforce-reskilling.html

Accessed 30 August 2019

World Economic Forum

The 10 skills you need to thrive in the Fourth Industrial Revolution

1. Complex problem solving
2. Critical thinking
3. Creativity
4. People management
5. Coordinating with others
6. Emotional intelligence
7. Judgement and decision making
8. Service orientation
9. Negotiation
10. Cognitive Flexibility

https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

Accessed 30 August 2019

McKinsey

Skill shift: automation and the future of the workforce

1. Physical and manual abilities
2. Basic cognitive abilities
3. Higher cognitive abilities
4. Social and emotional abilities
5. Technological abilities

https://www.mckinsey.com/~/media/McKinsey/Featured Insights/Future of Organizations/Skill shift Automation and the future of the workforce/MGI-Skill-Shift-Automation-and-future-of-the-workforce-May-2018.ashx

Accessed 30 August 2019

Various opinions of critical skills for the digital age

A selection of recent material (cont)

Increasing rigour and scholarly substance

RAND Corporation

Digital learning: Education and skills in the digital age

Two different types of skills are required:

1. **Digital skills:**
   technical skills required to use digital technologies

2. **Digital navigation skills**
   a wider set of skills needed to succeed in the digital world. These include
   - finding information,
   - prioritising information
   - assessing the quality and reliability of information.

   These digital navigation skills are not fundamentally different from the non-digital skills that were necessary in the past and that are still required today, although they have to be 'translated' for use in a digital context. These digital navigation skills were also referred to as 'eternal skills'

https://www.rand.org/content/dam/rand/pubs/conf_proceedings/CF300/CF369/RAND_CF369.pdf

Accessed 30 August 2019

OECD

Skills for a Digital World

1. ICT specialist skills
2. ICT generic skills
3. ICT complementary skills
4. Foundational Skills

https://www.researchgate.net/publication/308615679_Skills_for_a_Digital_World

Accessed 30 August 2019

The capability to programme and develop applications and manage networks.

The capability to access information online or from other systems, and use software as part of your core tasks

The capability to process complex information, communicate with co-workers and clients, solve problems, plan in advance and adjust quickly.

As per Dumont and Istance, 2010 (p. 23), this includes specifically to ability to:
- generate and process complex information
- think systematically and critically
- take decisions weighing different forms of evidence
- ask meaningful questions about different subjects
- be adaptable and flexible to new information
- be creative
- be able to identify and solve real-world problems

These requirements do not create a demand for new skills but rather increase the importance of some human competences that have been valuable for many centuries (National Research Council, 2012).

Literacy and numeracy proficiency (of students and adults)
- Sound levels of foundation skills are a prerequisite for the development of the skills demanded in the digital economy
- Usually developed in early years (OECD, 2015), most often before entering compulsory education.

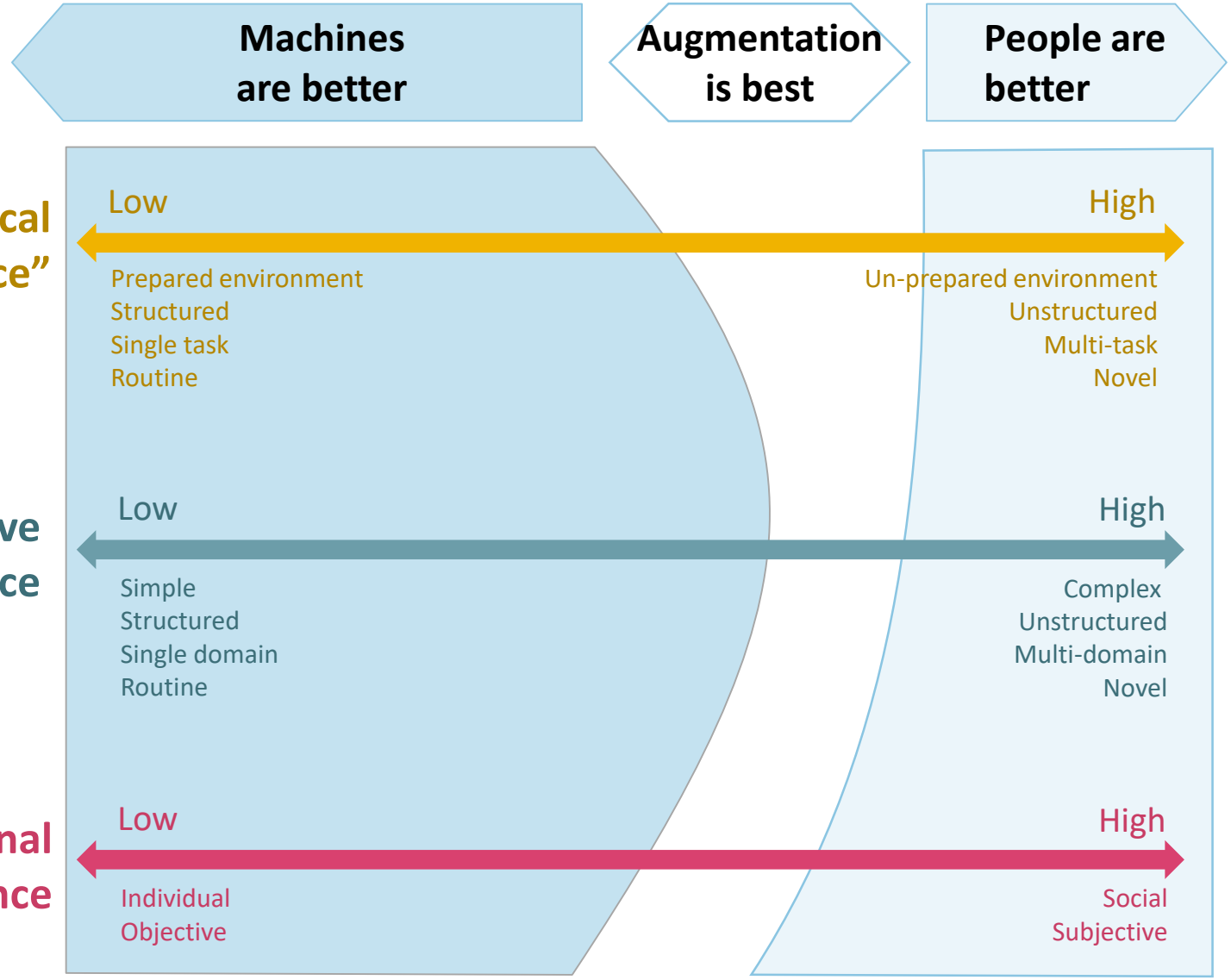
Digital literacy - the ability to read and autonomously navigate digital content (" targeted navigation skills").

People or Machines?

But for many years still to come we will need these also.

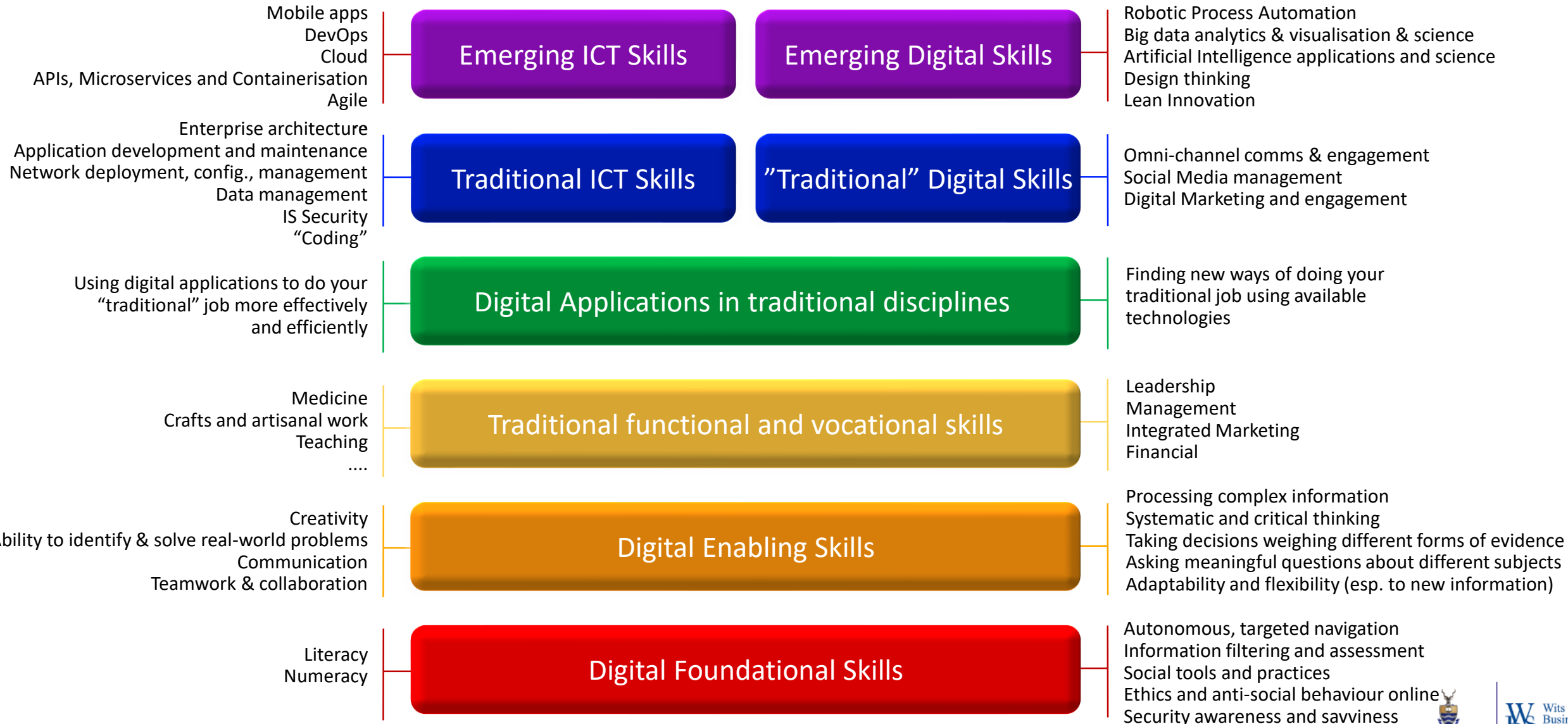
And professional jobs include a lot of higher-level cognitive intelligence

Many sources are now emphasizing this dimension as a focus for competence development



Illustrative

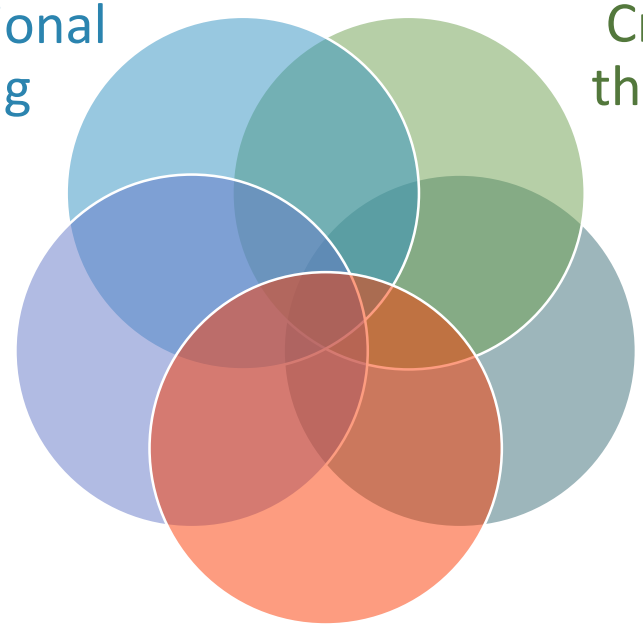
Skills Framework for a Digital World



But what about the “human-differentiating” skills

Problem abstraction
Problem decomposition
Problem solutioning
(Solution codification?

Computational Thinking



Critical thinking

Identifying critical issues & their interconnections
Gathering & selecting authoritative sources
Identifying potential approaches & solutions
Developing solutions systematically
Presenting & analysing competing points of view
Detect inconsistencies & mistakes in reasoning
Weighing options& selecting a solution
Reflecting on the justifications and assumptions

Divergent thinking
Inductive thinking
Lateral thinking

Creative Thinking

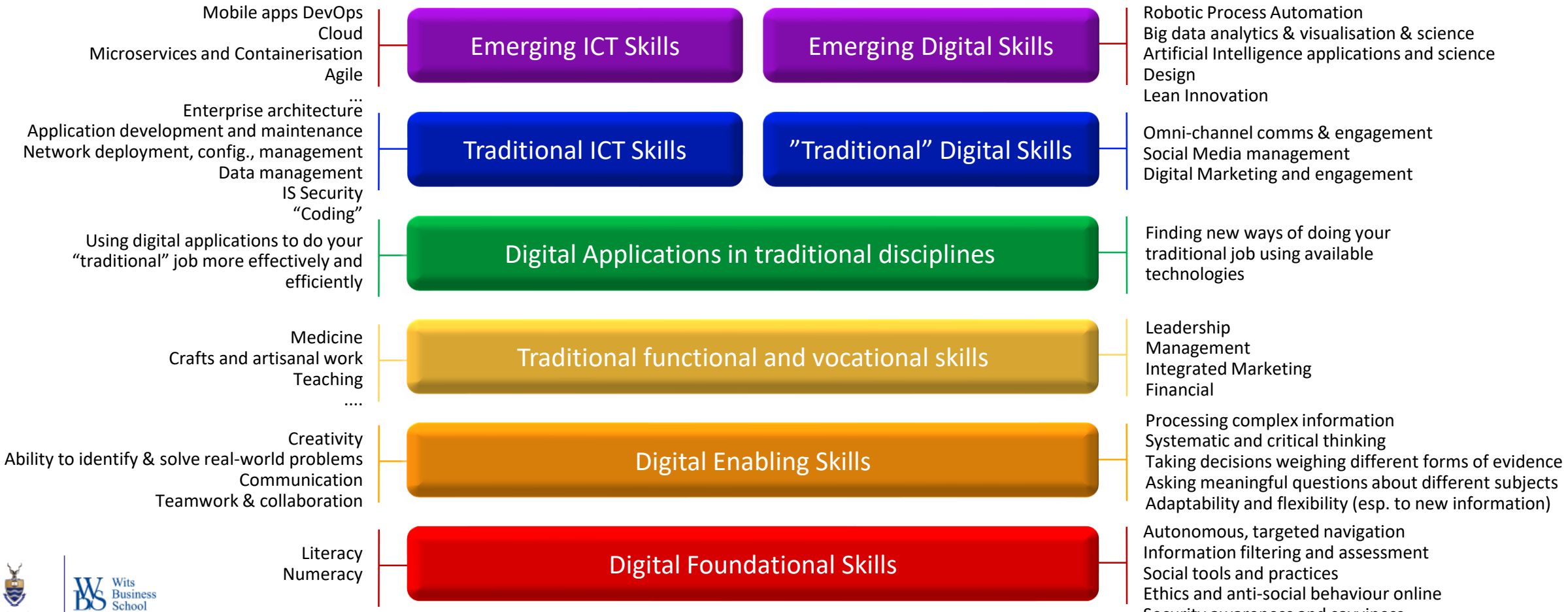
Complexity thinking

Systems thinking
Non-linearity
Interactions and interconnectivity
Feedback
Emergence

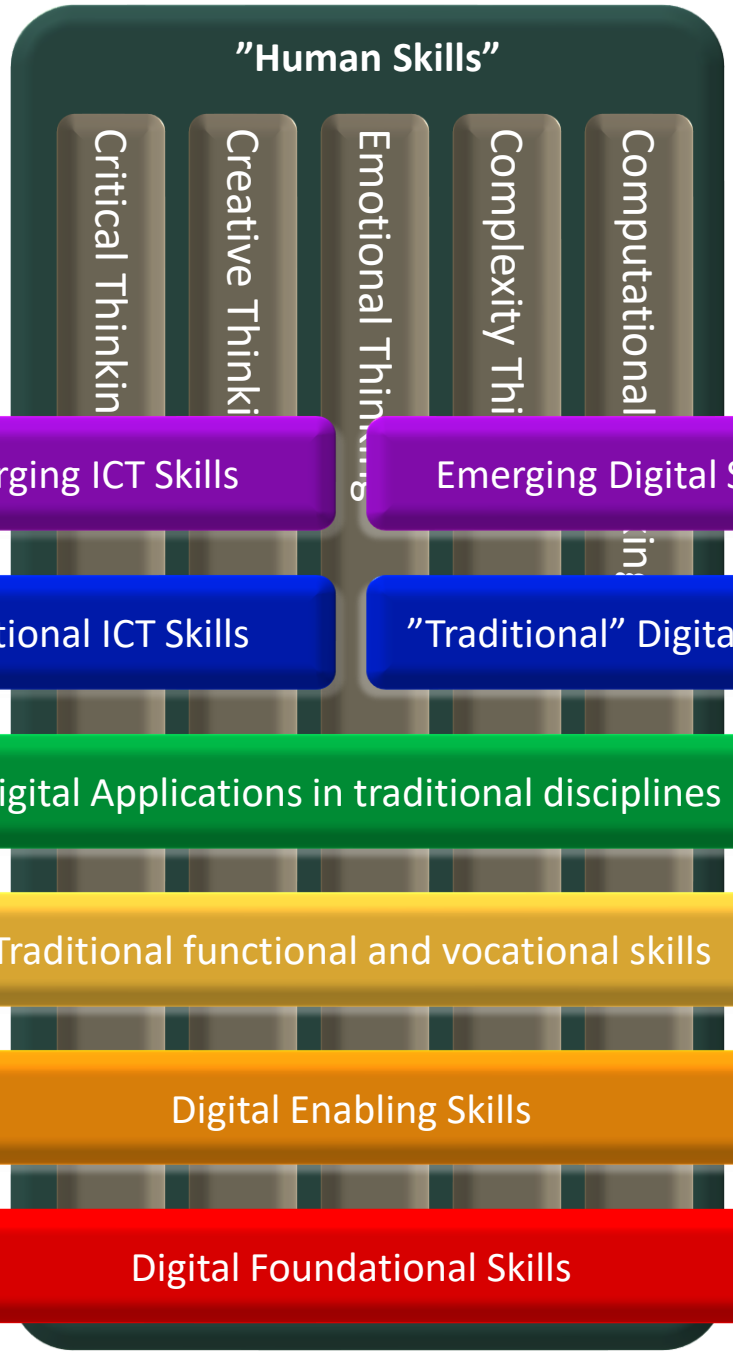
Emotional Intelligence

Self-awareness
Self-regulation
Motivation
Empathy / Interpersonal Sensitivity
Social Skills / Influence
Intuitiveness
Conscientiousness & Integrity

Skills Framework for a Digital World



Skills Framework for a Digital World



Mobile apps DevOps
Cloud
Microservices and Containerisation
Agile
...

Robotic Process Automation
Big data analytics & visualisation & science
Artificial Intelligence applications and science
Design
Lean Innovation

Enterprise architecture
Application development and maintenance
Network deployment, config., management
Data management
IS Security
"Coding"

Omni-channel comms & engagement
Social Media management
Digital Marketing and engagement

Using digital applications to do your "traditional" job more effectively and efficiently

Finding new ways of doing your traditional job using available technologies

Medicine
Crafts and artisanal work
Teaching
....

Leadership
Management
Integrated Marketing
Financial

Creativity
Ability to identify & solve real-world problems
Communication
Teamwork & collaboration

Processing complex information
Systematic and critical thinking
Taking decisions weighing different forms of evidence
Asking meaningful questions about different subjects
Adaptability and flexibility (esp. to new information)

Literacy
Numeracy

Autonomous, targeted navigation
Information filtering and assessment
Social tools and practices
Ethics and anti-social behaviour online
Security awareness and savviness
...

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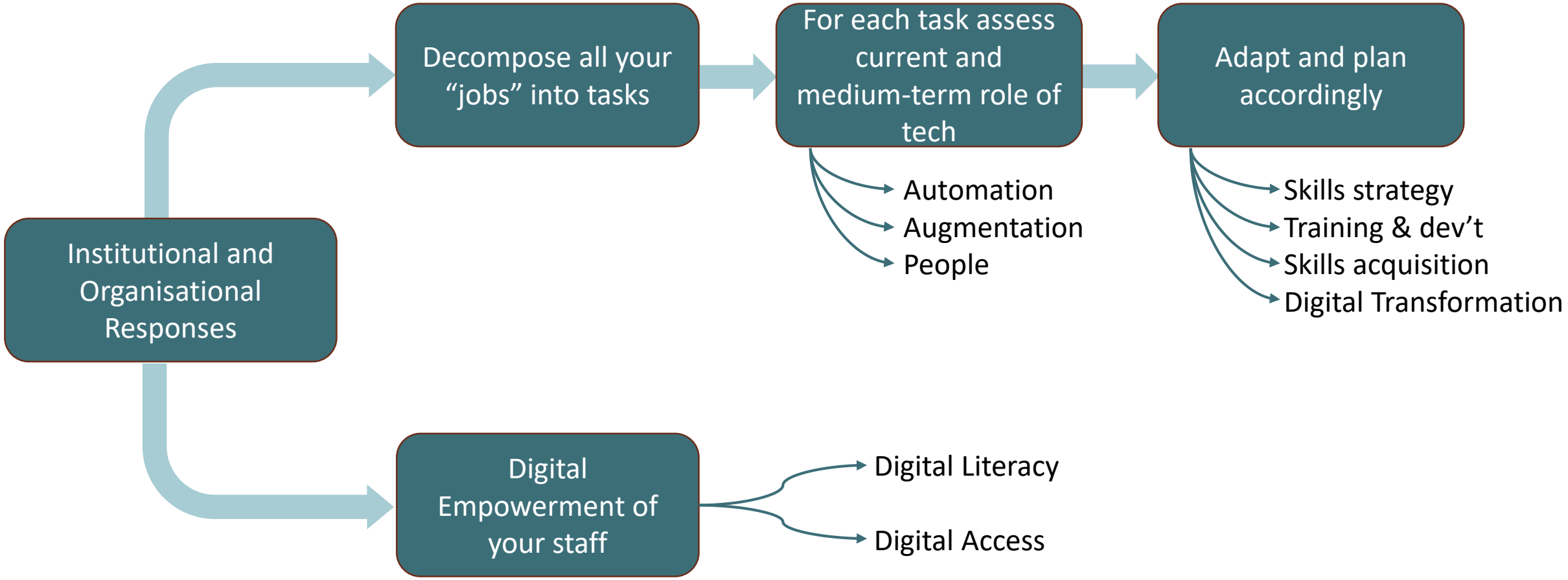
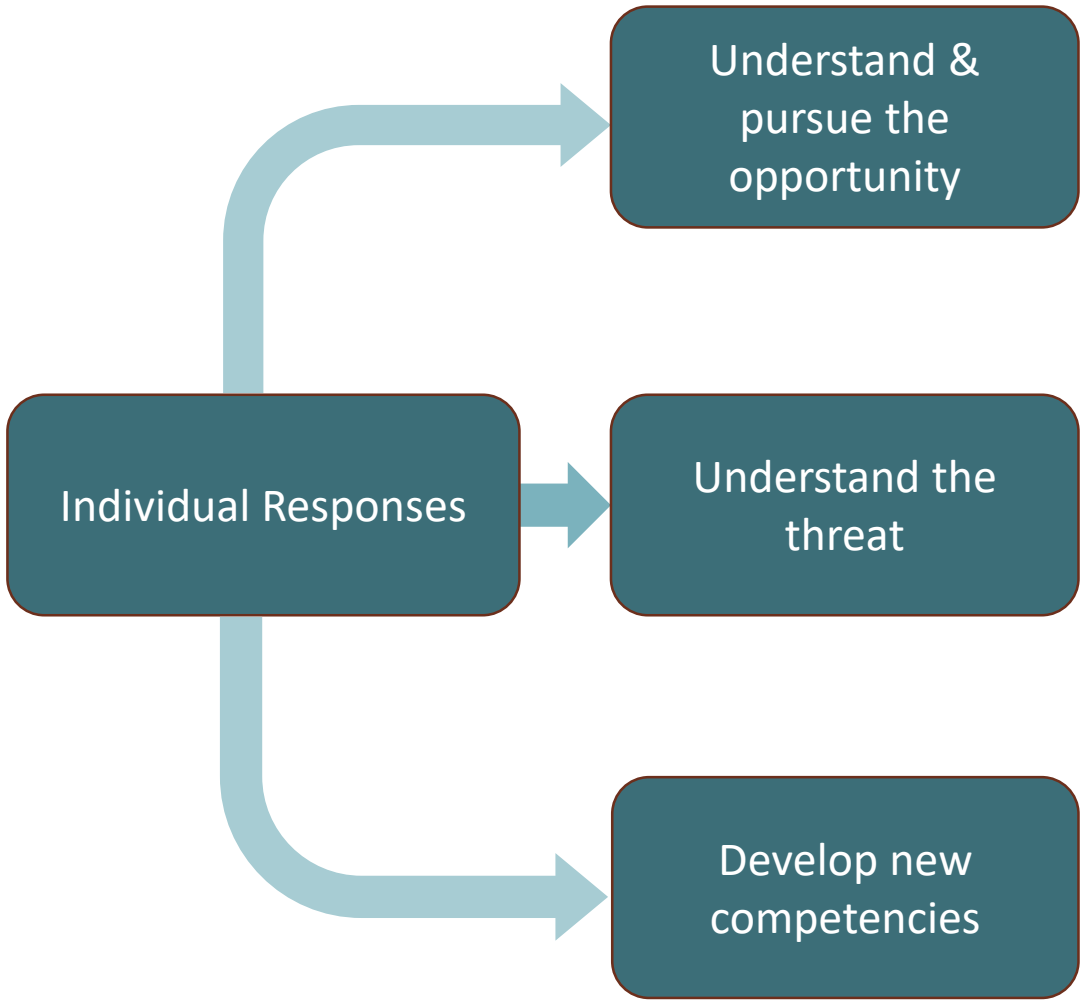
Institutional and Organisational Responses



Individual Responses



For my own role, ask:

- What tasks in my own job could a machine help me do better?
- Motivate the adoption thereof and develop the related user skills

For my own role, ask:

- What tasks does my job entail?
- What is structured and repetitive, individual and objective?
- What could GPT do?
- What could a machine likely do in the future?

- Creative thinking
- Critical Thinking
- Complexity thinking
- Computational thinking
- Emotional thinking

What comes first?

the tool?

or the skill?

Start digitalising your processes
and incorporating AI

So you can develop the competences to
work with emerging technologies

The key to developing any new ability is....

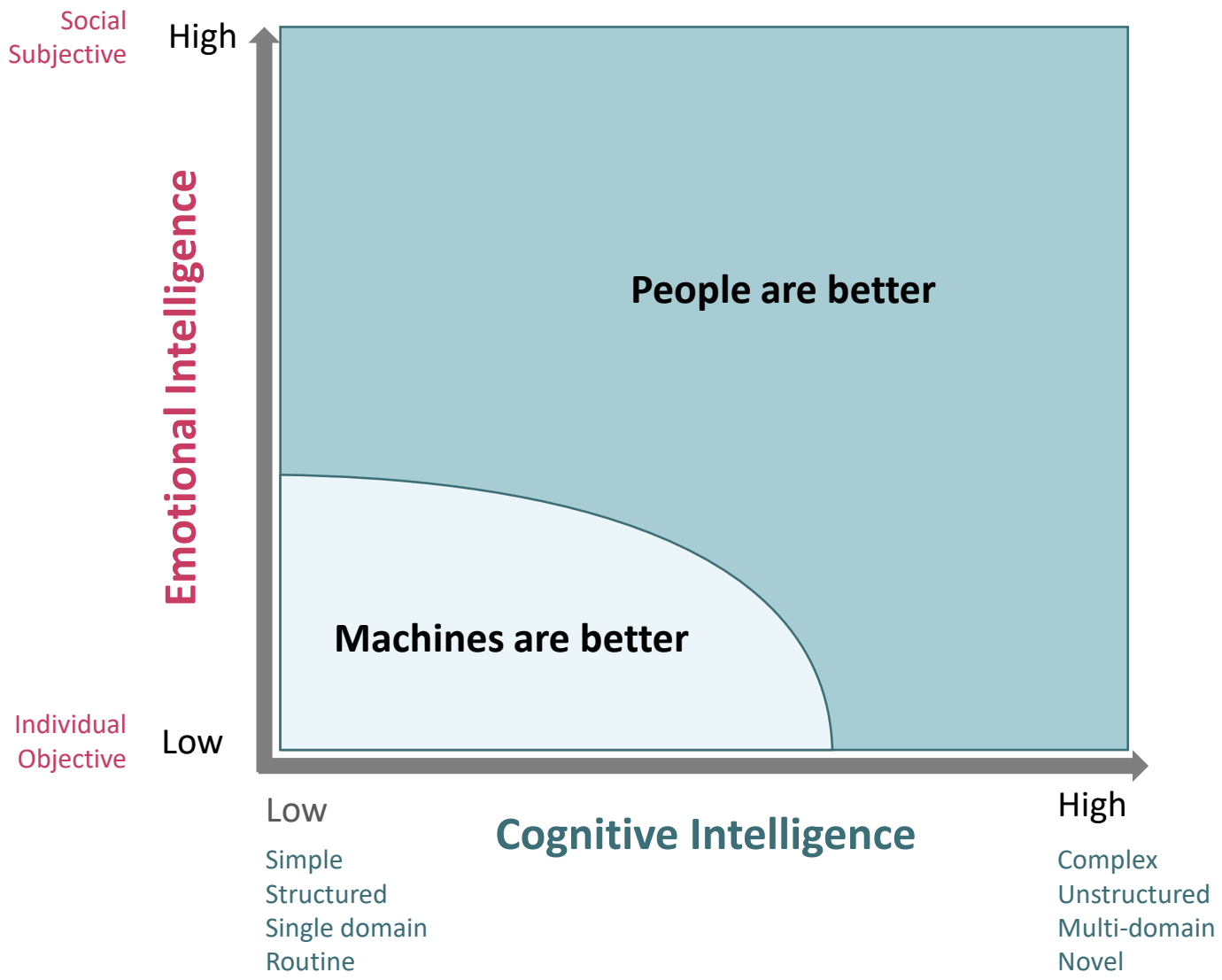
PRACTICE, PRACTICE, PRACTICE!

Let’s talk…..

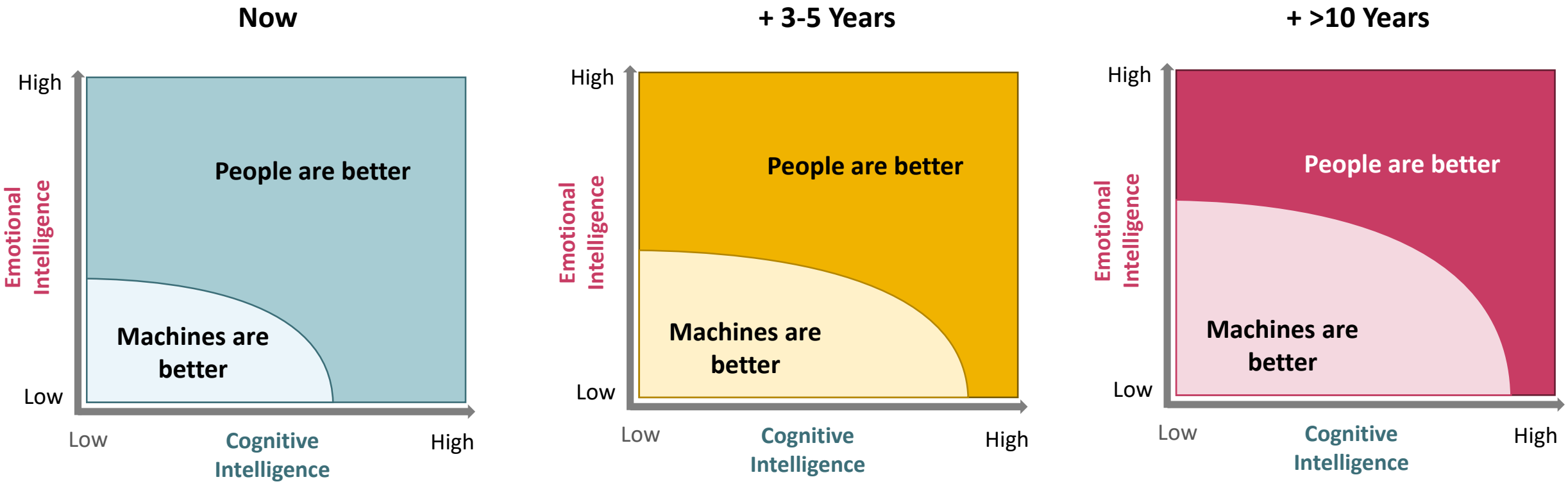
brian.armstrong@wits.ac.za

People or Machines?

It depends on the types and level of intelligence required for a particular ***task***



People or Machines?



We need to plan for the reality that machines are advancing faster than we anticipated

Over a skills strategic horizon of 10 years we need to take a progressive view

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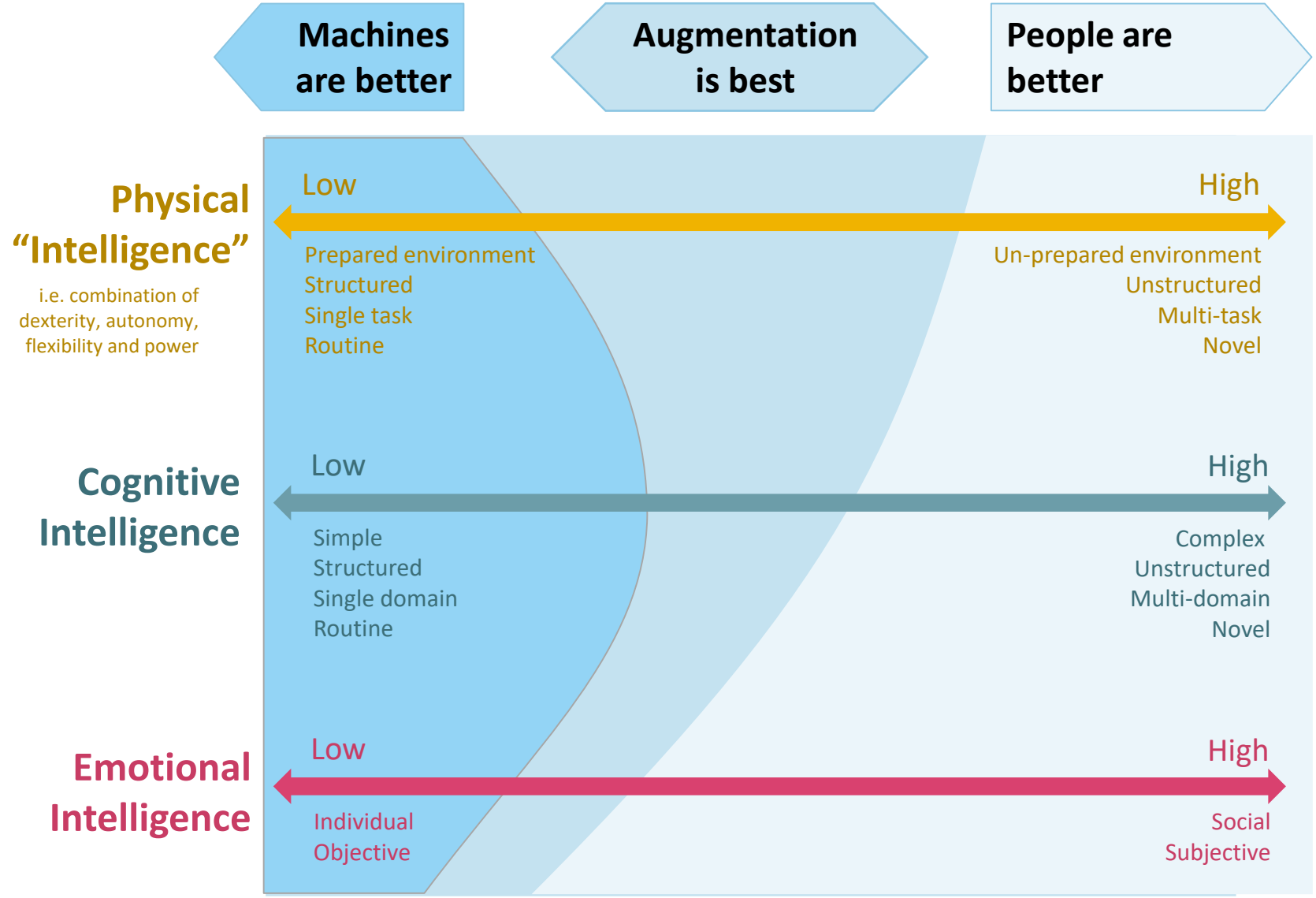
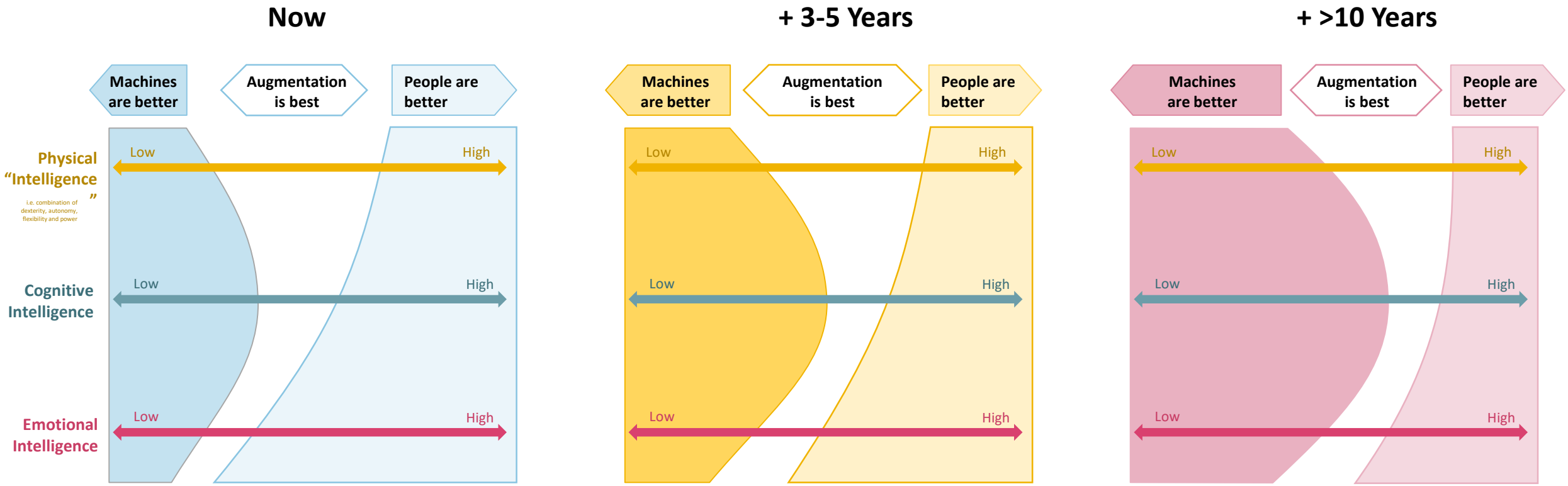


People or Machines?

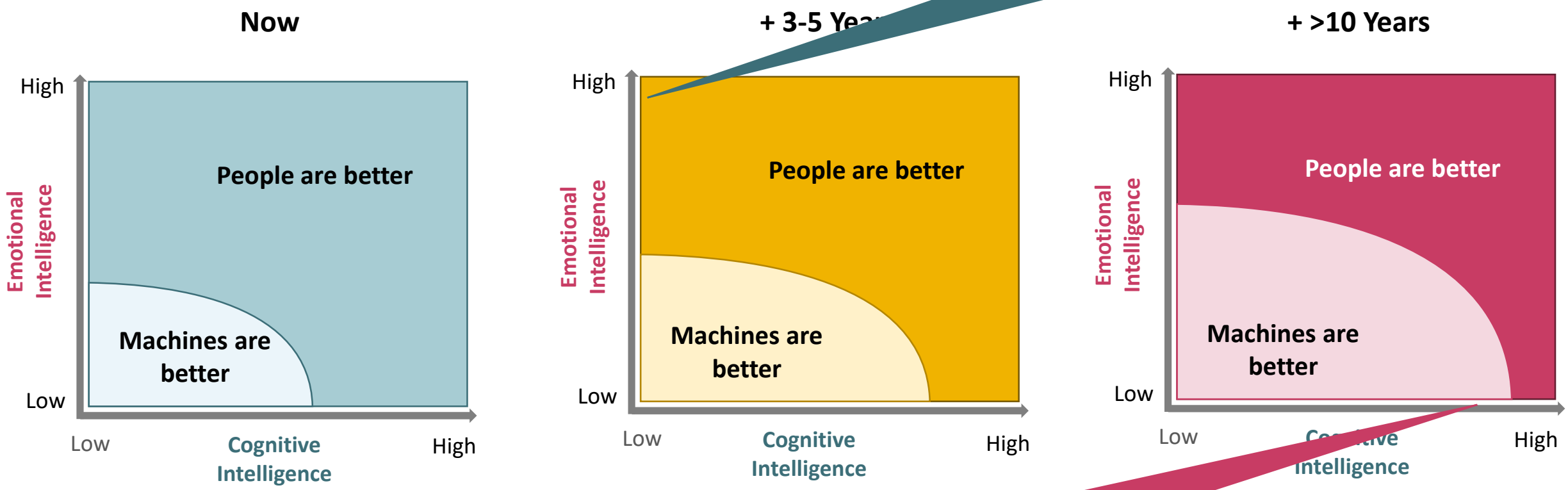


We need to plan for the reality that machines are advancing faster than we anticipated

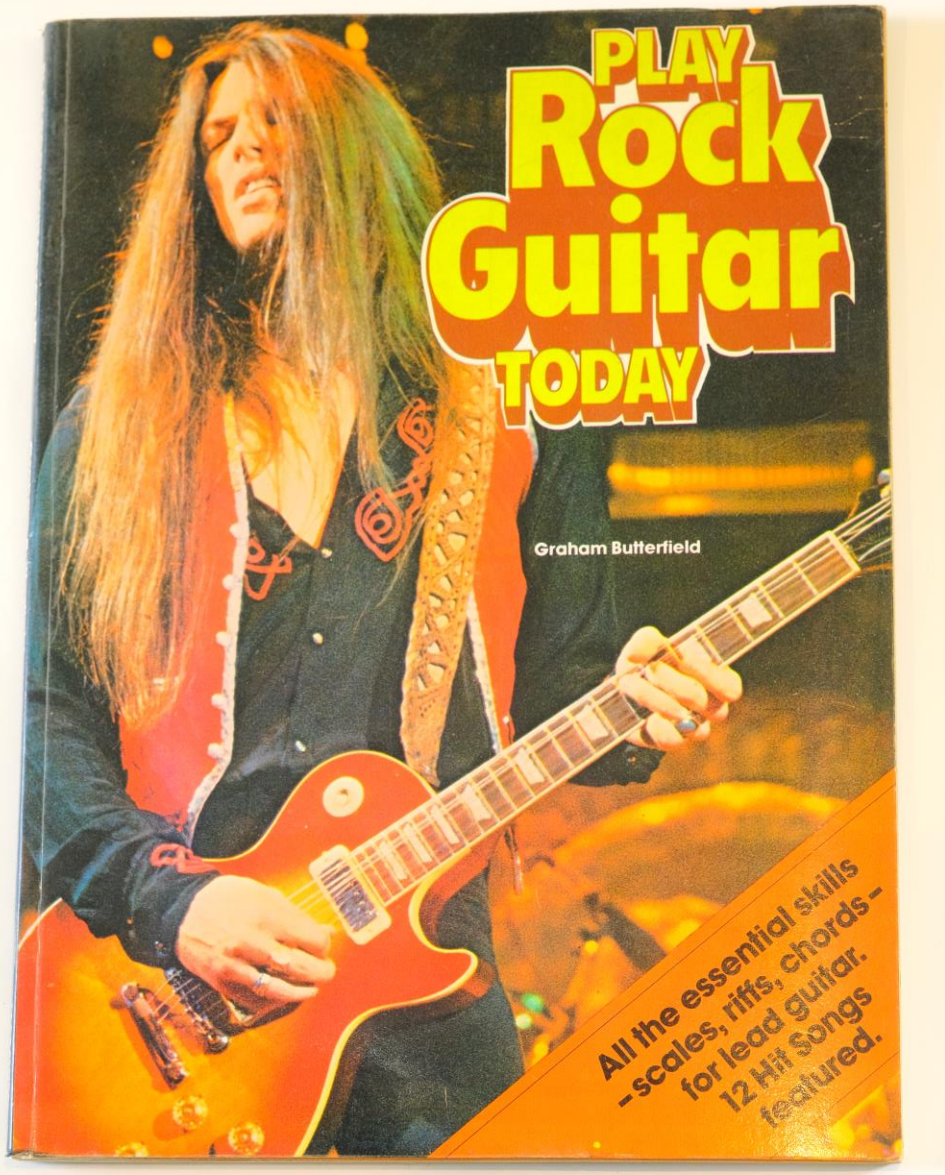
Over a skills strategic horizon of 10 years we need to take a progressive view

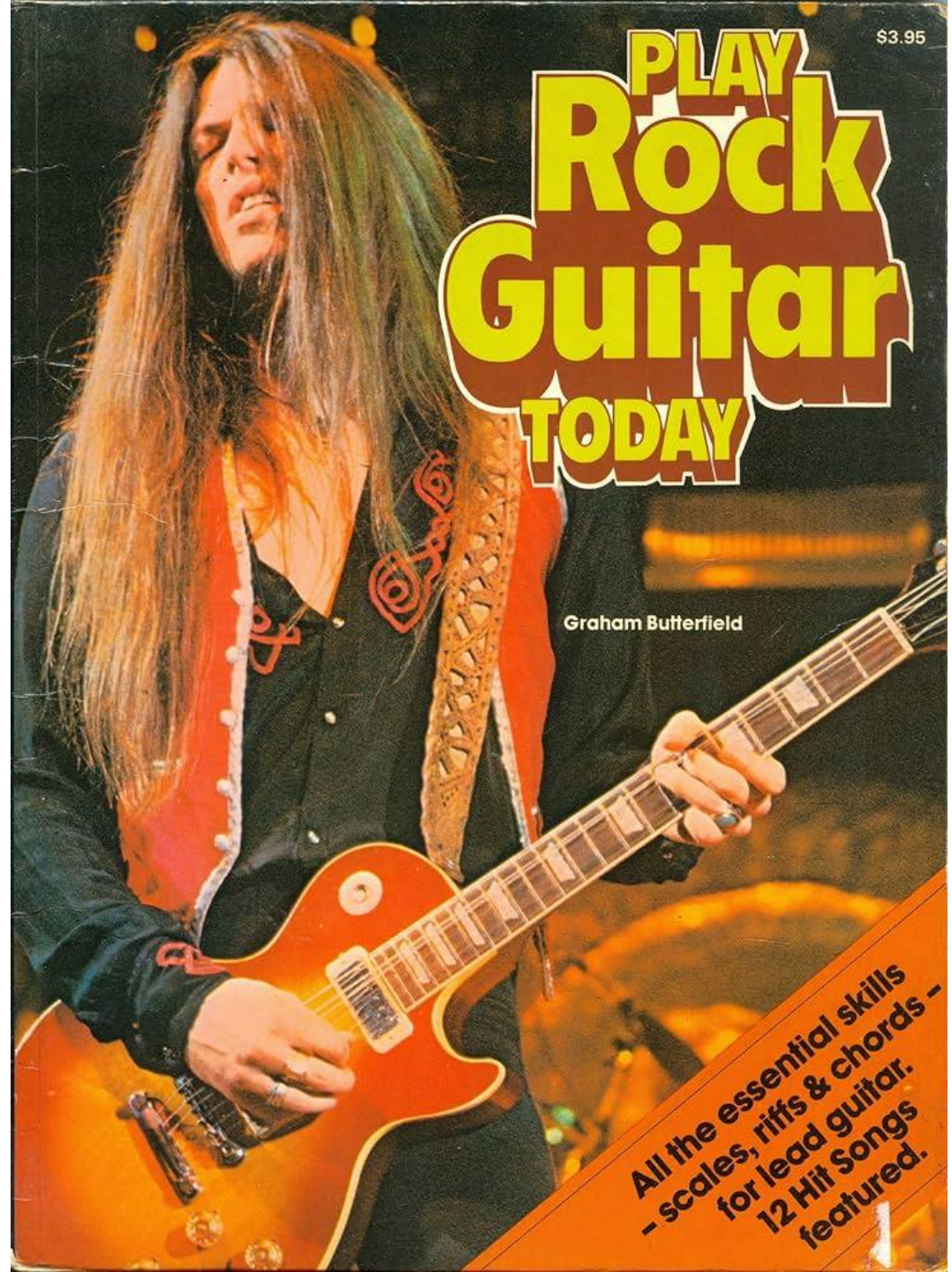
People or Machines?

Many sources are now emphasizing this dimension as a focus for competence development



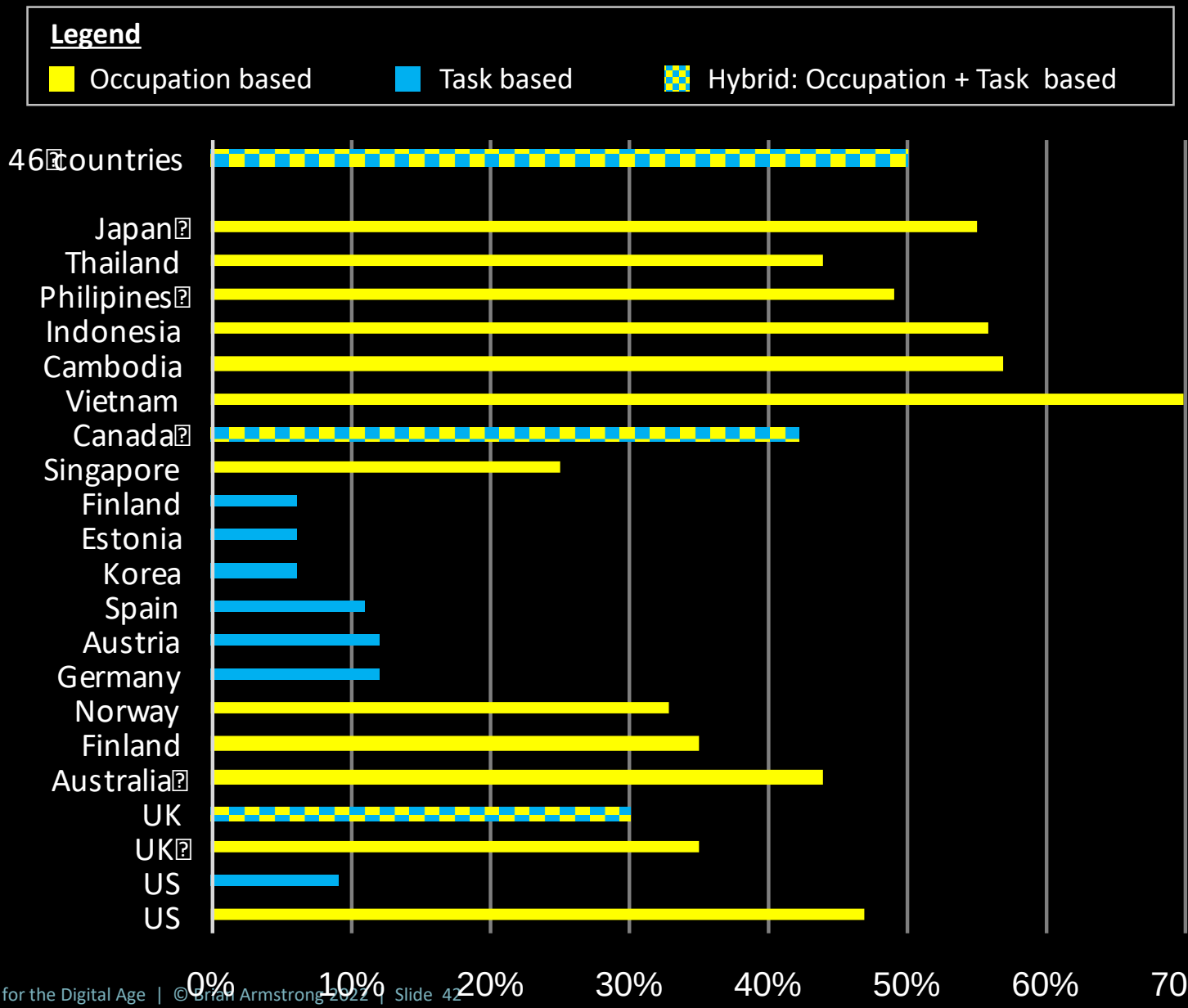
But for many years still to come we will need these also. And professional jobs include a lot of higher-level cognitive intelligence





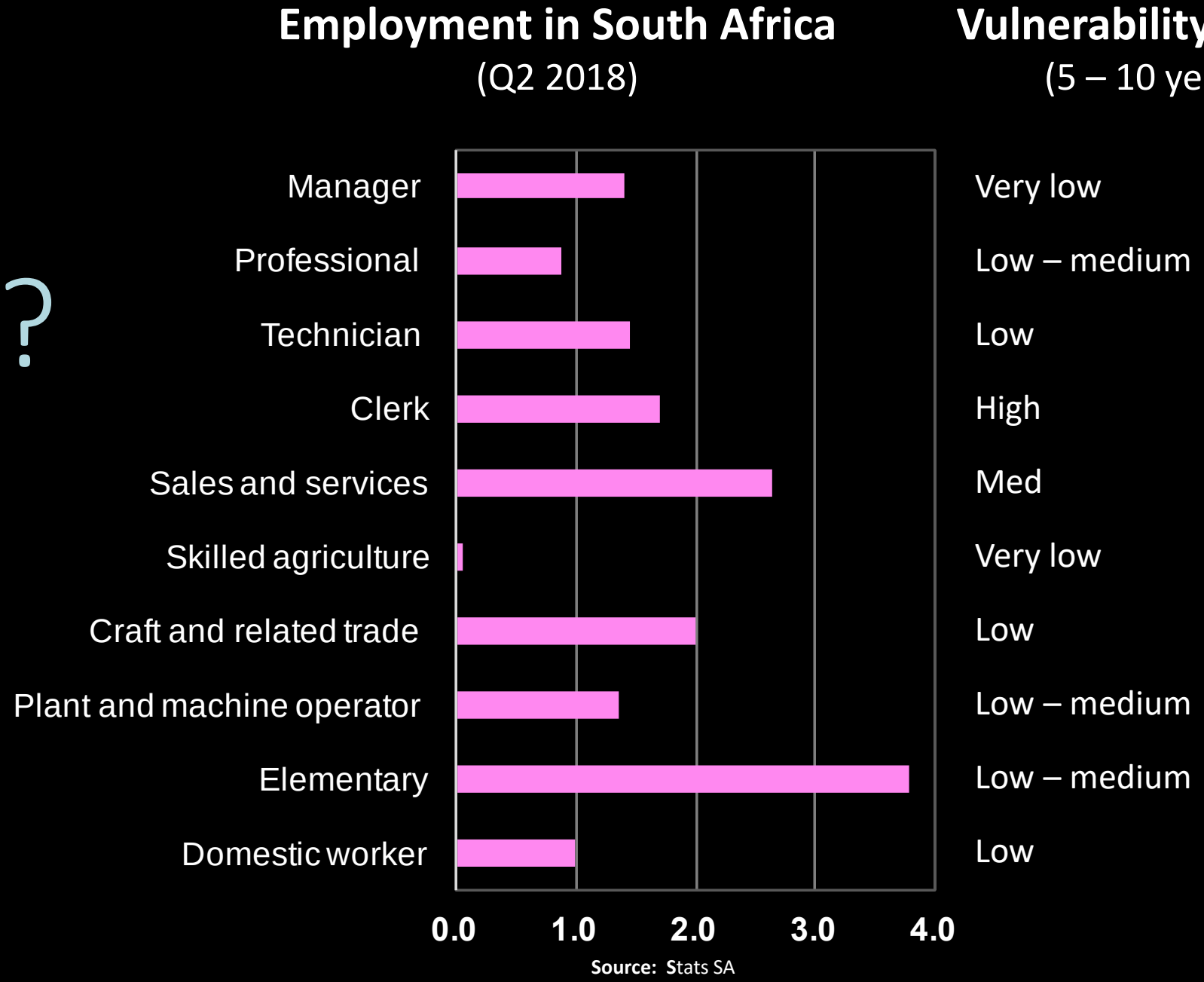
Summary of different studies:

% of Jobs / Tasks at high risk of Automation

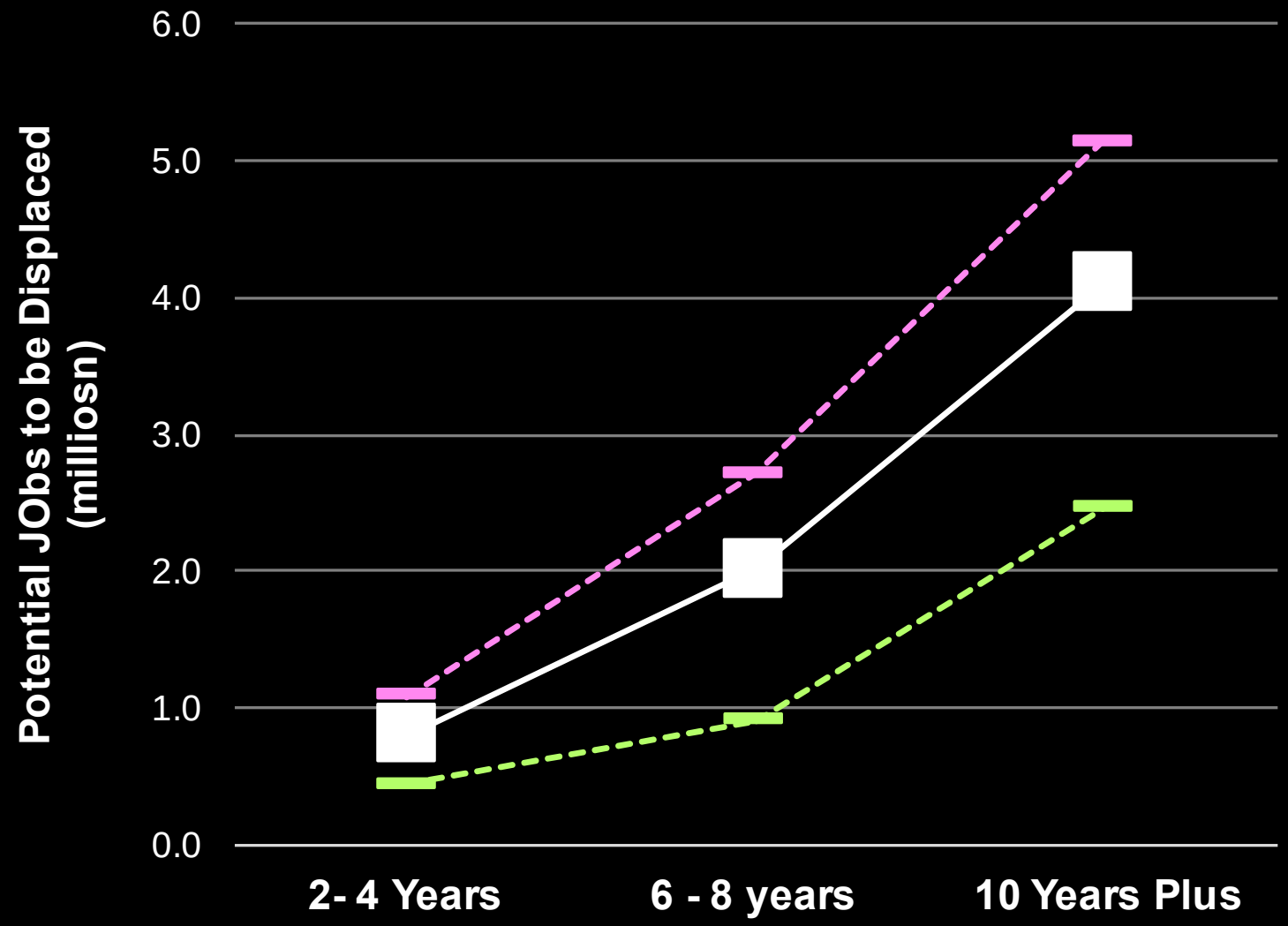


Source study
Summary analysis by Magida and Armstrong
Manyika et al, 2017
David, 2017
Chang & Huynh, 2016
Chang & Huynh, 2016
Chang & Huynh, 2016
Chang & Huynh, 2016
Chang & Huynh, 2016
Lamb, 2016
Lee, 2016
Arntz, Gregory and Zierahn, 2016
Arntz, Gregory and Zierahn, 2016
Arntz, Gregory and Zierahn, 2016
Arntz, Gregory and Zierahn, 2016
Arntz, Gregory and Zierahn, 2016
Arntz, Gregory and Zierahn, 2016
Pajarinen, Rouvinen and Ekeland, 2015
Pajarinen, Rouvinen and Ekeland, 2015
Reading, Thorpe and Peake, 2015
Berriman & Hawksworth, 2017
Frey and Osborne, Deloitte, 2014
Arntz, Gregory and Zierahn, 2017
Osborne and Frey, 2013

And in South Africa?



Potential Jobs Displacement in South Africa



Legend

- Aggressive case
- Moderate case
- Conservative case

Source: Brian Armstrong Estimates based on Stats SA jobs data

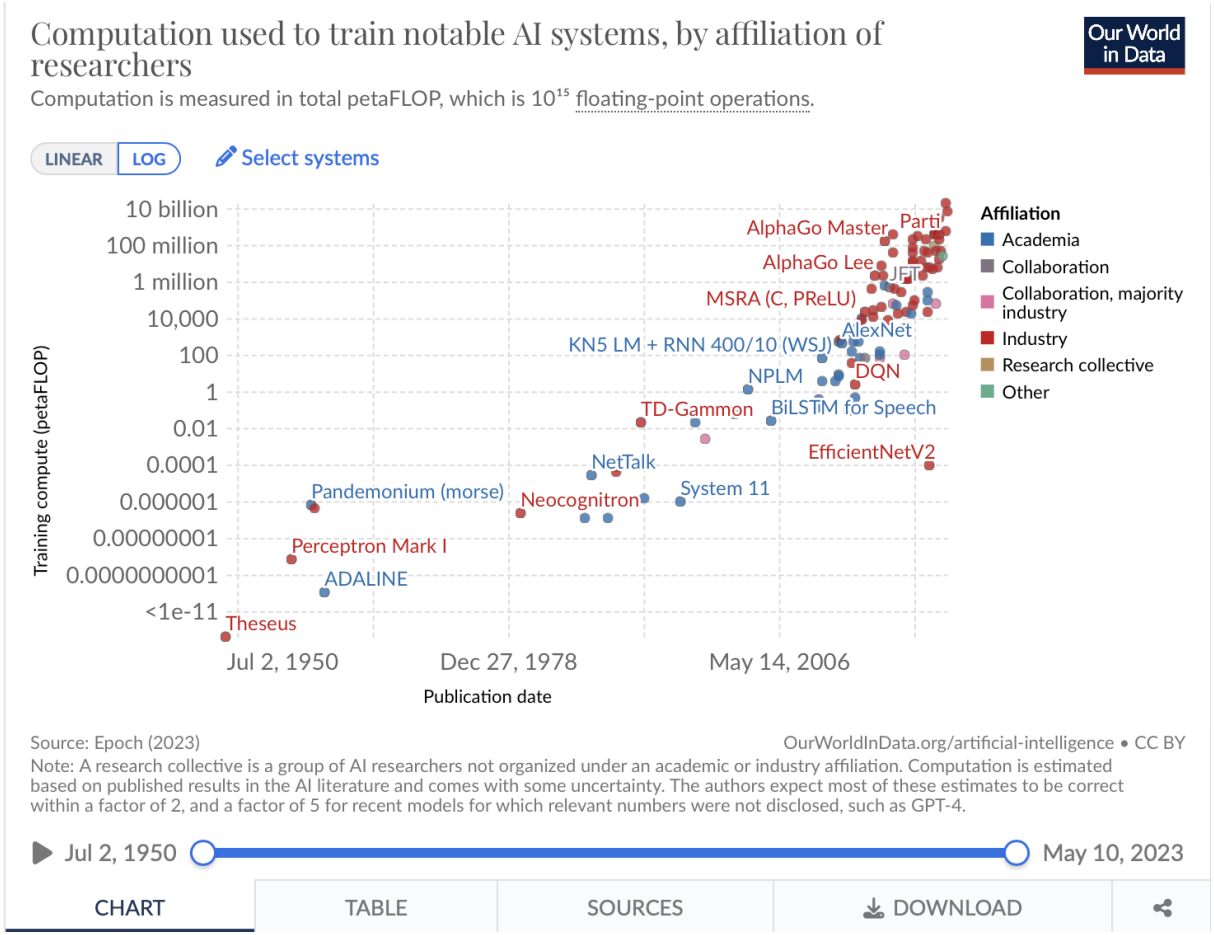
Notes:

1. Excludes impact of new, as yet unknown jobs, to be created
2. Rough estimate based on analysis of SIC 1-digit sectors or SIC 2-digit sectors where available.

The Economist

The future of work. Are you ready?

#futureforces



This data corresponds to the "Organization Categorization" and "Domain" columns in the primary sou data spreadsheet.

The authors selected the AI systems for inclusion based on the following necessary criteria:
— Have an explicit learning component
— Showcase experimental results
— Advance the state of the art

In addition, the systems had to meet at least one of the following notability criteria:
— Paper has more than 1000 citations
— Historical importance
— Important state-of-the-art advance
— Deployed in a notable context

The authors note that: "For new models (from 2020 onward) it is harder to assess these criteria, so w back to a subjective selection. We refer to models meeting our selection criteria as 'milestone models In cases where the model name was unavailable, OWID uses the institution name that published the for identification.

RESEARCHER AFFILIATION

Variable time span	547-27392
Data published by	Epoch, Parameter, Compute and Data Trends in Machine Learning.

Published online at epochai.org. Retrieved from: https://epochai.org/mlinputs/visualization

Link	https://epochai.org/mlinputs/visualization
Retrieved	2023-06-21

The affiliation of the research team building a particular notable AI system was classified according to following:
— Academia: 100% of researchers affiliated with academia
— Collaboration, Academia-majority: 71–99% affiliated with academia
— Collaboration: 30–70% affiliated with academia
— Collaboration, Industry-majority: 71–99% affiliated with industry
— Industry: 100% of researchers affiliated with industry

This data corresponds to the "Organization Categorization" and "Domain" columns in the primary sou data spreadsheet.

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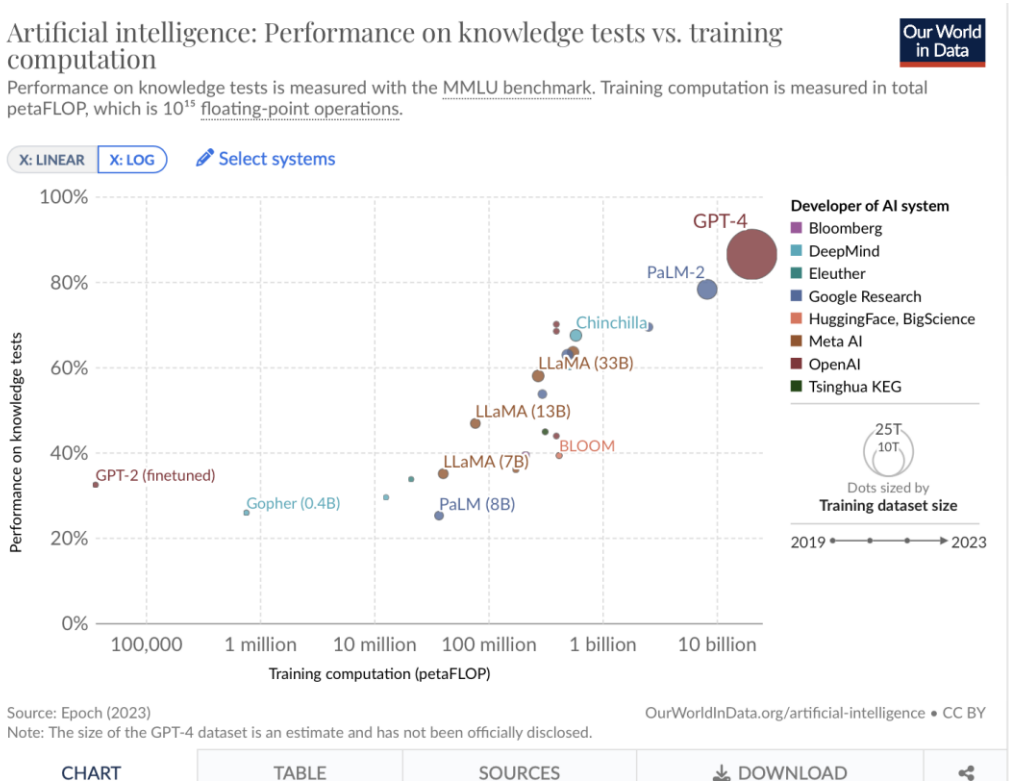


Sources

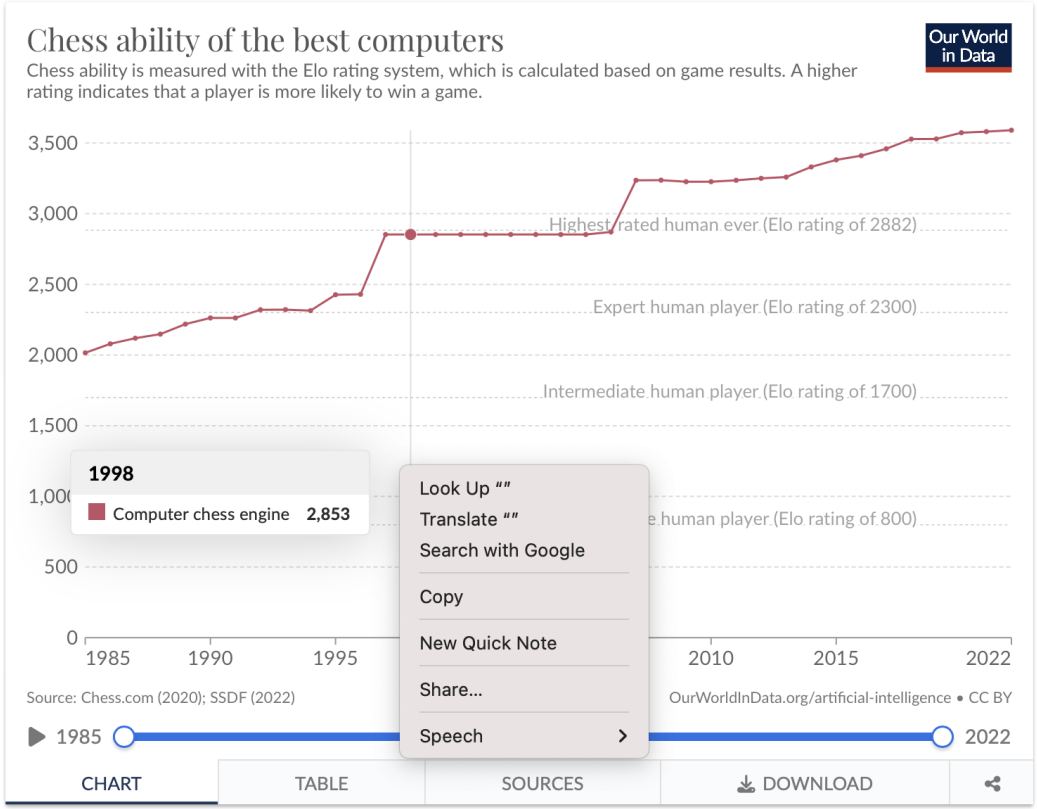
MMLU AVG
Variable description The MMLU benchmark covers a wide range of 57 subjects, including STEM, humanities, social sciences, and more. It encompasses subjects of varying difficulty levels, spanning from elementary concepts to advanced professional topics. This comprehensive benchmark assesses not only world knowledge but also problem-solving abilities.
Variable time span 2019-2023
Data published by David Owen (2023), Extrapolating performance in language modeling benchmarks. Published online at epochai.org. Retrieved from: 'https://epochai.org/blog/extrapolating-performance-in-language-modelling-benchmarks' [online resource]
Link https://docs.google.com/spreadsheets/d/1HSGbUVwGy3XLuChH_H16Keux2jmVfKT9rfDrC3uu-SQ/edit?usp=sharing
Retrieved 2023-07-12

Epoch dataset on how performance on a MMLU language benchmark scales with computational resources.

TRAINING COMPUTE (PETAFLOP)
Variable description Training computation, often measured in total FLOP (floating-point operations), refers to the total number of computer operations used to train an AI system. One FLOP is equivalent to one addition, subtraction, multiplication, or division of two decimal numbers, and one petaFLOP equals one quadrillion (10^15) FLOP.

The AI systems shown here were built using machine learning and deep learning methods. These involve complex mathematical calculations that require significant computational resources. Training these systems generally involves feeding large amounts of data through various layers and nodes and adjusting internal system parameters over numerous iterations to optimize the system's performance.

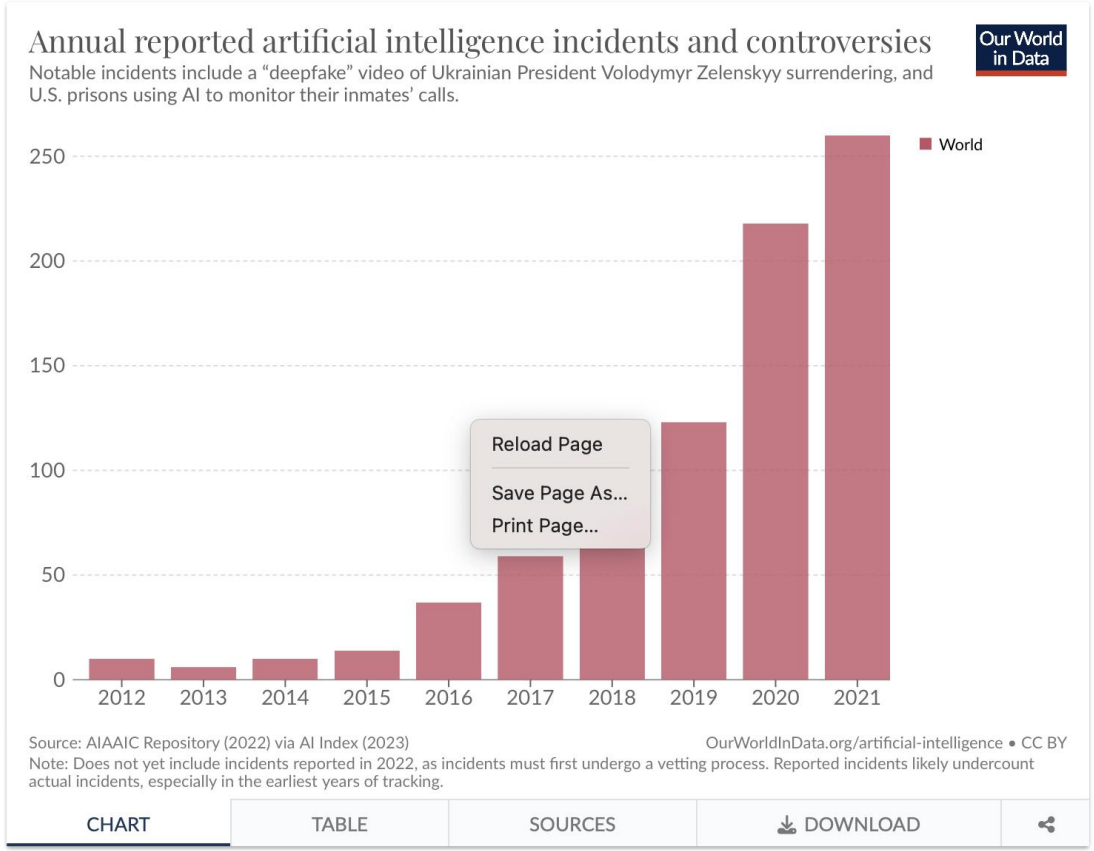
https://ourworldindata.org/artificial-intelligence



ELO_RATING
Variable time span 1985 – 2022
Data published by Chess.com (2020); SSDF (2022)
Link https://twitter.com/chesscom/status/1263457516605845505; https://ssdf.bosjo.net/list.htm
Retrieved 2023-02-01
The data for 1985–2019 comes from Chess.com, as detailed in this thread on Twitter. The primary data source is the Swedish Computer Chess Association (SSDF).

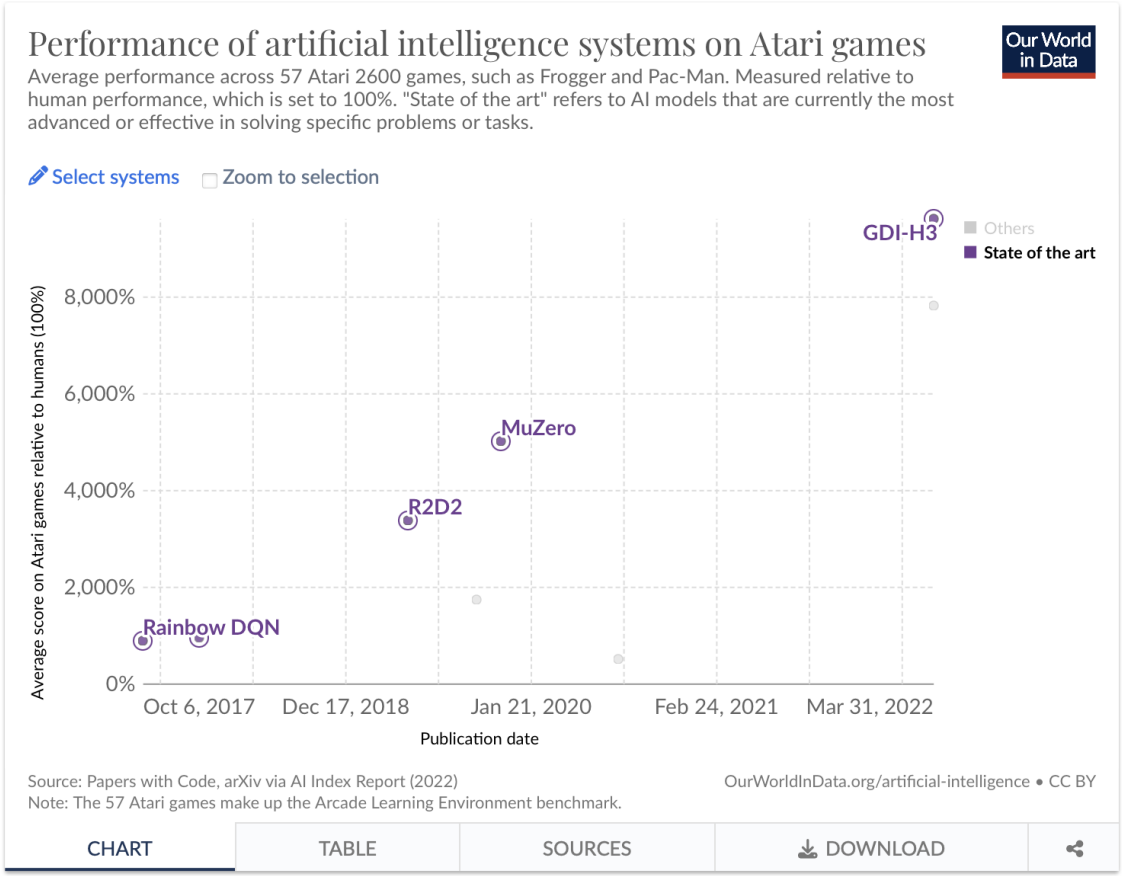
We manually extracted the data by watching the video, such that the chess engine with t highest ELO rating in a given year became our datapoint for that year. We were unable to the data in any other format.

The data after 2019 comes from SSDF:
- 2020 datapoint
- 2021 datapoint
- 2022 datapoint



NUMBER OF AI INCIDENTS AND CONTROVERSIES
Variable time span 2012-2021
Data published by AIAAIC Repository (2022) via 2023 AI Index Reportvia the AI Index 2023 Annual Report, AI Index Steering Committee, Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2023
Link
https://drive.google.com/drive/folders/1ma9WZJzKreS8f2It1rMy_KkkbX6XwDOK
Retrieved 2023-06-27
The AI, Algorithmic, and Automation Incidents and Controversies (AIAAIC) Repository is an independent, open, and public dataset of recent incidents and controversies driven by or relating to AI, algorithms, and automation. It was launched in 2019 as a private project to better understand some of the reputational risks of artificial intelligence and has evolved into a comprehensive initiative that tracks the ethical issues associated with AI technology. This dataset does not include AI incidents reported in 2022 yet, as the incidents submitted to the AIAAIC database undergo a lengthy vetting process before they are fully added.

The AI Index is an independent initiative at the Stanford University Institute for Human-Centered Artificial Intelligence. The mission of the AI Index is "to provide unbiased, rigorously vetted, and globally sourced data for policymakers, researchers, executives, journalists, and the general public to develop intuitions about the complex field of AI." Their flagship output is the annual AI Index Report, which has been published since 2017.



Sources

AVERAGE SCORE ON ATARI GAMES RELATIVE TO HUMANS (100%)
Variable description Average performance across 57 Atari 2600 games, such as Frogger and Pac-Man. Measured relative to human performance.
Variable time span -452-1253
Data published by Papers With Code
Link https://paperswithcode.com/
Retrieved 2023-06-14
The goal of Papers With Code website is to compile a comprehensive collection of ML papers, code implementations, datasets, methods, and evaluation tables, all made freely available.

The comparisons to human performance are very approximate and based on small samples of people — they are only meant to give a rough comparison. You can read more details in the papers that describe the benchmarks:

-Hendrycks et al (2021) Measuring Massive Multitask Language Understanding (MMLU) (page 3): https://arxiv.org/pdf/2009.03300.pdf

-Hendrycks et al (2021) Measuring Mathematical Problem Solving With the MATH Dataset (page 5): https://arxiv.org/pdf/2103.03874v2.pdf

AVERAGE SCORE ON ATARI GAMES RELATIVE TO HUMANS - STATE OF THE ART COLOR CODE
Variable time span -2222-1612
Data published by Papers With Code
Link https://paperswithcode.com/
Retrieved 2023-06-14
The goal of Papers With Code website is to compile a comprehensive collection of ML papers, code implementations, datasets, methods, and evaluation tables, all made freely available.

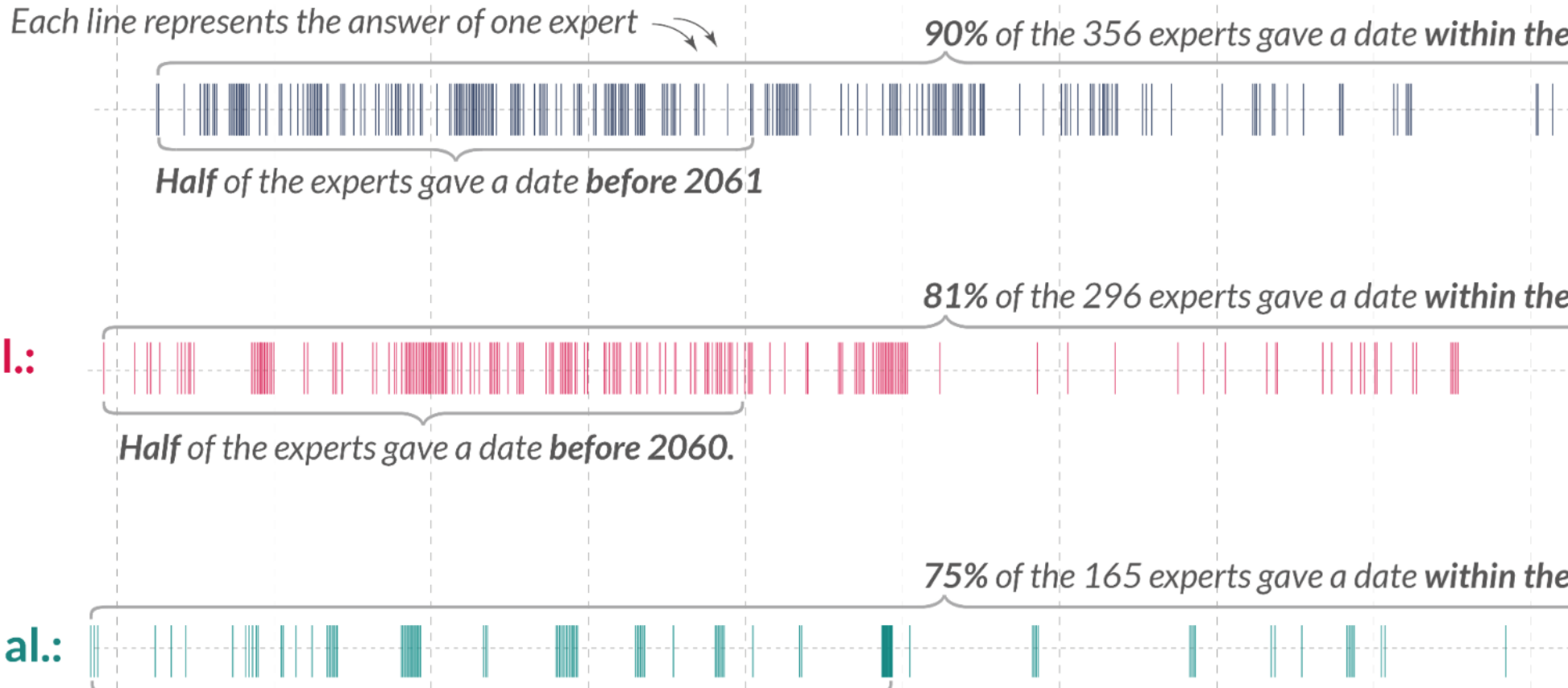
The comparisons to human performance are very approximate and based on small samples of people — they are only meant to give a rough comparison. You can read more details in the papers that describe the benchmarks:

-Hendrycks et al (2021) Measuring Massive Multitask Language Understanding (MMLU) (page 3): https://arxiv.org/pdf/2009.03300.pdf

-Hendrycks et al (2021) Measuring Mathematical Problem Solving With the MATH Dataset (page 5): https://arxiv.org/pdf/2103.03874v2.pdf

50% chance that Human-level Artificial Intellig

e studies between 2018 and 2022.



22 by Katja Grace et al.:
s will be able to accomplish
workers.

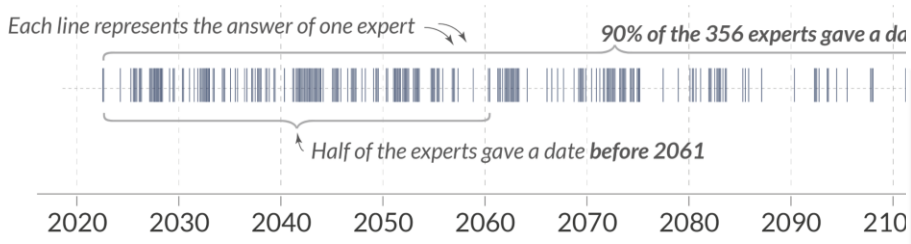
19 by Baobao Zhang et al.:
ectively be able to perform
y relevant better than the

18 by Gruetzemacher et al.:

When will there be a 50% chance that Human-level Artificial Intelligence exists?

Our World in Data

Timelines of **356 AI experts**, surveyed **in 2022** by Katja Grace and colleagues.
The experts were asked when unaided machines will be able to accomplish every task better and more cheaply than human workers.



Data from Zach Stein-Perlman, Benjamin Weinstein-Raun, Katja Grace – 2022 Expert Survey on Progress in AI.

AI timelines: What do experts in artificial intelligence expect for the future?

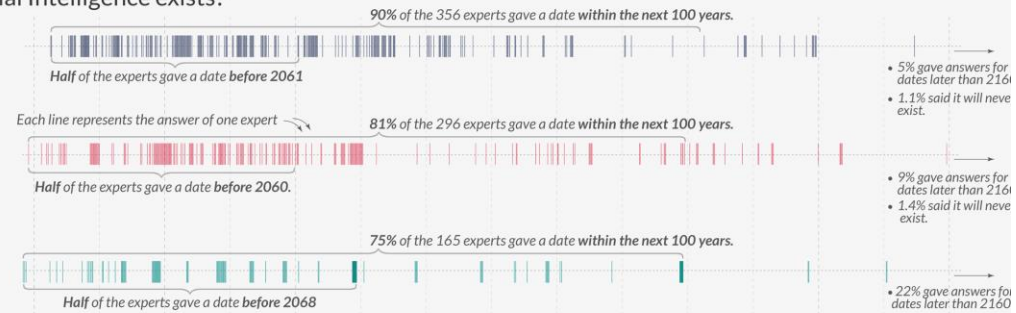
Our World in Data

When will there be a 50% chance that Human-level Artificial Intelligence exists?

1) Timelines of **356 AI experts**, surveyed **in 2022** by **Katja Grace et al.**:
The experts were asked when unaided machines will be able to accomplish every task better and more cheaply than human workers.

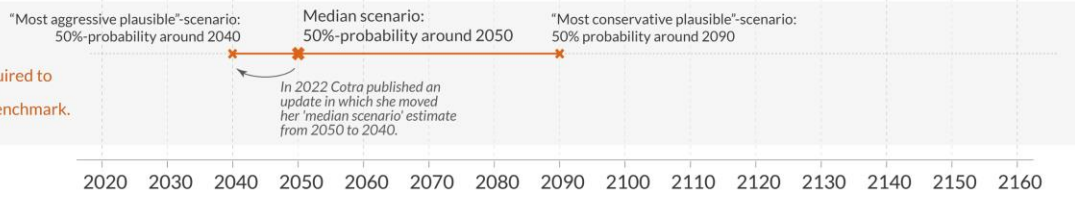
2) Timelines of **296 AI experts**, surveyed **in 2019** by **Baobao Zhang et al.**:
The experts were asked when machines will collectively be able to perform more than 90% of all tasks that are economically relevant better than the median human paid to do that task.

3) Timelines of **165 AI experts**, surveyed **in 2018** by **Gruetzemacher et al.**:
The experts were asked when AI systems will collectively be able to accomplish 99% of tasks that humans are paid to do at or above the level of a typical human.



When will the first 'Artificial General Intelligence'-system be devised, tested, and publicly announced?
Community prediction of 315 forecasters on **Metaculus.com**, as of Oct. 27, 2022:
The forecasters on this open forecasting platform are asked when the first general AI system — a single, unified software system — will be "devised, tested, and publicly announced".
The system must possess certain capabilities, such as "general robotic capabilities" and "high competency at diverse fields of expertise."

Ajeya Cotra's timeline for 'Transformative AI'
In her research Ajeya Cotra estimated the computation that would be required to train a human-level AI-system using existing architecture and algorithms.
The estimates of the required computation rely on the human brain as a benchmark.



Full details on all studies and the questions that the AI experts were asked can be found in the text at OurWorldInData.org/AI-timelines.

OurWorldinData.org – Research and data to make progress against the world's largest problems.