Getting clarity by defining Artificial Intelligence — A survey

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Motivation

- ➔ *"It is very hard to define what intelligence is."* (Kambhampati, 2017)
- ➔ There is a lack of a coherent identity and goal for AI (Nilsson, 2010)
- ➔ Smale's problem number 18, *The Limits of Intelligence* — intelligence remains unsolved. There is still a need for *"a broader study [....], one which involves deeper models of the brain, and of the computer, in a search of what artificial and human intelligence have in common, and how they differ"* (Smale, 1998).
- ➔ Creating an agreed upon message on the goal and definition of AI is far from obvious or straightforward.
- ➔ Our work: partial results, research survey **Defining (machine) Intelligence** [So far the **first 400 responses**, the survey is still accepting responses! https://goo.gl/hMjaE1]
- ➔ Aim: to gather opinions, from a cross sector of professionals, ultimately to help create a unified message on the goal and definition of AI

Kambhampati, S. (2017). On the Past and Future of AI. Interviews with Experts in Artificial Intelligence, Iridescent. Retrieved from https://goo.gl/nspv6y.
Nilsson, N. J. (2010). The Quest for Artificial Intelligence. A History of Ideas and Achievements. Cambridge University Press.
Smale, S. (March 1998). Mathematical problems for the next century. The Mathematical Intelligencer, 20(2):7–15.

Survey stats. Preliminary results

- ➔ **400+** fully completed responses by September 10th, 2017
  - ◆ Respondents from **48 countries**
    - Top nationality: United States (35%), Germany (6.3%), France (5.8%), United Kingdom (5.5%), Italy (4.5%)
    - Top country of work: United States (37.5%), United Kingdom (9.3%), France (6%), Germany (4.5%), Canada (3.3%)
  - ◆ **131** different **institutions** (*N*=146, 36.5%)
    - Top: Microsoft, INRIA, Virginia Tech
- ➔ Branch, top three:
  - ◆ **Academia** (*N*=308, **77%**)
  - ◆ Industry (*N*=85, 21.3%)
  - ◆ NGO, Not-for-Profit (*N*=10, 2.5%)
- ➔ Role, top three:
  - ◆ **Researcher** (*N*=301, **75.3%**)
  - ◆ Educator (*N*=144, 36%)
  - ◆ Developer, Engineer (*N*=67, 16.8%)

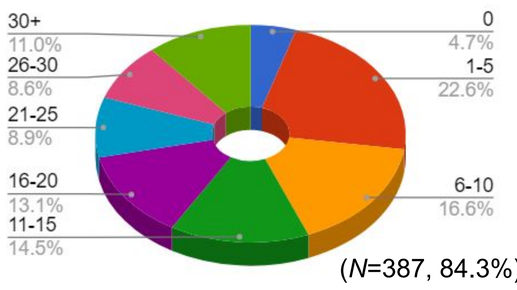
Work in Artificial Intelligence

Do you work or have worked in Artificial Intelligence?

"Yes"	(*N*=333, **83.2%**)
"No"	(*N*=52, 13%)
No answer	(*N*=15, 3.8%)

(*N*=400)

Years of experience in AI

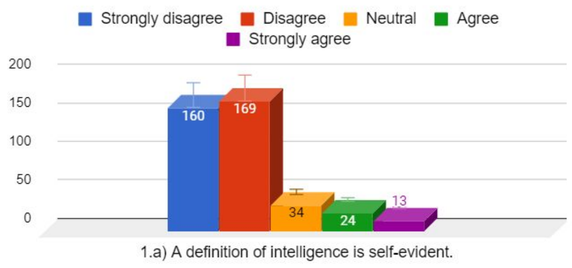


(*N*=387, 84.3%)

Consensus on defining the goal of AI

Questions adapted from (De Boeck, 2013). **De Boeck**, P. (2013). Intelligence, Where to Look, Where to Go? J. Intell. 1:5-24.

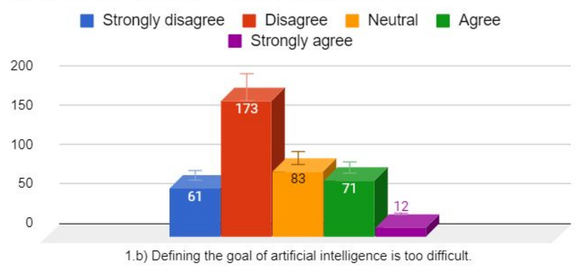
Level of consensus with the statement 1.a.



1.a) A definition of intelligence is self-evident.

D&SD: **82.3%** N: 8.5% A&SA: 9.3%

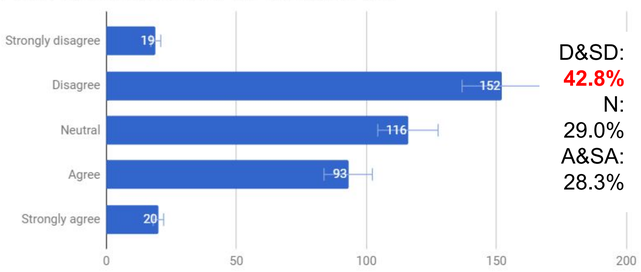
Level of consensus with the statement 1.b.



1.b) Defining the goal of artificial intelligence is too difficult.

D&SD: **58.5%** N: 20.8% A&SA: 20.8%

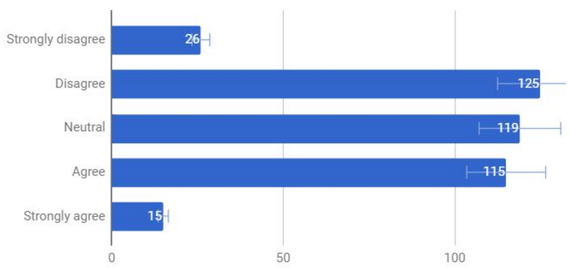
Level of consensus with the statement 1.c.



1.c) There are differences in opinion concerning a definition of artificial intelligence that are too large to bridge.

D&SD: **42.8%** N: 29.0% A&SA: 28.3%

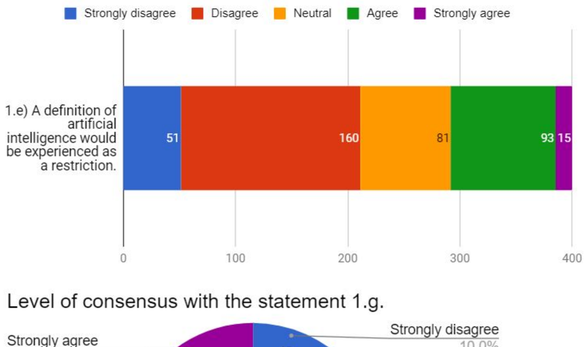
Level of consensus with the statement 1.d.



1.d) There is an implicit or even explicit belief that a definition of artificial intelligence does not pay off.

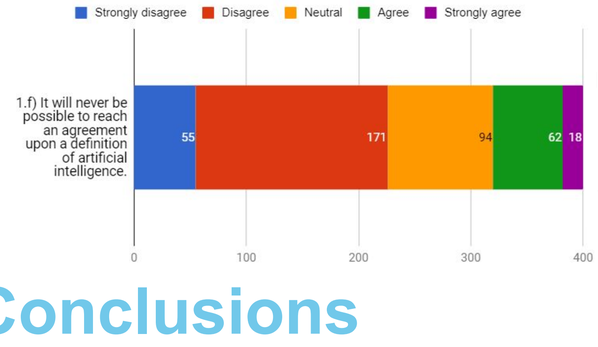
D&SD: **37.8%** N: 29.8% A&SA: 32.5%

Level of consensus with the statement 1.e.



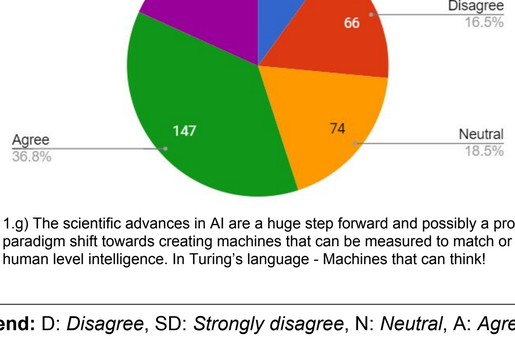
D&SD: **52.8%** N: 20.3% A&SA: 27.0%

Level of consensus with the statement 1.f.



D&SD: **56.5%** N: 23.5% A&SA: 20.0%

Level of consensus with the statement 1.g.



1.g) The scientific advances in AI are a huge step forward and possibly a promising paradigm shift towards creating machines that can be measured to match or exceed human level intelligence. In Turing's language - Machines that can think!

D&SD: 26.5% N: 18.5% A&SA: **55.0%**

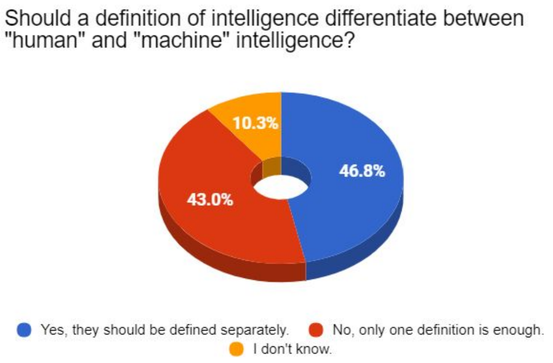
Legend: D: *Disagree*, SD: *Strongly disagree*, N: *Neutral*, A: *Agree*, SA: *Strongly agree*.

Definitions of human and machine intelligence

Level of consensus regarding separate definitions of human and machine intelligence

Many respondents (*N*=187, **46.8%**) expressed agreement or strong agreement concerning the need for having separate definitions of human and machine intelligence, although a slightly equal number (*N*=172, 43%) indicated that only one definition is enough.

Should a definition of intelligence differentiate between "human" and "machine" intelligence?



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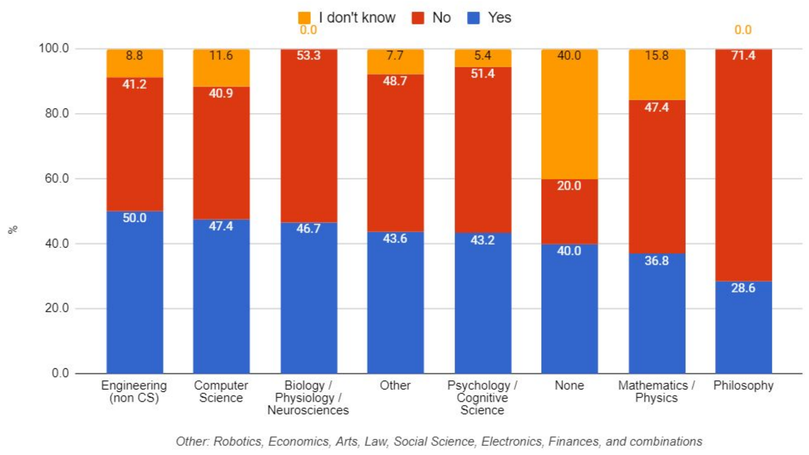


Other: Robotics, Economics, Arts, Law, Social Science, Electronics, Finances, and combinations

(known) Definitions of machine intelligence

(Bostrom, 2014; Goertzel, 2010; Laird et al., 2009; Legg & Hutter, 2007; Lewis & Monett, 2017; Nilsson, 2010; Russell & Norvig, 2010; Wang, 2008; Winston, 1992)

Most accepted definition:

"The essence of intelligence is the principle of adapting to the environment while working with insufficient knowledge and resources. Accordingly, an intelligent system should rely on finite processing capacity, work in real time, open to unexpected tasks, and learn from experience. This working definition interprets "intelligence" as a form of "relative rationality." **(Wang, 2008)**

D&SD: 20.5%
Neutral: 23.5%
A&SA: **56.0%**
Mdn: "Agree"
Mo: "Agree"

(known) Definitions of human intelligence

(Anastasi, 1986; Bigge, 1976; Deary, Penke, & Johnson, 2010; Fontana, 1988; Gottfredson, 1997; Humphreys, 1984; Stanovich, 2014; Sternberg, 1986; Wechsler, 1939)

Most accepted definition:

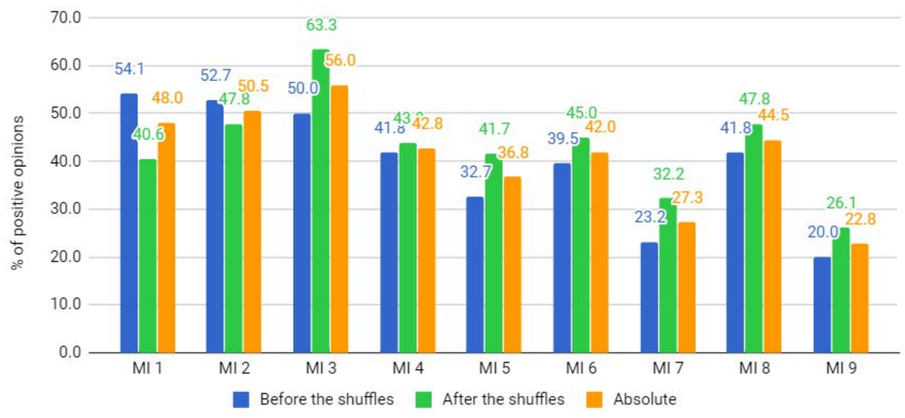
"Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather it reflects a broader and deeper capability for comprehending our surroundings — "catching on," "making sense" of things, or "figuring out" what to do." **(Gottfredson, 1997)**

D&SD: 16.7%
Neutral: 21.8%
A&SA: **61.5%**
Mdn: "Agree"
Mo: "Agree"

Cognitive bias: Anchoring effect?

The percentages of positive opinions decrease — Strong dependence on the position of the definition.

- ➔ Cognitive bias? It seems respondents tend to rely heavily on the first definitions (the "**anchors**") that are presented. 7 out of 9 MI definitions benefit from random positioning. HI defs: same behaviour.



Rankings in the level of consensus with the definitions of machine intelligence (*N*=400)

Participants' suggested definitions

- ➔ **Definitions**, related opinions, and feedback:
  - ◆ **213** (53.3%) suggested definitions of or opinions on machine intelligence
  - ◆ **142** (35.5%) suggested definitions of or opinions on human intelligence
  - ◆ **99** (24.8%) **feedback** comments and/or **literature suggestions**
  - ◆ **222** (55.5%) email addresses provided: **follow up** and **inclusion** of definitions

> *"Intelligence is the art of rapid and reliable gist-finding, crux-spotting, bull's-eye hitting, nub-striking, essence-pinpointing. It is the art of, when one is facing a new situation, swiftly and surely homing in on an insightful precedent (or family of precedents) stored in the recesses of one's memory. That, no more and no less, is what it means to isolate the crux of a new situation. And this is nothing but the ability to find close analogues, which is to say, the ability to come up with strong and useful analogies."*
> —**Douglas Hofstadter**, Indiana University.

> *"Intelligence is the ability to do the right thing at the right time given a dynamic environment (that is, a shifting landscape of "right times" requiring more "right things"). AI is intelligence constructed deliberately as an artefact of a culture."*
> —**Jürgen Schmidhuber**, Swiss AI Lab, IDSIA, NNAISENSE.

Conclusions

- ➔ Significant volume of responses from around the world.
- ➔ High level comments and recommendations concerning definitions of MI and HI.
- ➔ Highly polarized: one vs. separate definitions of MI and HI.
- ➔ Work in progress: concept analysis suggested defs, catalog of factors contributing to intelligence, methodology for and best practices to be applied when defining (machine) intelligence
- ➔ We hope we can help to spread a stronger, more coherent message, to the mainstream media, policymakers, investors, and the general public to help dispel myths about AI.

References

(See attached sheets)