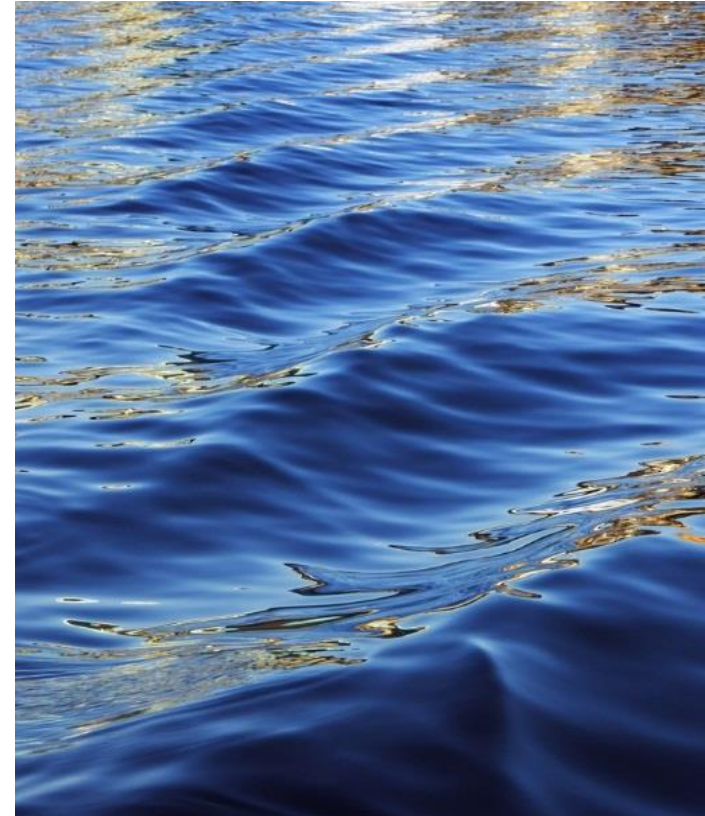


Technological Innovations

improving evaluations
and implementations



Contents

- Multiple limitations of innovation hype
- Three steps to improving innovation evaluation and management
 1. Reframing innovations for balance and specificity: The Innovation Big Picture
 2. Analysing innovations for successful implementation: Critical realism
 3. Measuring innovations for successful implementation: Rigorous metrics
- Some references



Limitations of hype



Limitations of hype - overview

Nobel Prize winning research shows that human choices are remarkably susceptible to the manner in which options are presented (e.g. Kahneman and Tversky, 1979).

Framing promotes a particular perspective about a topic by highlighting some aspects of that topic, while underplaying or excluding other aspects.

Research findings indicate that framing bias can lead to suboptimal decisions not just at the outset of, but also throughout, projects (e.g. Mähring and Keil, 2008).

Limitations of hype - overview

- Hype framing promotes positive perspectives, while underplaying importance of enabling factors and excluding negative aspects: e.g.

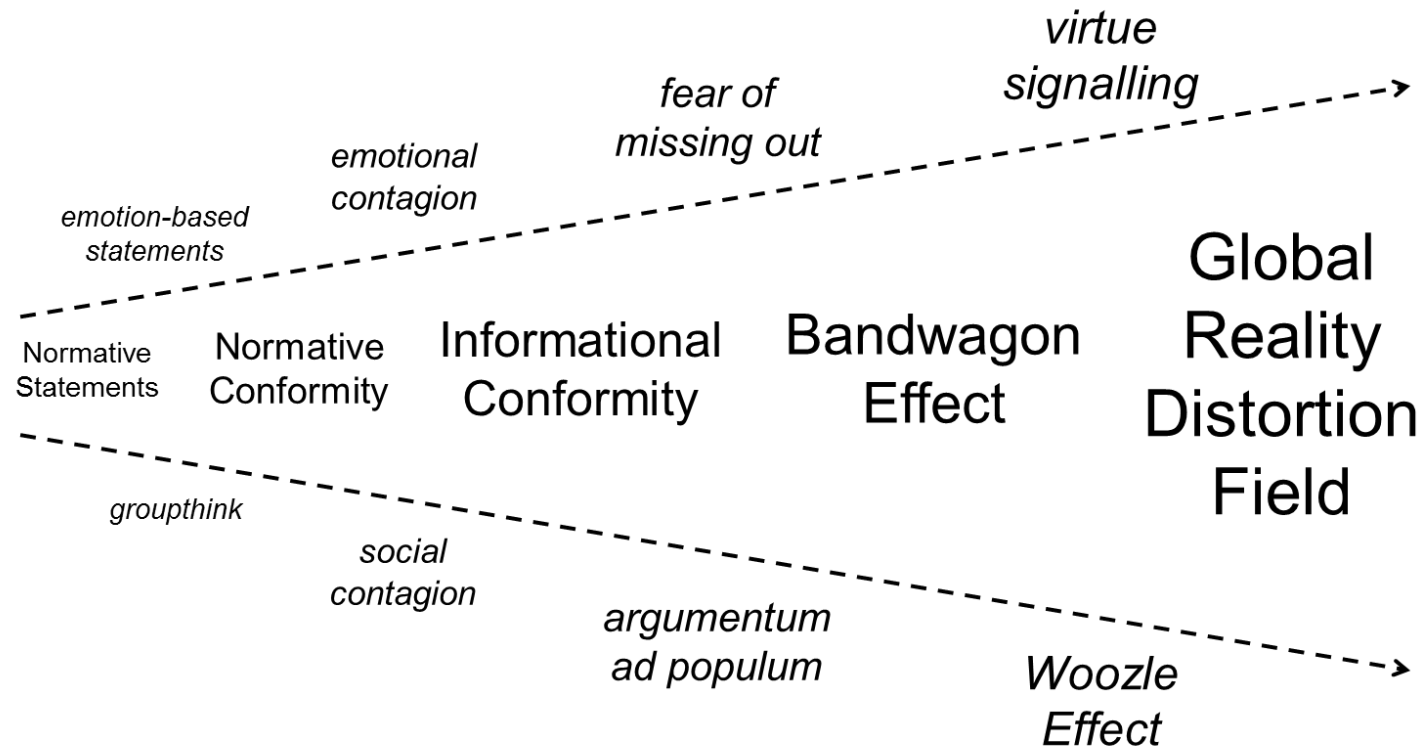
“AR (Augmented Reality) likely to alter industries”

“Big Data is next frontier for innovation, competition, and productivity”

“BIMs can revolutionize building design and construction”

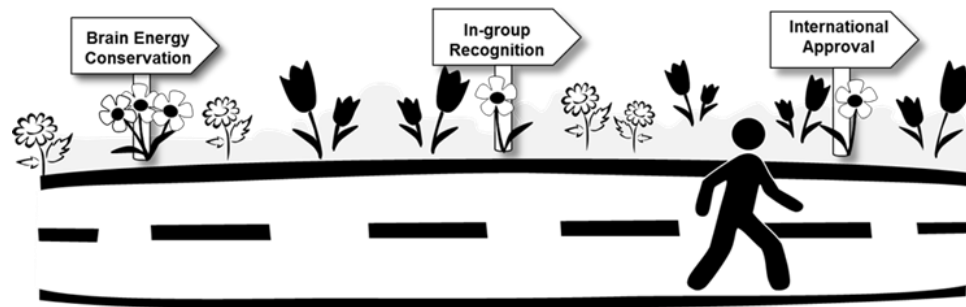
Limitations of hype - overview

Even though there may be little or no objective evidence to support hype claims, hype can spread rapidly throughout the world (Fox, 2018)

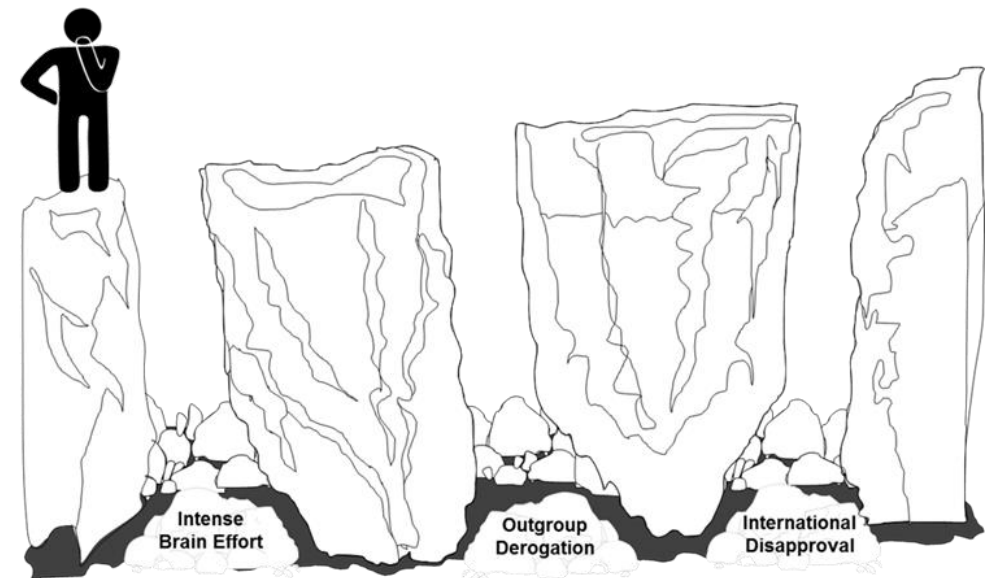


Limitations of hype - overview

Even though there may be little or no objective evidence to support hype claims, hype is easy to go along with because doing so can involve minimal mental effort. Also, participating in hype can bring ingroup recognition, and international approval (Fox, 2018).



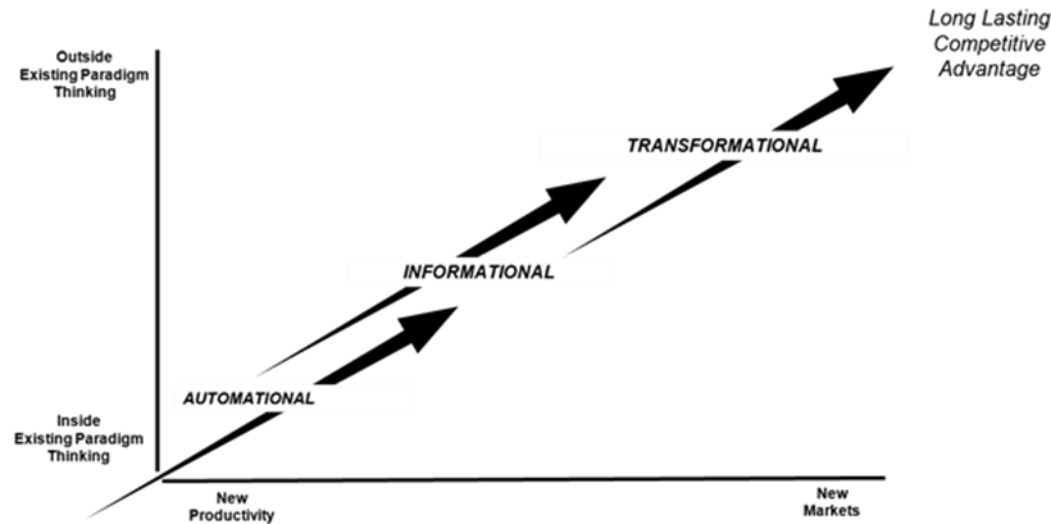
Hype Path



Independent Path

Limitations of hype – too positive

Even though there may be little or no objective evidence to support hype claims, hype can spread rapidly throughout the world. No innovation on its own can guarantee business success or even less ambitious goals such as improved decision-making and higher productivity. Rather such positive effects are much dependent upon human capabilities, such as creative thinking (Fox 2016).

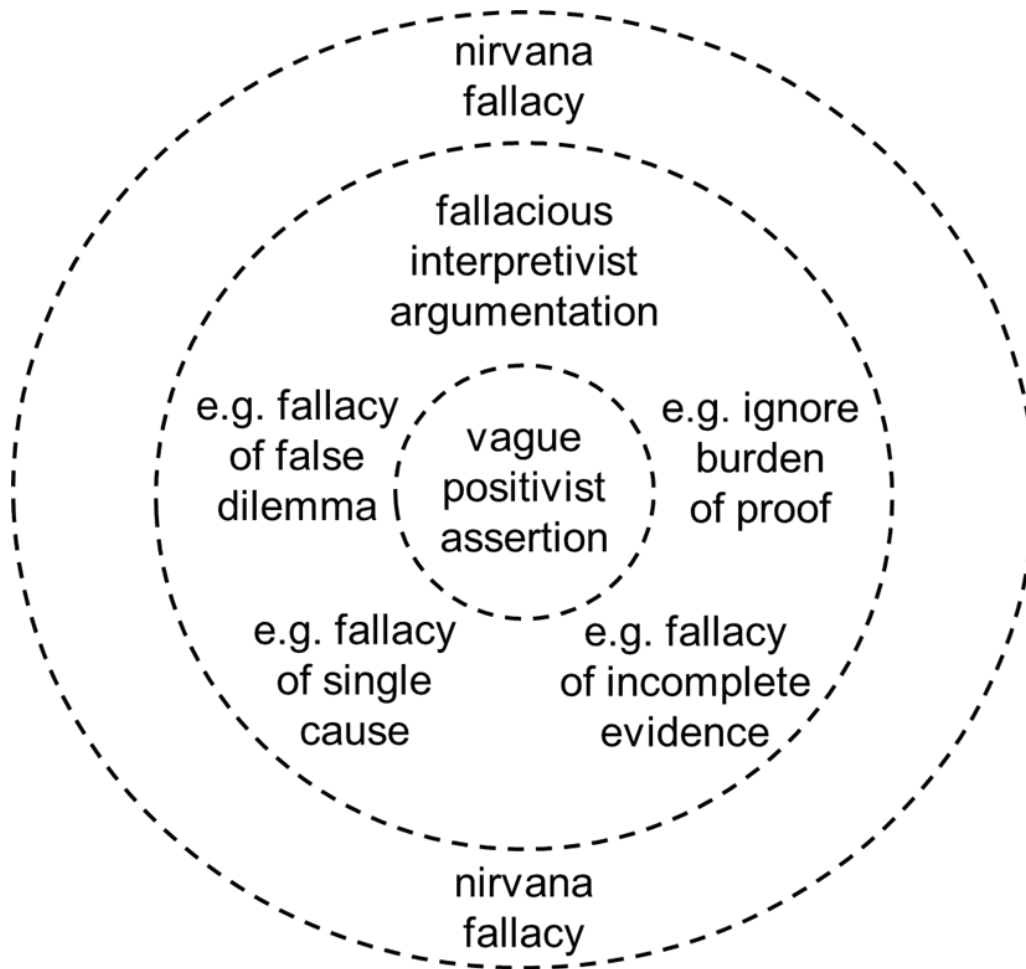


Limitations of hype – too positive

Entirely positive perspectives are not realistic, because all innovations have potential for negative unintended consequences. As illustrated in the Table below, negative consequences can become increasingly far reaching and difficult to control (Fox, 2008; 2012a; Fox et al. 2020a).

Transport Innovation	Disbenefit	Negative consequences
Horse carriage	Tons of horse dung	Public health dangers
Automobile	Exhaust emissions	Contribution to climate change
MTBE	Local water contamination	Widespread ground contamination
Ethanol fuels	Diversion of agricultural resources	Global hikes in food prices

Limitations of hype – too vague

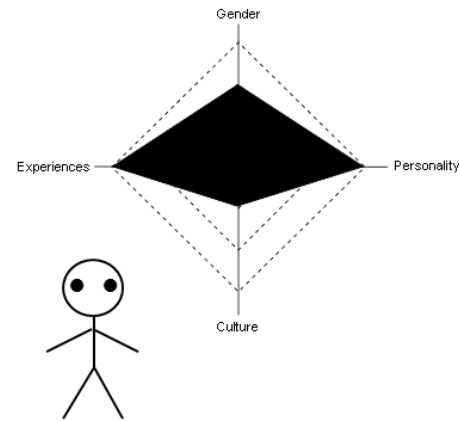


Rather than offering causal explanations, hype descriptions offer fallacious vague positivistic assertions that are supported by fallacious interpretivist argument predicated on the nirvana fallacy. This involves proponents of an innovation presenting their innovation option as having sweepingly positive effects (Fox, 2014).

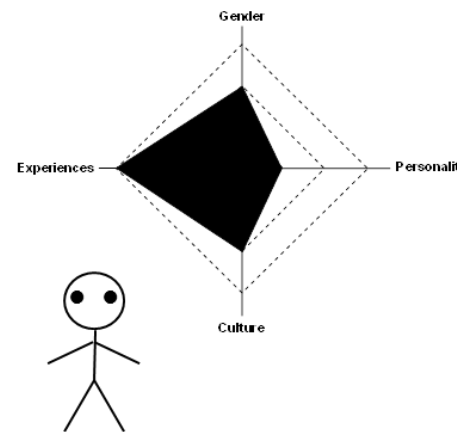
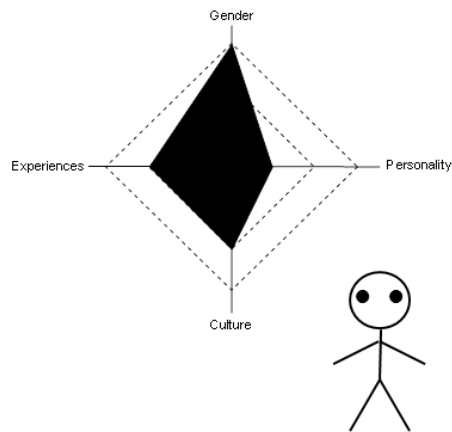
Limitations of hype – too vague

Lack of explanation about an innovation does not facilitate evaluation or implementation

This is because decisions and actions related to the innovation are then based on preconceptions arising from gender, culture, personality type, past experiences, etc., rather than based on understanding about the innovation (Fox, 2011)



An Innovation



Limitations of hype – Q & A

Q) What are the limitations of hype?

Limitations of hype – Q & A

Q) What are the limitations of hype?

A) Too positive

All innovations have potential for negative unintended consequences, and no innovation on its own can guarantee business success

A) Too vague

Offering fallacious assertions rather than causal explanations can lead to decisions and actions being based on preconceptions rather than on understanding of the innovation



Reframing Hype – The Innovation Big Picture

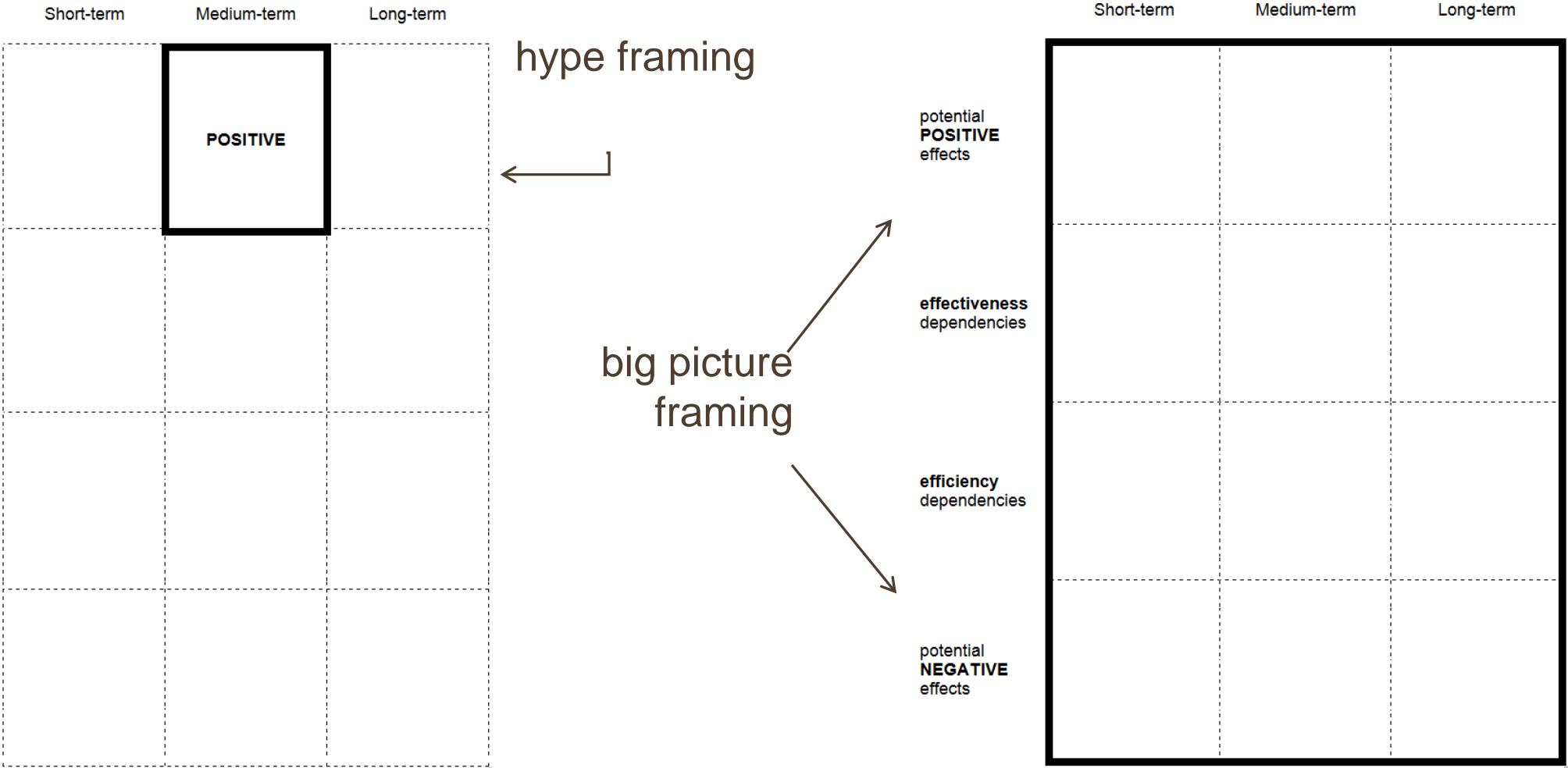


1) Reframing Hype – The Innovation Big Picture

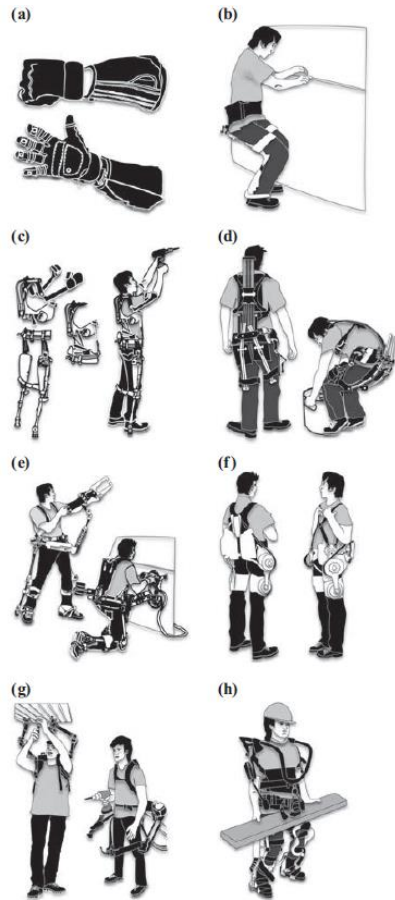
Research indicates that vague hype can be reframed by presenting specific balanced information in formats that have four characteristics, which can together reveal The Innovation Big Picture (Fox, 2013c).

- Presents divergent frames: e.g. positive and negative; short-, medium-, and long-term.
- Explains causation: e.g. how effects can be caused efficiently
- Balances sequence of information: e.g. simultaneous presentation of divergent frames.
- Presents information in formats that minimize cognitive effort e.g. tabular format.

1) Reframing Hype – The Innovation Big Picture



1) Reframing Hype – The Innovation Big Picture



Type of exoskeleton	Enhancement (potential positive effects)	Restriction (potential negative effects)
Power glove ^a	Reduces hand force needed by up to half	Generation of human hand force is generated by wider musculoskeletal systems, which can be strained by erratic loading to hand when glove is and is not worn
Chairless chair ^b	Support for intermittent sitting	Mismatches between the standard height of the chair and the varying height of work tasks leads to balance problems that introduce musculoskeletal tension
Lightweight modular ^c	Transfer workload to core musculature	Highly repetitive use causes friction at support points
Full body carbon fibre ^d	Reduce strain from lifting	Limits human three-dimensional rotational movements that are typically involved in lifting
Full body gravity balancing ^e	Supports the weight of heavy tools	Gravity-balancing arm may provide only two-dimensional support, but work may require three-dimensional movement
Lightweight powered ^f	Provides mechatronic support for handling loads	Limits human rotational movements that are typically involved in lifting
Powered additional limbs ^g	Provides immediately available extra support at work locations with limited access	Introduces multiple new and unpredictable loads to the musculoskeletal systems
Heavy-duty powered ^h	Increases human strength for carrying heavy loads	Greatly reduces the range of human movement

(Fox et al, 2020a)

1) Reframing Hype – The Innovation Big Picture

	Short-term	Medium-term	Long-term
potential POSITIVE effects	<i>single function automatic simplex messaging</i>	<i>single function automatic half-duplex messaging</i>	<i>multi-function automatic half-duplex messaging</i>
effectiveness dependencies	<i>enthusiasm of end-user to wear and charge smart clothing and smart phone</i>	<i>plus enthusiasm and ability of end-user to learn, remember and carry out operating procedures</i>	<i>plus enthusiasm and ability of end-user to learn and remember functionalities and messaging participants</i>
efficiency dependencies	<i>comprehensive reliable wireless connectivity ease of smart clothing charging smart phone interoperability</i>	<i>plus intuitively understandable smart clothing user interfaces</i>	<i>plus improved ratio of battery size to battery energy</i>
potential NEGATIVE effects	<i>wearing, washing, repair, recycling, disposal, of apparel becomes more hazardous</i>	<i>plus increased reliance on automatic messaging at expense of reduced person to people interactions</i>	<i>plus threat to privacy</i>

Potential effects, and the factors upon which they depend, can be presented together in simple template containing succinct statements. The example is of an application of the much hyped Internet of Things - smart clothing that can, for example, automatically send messages about wearers' conditions to medical centres via the Internet (Fox, 2013c).

1) Reframing Hype – Q & A

Hype framing

Hype framing promotes positive perspectives, while underplaying importance of enabling factors and excluding negative aspects: e.g., “AR likely to alter industries”.

What is Big Picture framing?

1) Reframing Hype – Q & A

Hype framing

Hype framing promotes positive perspectives, while underplaying importance of enabling factors and excluding negative aspects: e.g., “AR likely to alter industries”.

Big Picture framing

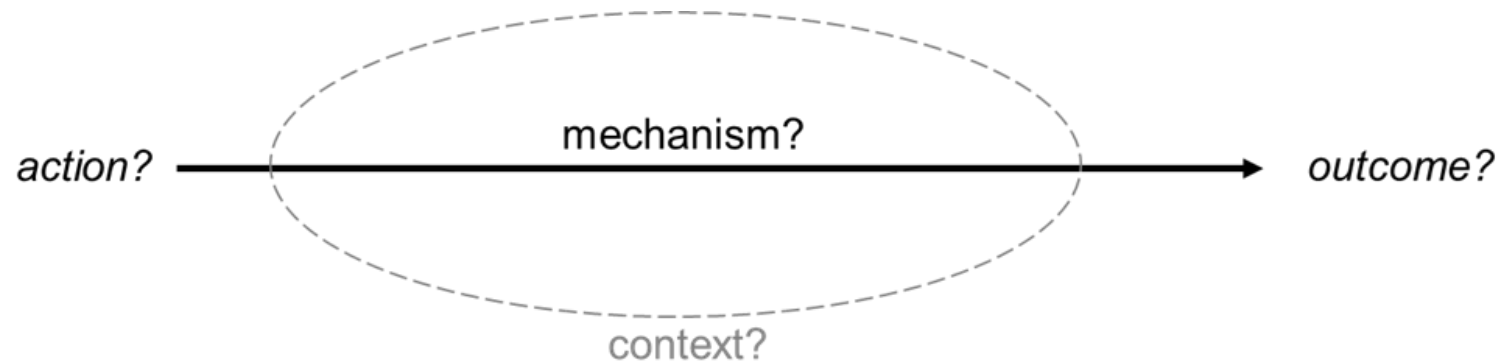
Simultaneous presentation of balanced specific information about potential positive effects, potential negative effects, and the factors upon which they depend. As summarized in the following slides, potential effects and their dependencies can be determined through application of critical realism.



Analyzing innovations for successful implementations

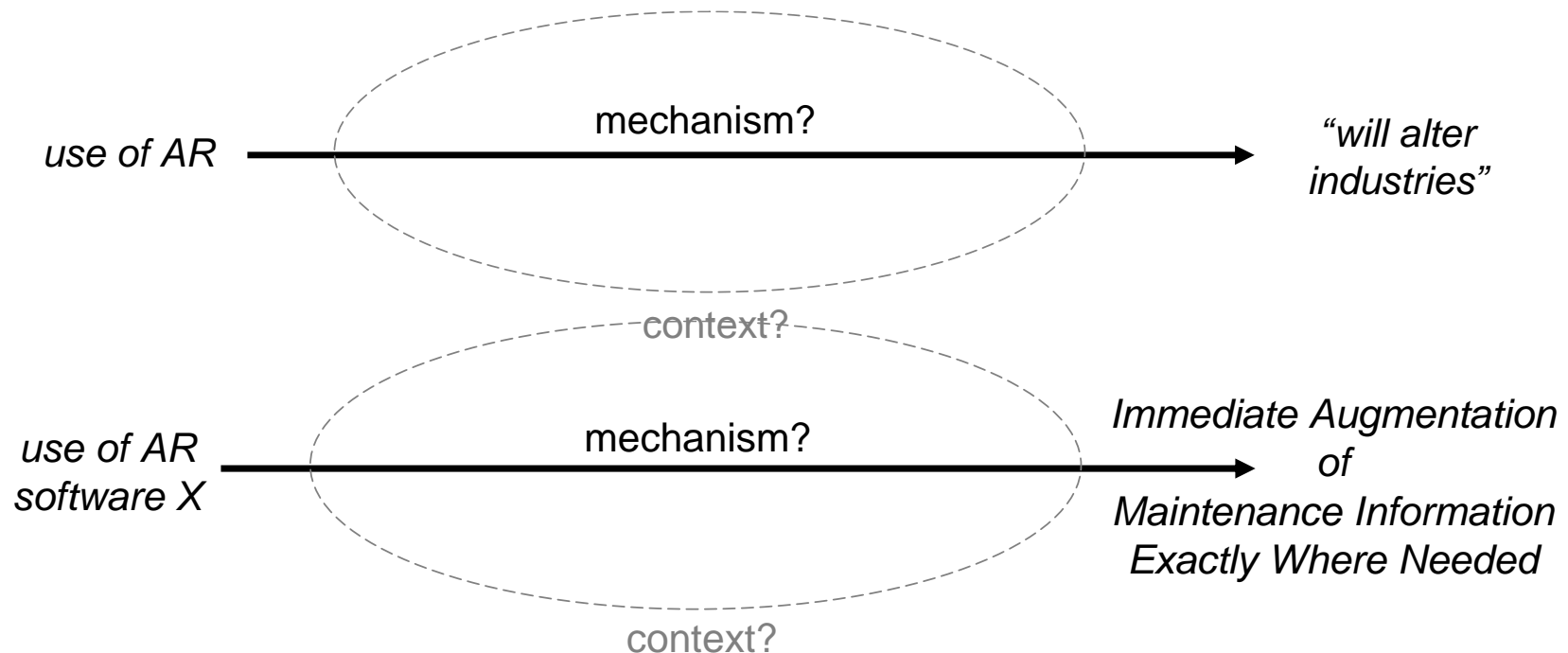
2) Analyzing innovations for successful implementations

Critical realism is a philosophy of science that has been developed during the past four decades as an alternative to positivism's search for universal laws of causation and interpretivism's dismissal of laws of causation in human endeavors. In particular, critical realist perspective is that generalizable causal mechanisms can exist, but can only bring about outcomes during human endeavors within appropriate contexts (Fox, 2012b; 2013a; 2013b).



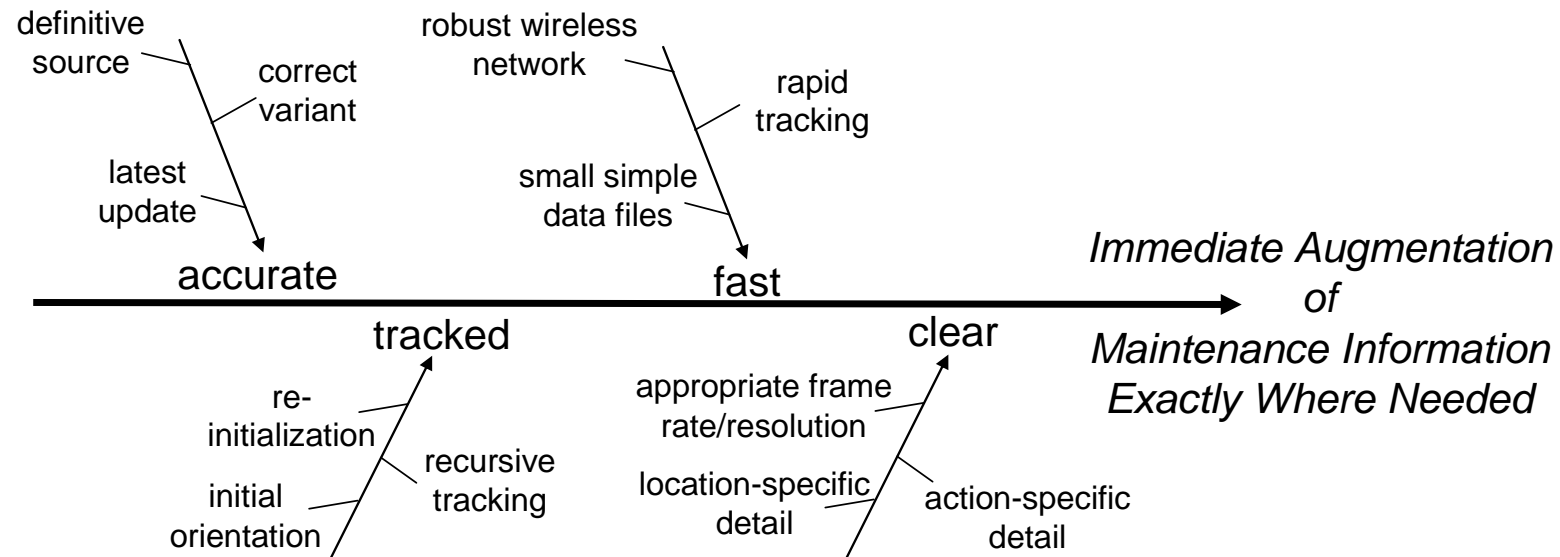
2) Analysis: from vague outcome to specific outcome

Critical realism can be applied to reframe hype by revealing the causal mechanism and causal context that can enable intended outcome.



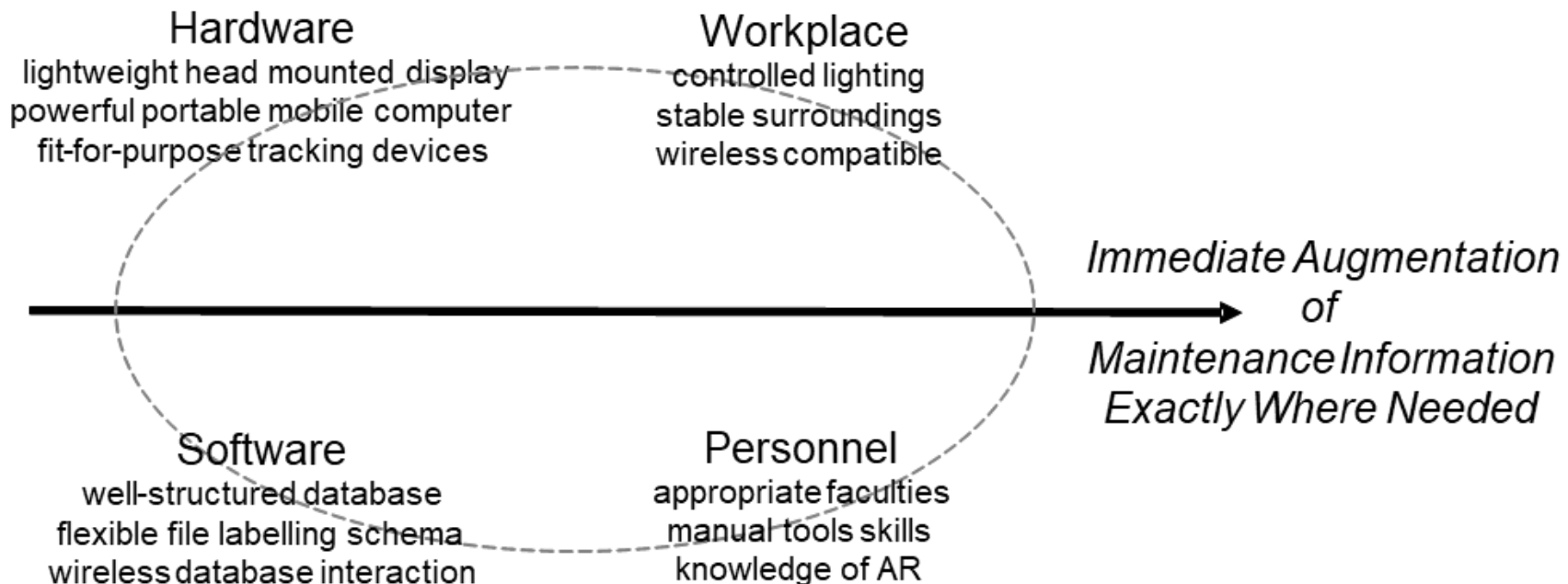
2) Analysis: from vague explanation to causal mechanism

Critical realism can be applied to reframe hype by revealing the causal mechanism of mediating variables that can enable intended outcome. Causal mechanism comprises many inter-related mediating variables. The absence or failure of just one of these mediating variables can prevent the intended outcome (Fox, 2010)



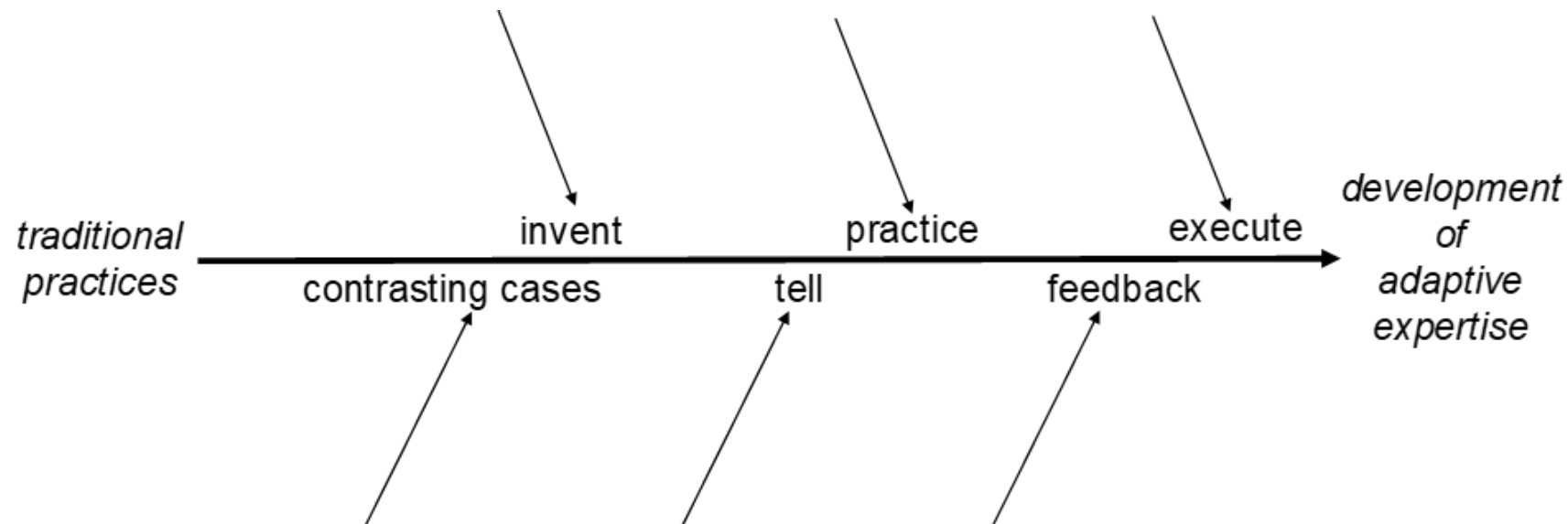
2) Analysis: from vague explanation to causal context

Critical realism can be applied to reframe hype by revealing the causal mechanism of moderating variables that can enable causal mechanism for intended outcome. The absence or failure of just one of these moderating variables could prevent the intended outcome



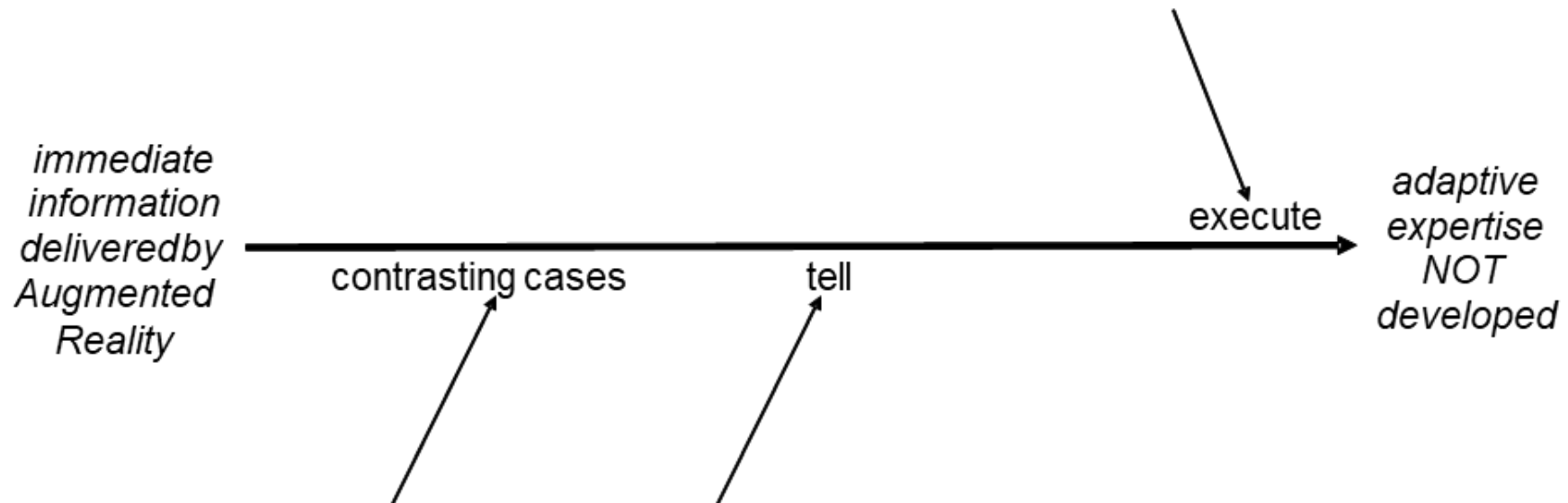
2) Analysis: from too positive to balanced perspective

Critical realism can be applied to reframe hype by revealing negative unintended outcomes. For example, all six mediating variables shown in the diagram below are needed for the development of human skills.



2) Analysis: from too positive to balanced perspective

Critical realism can be applied to reframe hype by revealing negative unintended outcomes. For example, three of the mediating variables needed for the development of human skills are eliminated if immediate information is delivered by AR.



2) Analysing innovations – Q & A

Hype framing

Hype framing promotes positive perspectives, while underplaying importance of enabling variables and excluding negative aspects: e.g “AR likely to alter industries”.

What is critical realist framing?

2) Analysing innovations – Q & A

Hype framing

Hype framing promotes positive perspectives, while underplaying importance of enabling variables and excluding negative aspects: e.g “AR likely to alter industries”.

Critical realist framing

AR has potential to bring about specific positive outcomes, such as immediate augmentation of maintenance information, provided multiple inter-related enabling variables are continually implemented. On the other hand, AR has potential to bring about negative unintended consequences, which can reduce competitiveness, such as limiting development of human expertise.

3) Quantifying innovations for successful implementation

Rigorous metrics, such as information-theoretic entropy metrics, can be applied to quantify performance. If information-theoretic entropy increases, the probability of completing tasks right-first-time decreases, the worst-case number of task attempts increases, and the number of task attempts on the average also increases. Thus, information-theoretic entropy can lead to statistical physics entropy, and thermodynamic entropy (Fox, 2022). As summarized in the table below, entropy can be applied to quantify the performance of existing options (Fox et al., 2018).

Type of Information Gain / Load Reduction	Example Knowledge Unit	Sources of Entropy	Entropy		
			Number of Different Ways of Carrying Out the Same Work	Entropy	
Extraneous	Work Instructions	Information	Conceptual	1	0.00
			Presentation	2	1.00
			Linguistic	1	0.00
			Target		1.00



Quantifying innovations for successful implementation

3) Quantifying innovations for successful implementation

Then, as summarized in the table below, information entropy can be applied to quantify the performance of innovations such as AR (Fox et al., 2018). Information-theoretical entropy of 3.58 bits brings the physical disorder of seven different ways of carrying out three task, which leads to the thermodynamic entropy of unproductive energy expenditure.

Type of Information Gain / Load Reduction	Example Knowledge Unit	Sources of Entropy	Entropy Number of Different Ways of Carrying Out the Same Work	Entropy	
Extraneous	Augmented Reality Work Instructions	Information	Conceptual	1	0.00
			Presentation	1	0.00
			Linguistic	1	0.00
		Communication	Task fit	3	1.58
			Place fit	2	1.00
			Person fit	2	1.00
			Target		3.58

3) Quantifying innovations for successful implementation

As summarized in the table below, information-theoretic entropy, physical statistics entropy, and thermodynamic entropy can involve interactions between people and innovations such as digital twins (Fox, 2022).

Situated entropy		Examples of relative potential for situated entropy		
		Aquaponics	Vertical farming	Urban allotments
Physical disorder	Automation	Low	High	Medium
	Human	Low	High	Medium
Information uncertainty	Automation	Low	Medium	High
	Human	Medium	High	Medium
Unproductive energy	Automation	Low	Low	Medium
	Human	Depends on agreement with digital twin and with people competing for water supply	Depends on extent of physical disorder at heights, on agreement with digital twin and with people competing for water supply	Depends on extent of physical disorder on the ground, on agreement with digital twin and with people competing for water supply

3) Quantifying innovations - Q & A

Hype framing

Hype framing promotes positive perspectives, while underplaying importance of enabling variables and excluding negative aspects: e.g “AR likely to alter industries”.

What is framing with metrics?

3) Quantifying innovations - Q & A

Hype framing

Hype framing promotes positive perspectives, while underplaying importance of enabling variables and excluding negative aspects: e.g “AR likely to alter industries”.

Framing with metrics

Application of AR to work instructions can reduce entropy from information, but introduce entropy for task-, place-, and person-fit of communication (Fox et al., 2020b). This can lead to an increase in entropy from the introduction of AR. For example, as summarized in the preceding tables from 1.0 bits to 3.58 bits. This indicates that the probability of completing tasks right-first-time can decrease when AR is introduced.

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