Metrics for uncertainty in organizational decision-making

W.F. Lawless	Laurent Chaudron	C.P. Abubucker
Paine College	ONERA-CERT, Département Commande des systèmes et dynamique du vol,	Department of Mathematics
1235 15th Street	Toulouse, FRANCE	Paine College
Augusta, GA 30901-3182	Laurent.Chaudron@cert.fr	1235 15th Street
lawlesssw@mail.paine.edu		Augusta, GA 30901
		abubuckerc@mail.paine.edu

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[1] Professional Engineer (Mechanical Engineering; Nuclear Waste Management). Past and current member Savannah River Site Citizens Advisory Board (SAB; 1994-2000; 2003-current), SAB Co-Technical Lead Consolidated Incinerator Facility Focus Group (2000-03); European Trustnet hazardous decision-group (2002-current); past member Department of Energy (DOE) Mixed Wastes Tribal and Stakeholders Working Group (1995-6); and DOE nuclear waste management whistleblower, 1983 (see Lawless, 1985).

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NVO Problem: Autonomy and Control of Human-Robot Organizations

- 5-6 humans per Predator w/staff of 20 (Russ Richards, JFC, 2003); 4 airborne over OIF
  - DARPA: Organizations ≈ 1 human w/many robots = "live weapons"
- Organizations based on traditional models:
  - Tambe (2003): ABM autonomy currently not possible
  - Bankes (2002): validating social ABMs not possible
- ANL's EMCAS (North, 2005): "The purpose of an ABMS model is **not necessarily to predict** the outcome of a system, rather … to reveal and **understand** the complex … system behaviors that emerge…"
- The danger is that ABM's -> "toys" (Macy, 2004).

Traditional Cognitive, AI Organization Theory

- "Methodological individualism" (MI) ∋ game theory (Nowak & Sigmund, 2004)
  - Assumes: Stable Reality, mostly accessible *I*
    - multiple preferences can be resolved into a **consensus**
    - cooperation = highest social value
    - ∑(multiple preferences) = organization's preferences ∋ **interviews**
  - Problems
    - Arrow impossibility & Nash possibility theorems limit multiple prefs
    - CR -> groupthink (Janis, 1982)
    - ∑ **individual surveys ≠ groups** (Levine & Moreland, 1998)
    - **Baumeister** (2005, Scientific Am): SE ≠ performance
    - **Shafir & LeBeouf** (2002, ARP): Rational model has failed
    - Organizational theory has failed (Pfeffer & Wong, 2005; Weick & Quinn, 1999)

Alternative Organization Theory

- Math physics of uncertainty (Quantum model of interdependence):
  - Assumption: Reality is bistable with *I* that is mostly inaccessible
    - Bohr's non-linear relations for the **dynamic interdependence of uncertainty between action and observation**
    - competition => "truth seeking"
    - **M problem**: M(bistability ɘ group, org) -> individual (classical) *I*
- **Paradox**: data => rational d.m. from individual perspective is a fiction, yet m.p.u. => only classical *I* available from group
  - Predicts tradeoffs:
    - **Consensus (CR) -> + Risk Perceptions, + rational worldview**
    - **Majority (MR) -> + Risk Determinations, + practical actions**

Case Study I: Field Problem: DOE History -> Citizen Advisory Boards

- DOE claimed that its actions "Protect … [the] environment [and] health and safety of employees and public" (ERDA 1537, 1977)
- 1980's exposed DOE cover-up of extraordinary environmental contamination (Lawless, 1985)
- Collapse of public trust -> Boards (≈ 1993)
- DOE current cleanup estimate Hanford + SRS ≈ $100B
- DOE-EM has 9 Boards (4 consensus, 5 majority rule)
- **CR versus MR = "microscope" into dynamic interdependence**

Field Problems w/DOE's Policy of Consensus Rules (CR)

- DOE-EM's **evaluation** (w/interviews): citizens "need to understand the science of the problem"
- But to let "participants reach an agreement that recognizes the validity of what the speakers say" (Bradbury et al., 2003) permits any opinion no matter how far fetched
- Thus, CR reduces responsibility of citizens to weigh evidence

CR -> Wider Conflict & - Diversity

- HAB consensus-seeking generates conflict w/its sponsor, DOE
  - DOE Manager of Hanford (1998): talks w/HAB on tanks ”have become increasingly contentious and do not provide a supportive environment where individuals and organizations can work together to effectively address these issues”
- HAB consensus-seeking -> less diversity
  - DOE Managers at Hanford: “HAB should strengthen its representation of the views of the broader Pacific Northwestern public … organized special interest groups appears to be dominating … the board’s actions.” (Schepens & Klein, 2003)

Literature on CR

- In Support of CR:
  - Miller (1989): **CR promotes discussion**, compromise decisions, public and private change in group member positions, and **satisfaction** with a group decision
  - Hardin (‘68), Axelrod (‘84): **cooperation requires coercion**
  - Dennett (2003): competition is “toxic”
- Against CR:
  - Janis (1982): **consensus-seeking is groupthink**
  - EU White Paper (2001):
    - “The requirement for consensus in the European Council often **holds policy-making hostage** to national interests in areas which Council should decide by a qualified majority” (p. 29)
  - The more competitive a nation => + scientific wealth, better human health, and less corruption (Lawless & Grayson, 2004)
  - Levine & Moreland (2004): **forcible CR -> poorer decision quality**
  - Kruglanski et al. (2005): **reaching CR takes considerable effort**

WM'04: Board Statements: Tru & HLW

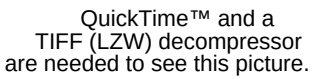
HAB	HAB Recommendation 142; February 7, 200 2 [41]	"The recent shipments o f transuranic (TRU) wastes fro m Battelle Columbus (BCK) and Energ y Technolog y Engineering Center (E TEC) to Hanf ord caused grave concern to the Hanf ord Advisory Board (Board)."
SAB	SA B Recommendation 130; September 26 , 2000 [42]	"Due to the considerable taxpayer savings, the relatively lo w risk , and the use of fundin g external to SRS fo r the activity, th e SRS CAB recommends that DOE -SR accept th e [o ffsite] TRU waste shipments from Moun d as long as the following condi tions are met : 1 . DOE receives approval t o ship mor e TRU waste volume fr om SR S than received fro m Mound. The SRS CAB preference is … twic e the volume"

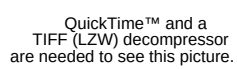
HAB	DOE/RL 200 2-47 Rev. D [8]	Hanford plans to close it s first H LW tank no sooner tha n 2004 , nor later tha n 5 years; Hanfor d plans to ini tiate vitrification b y 201 0.
SAB	WSRC -RP -2002 -00245 Rev 6 [3 8]	SRS has closed 2 HLW tanks (Numbers 20 and 1 7, in 1997) unde r supervision of Sout h Carolina's DHEC , the first tw o regulated closures in the world, an d two m ore are ready for closure (Tanks 18 an d 19) .

DOE Savannah River Site, Aiken, SC: LLW

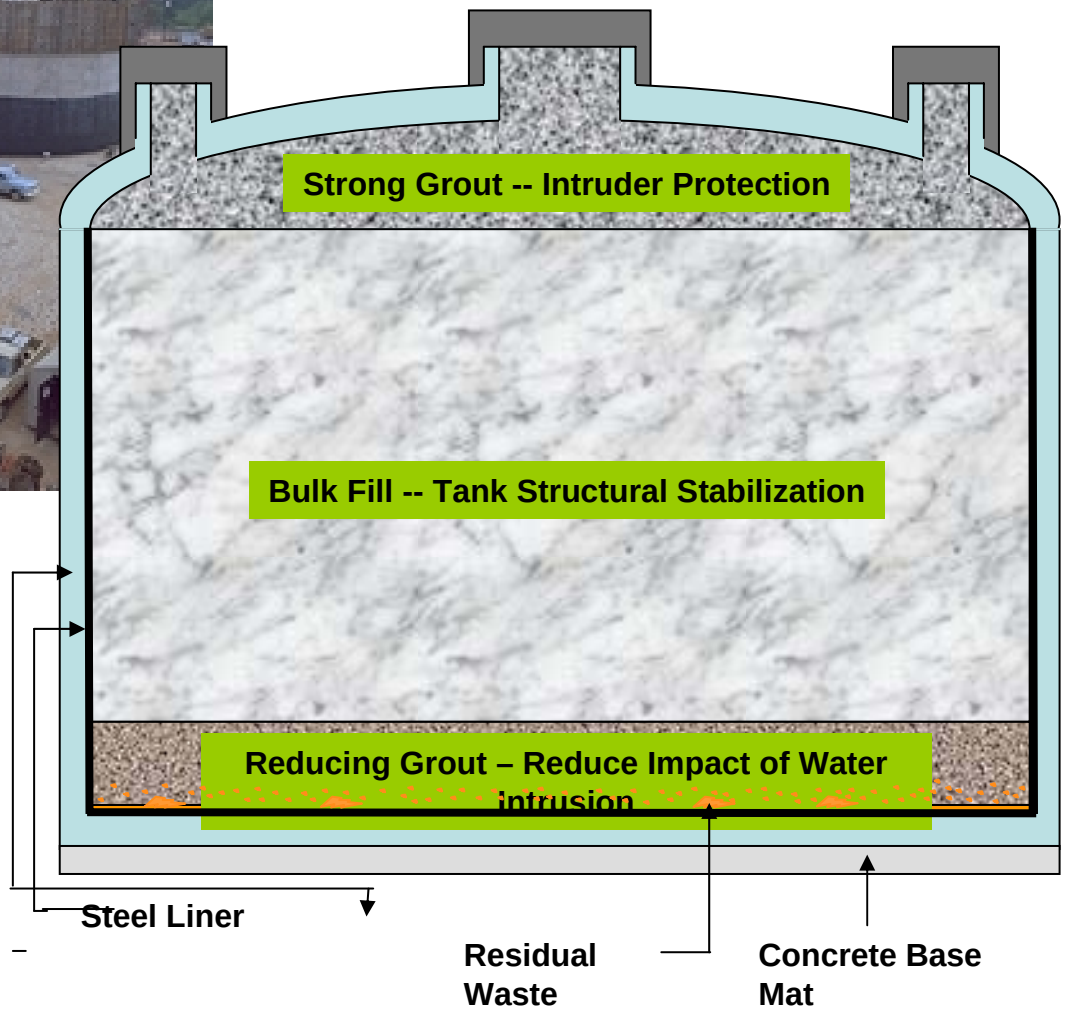
QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

ER: Seepage Basins and Trenches (SRL trenches v Z-9 at Hanford)





HLW: Tanks 17F and 20F Closed

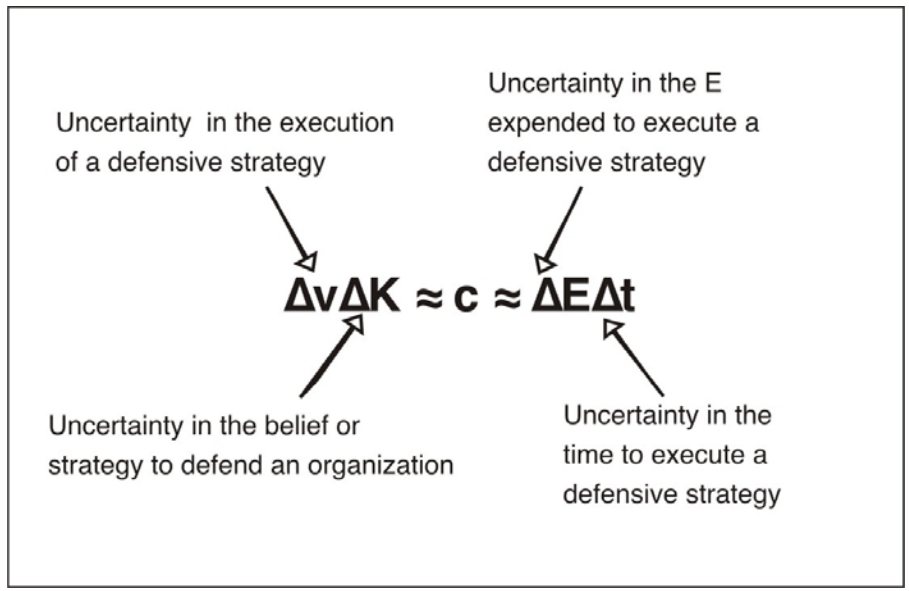


Interviews versus Field data

Based on interviews, you must conclude that HAB is more successful than SAB; however, based on field results, this conclusion is wrong.

	MI	**MPU**
	Hanford/HAB **(CR: cooperation)**	Savannah River Site/SAB **(MR: competition)**
ER	ER about 7.1% in 2002	ER cleanup today ~ 62%
HLW	0/177 HLW tank closures postponed indefinitely HLW vitrification maybe in 8 y	2/51 HLW tanks closed 1997, closing tanks 19 and 18 in FY2007 2023 of 5060 canisters of v-HLW (- 32 ci/gal) Low-curie salt processing from tanks ~ 6/2006
Tru	TRU - 10% of SRS but w/much larger legacy (Gold Metrics, 2004) **Battelle Columbus tru blocked**	18,000 drums/33,000 legacy tru in WIPP w/Trupact II; Trupact III in 2008 => all legacy tru in FY09; **BC waste rec'd 12/05**
Results	**"Gridlock"**	**Successes**

Perturbations -> Measurement paradox (e.g., **hostile merger** of PeopleSoft by Oracle) = Heisenberg U.P. in Social interaction

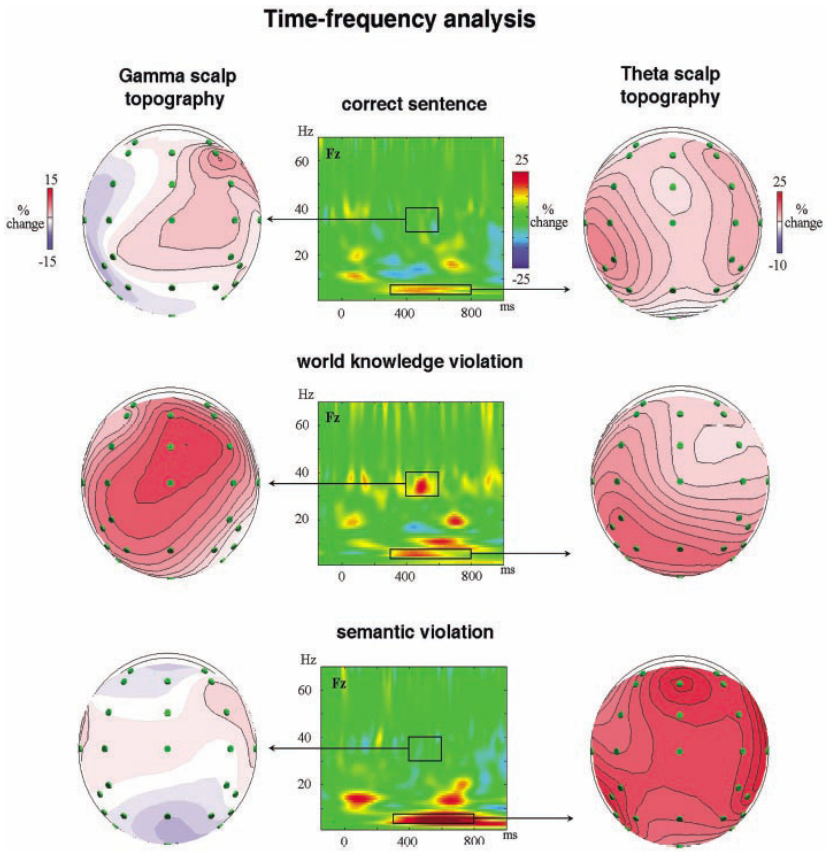


Lawless & Grayson, 2004

What is the constant "*c*" ? Penrose: $\Delta t \Delta E \geq h \Rightarrow \Delta t \Delta \omega \geq 1$

correct: The Dutch trains are yellow and very crowded.
world knowledge violation: The Dutch trains are white and very crowded.
semantic violation: The Dutch trains are sour and very crowded.

Hagoort et al., 2004, Science, 304, 438-441, Fig. 2 [Note: 29 EEG recordings per subject, 30 subjects].



- ***wdp*** **=> Perturbation Theory**
  <-- Note lack of *I*

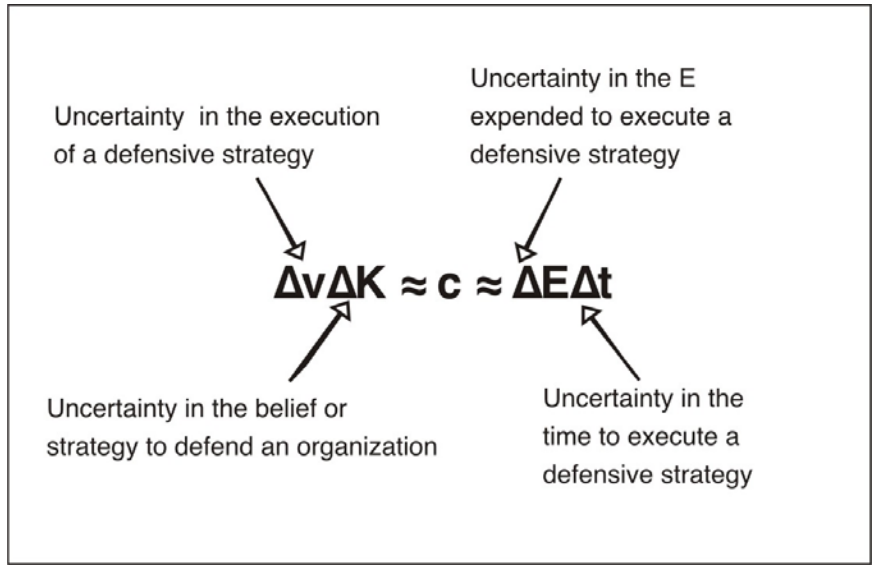
- **Gamma Waves (feature binding): $\Delta t = 1/\Delta\omega = 1/(40$ Hz$) = .025$ s $\geq$ 25 ms**
  <-- EEG data ≈ 50-75 ms

- **Theta Waves (episodic and working memory): $\Delta t = 1/\Delta\omega = 1/(5$ Hz$) = .200$ s $\geq$ 200 ms**
  <-- EEG data ≈ 3-400 ms

- **Voice data agrees (NRL: Kang & Fransen, 1994)**

Case Study 2

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

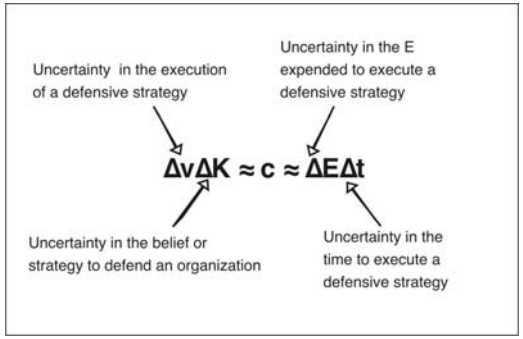


M (field test): In 2003, 13 Recommendations by DOE Scientists to CABs (N=105) for citizen endorsement to accelerate disposition of Tru at WIPP

Results: The SSAB Tru Workshop in Carlsbad agreed to accelerate Tru Wastes to WIPP (2003, January; *N*=105). Afterwards, however, the result: 5 of 9 Boards approved these recommendations (*MR Boards*: SAB (SRS), Oak Ridge, Nevada Test Site, Northern New Mexico; *CR Boards*; Idaho); 4 of 9 Boards disapproved (*MR Boards*: Paducah; *CR Boards*: Hanford, Fernald, Rocky Flats Plant), giving $\chi^2(1)=2.74$, $p\approx.10$. (Lawless et al., 2005)

Pilot lab experiment worked

- *Hypothesis*:
  - MR decisions not dominated by a single person or conflict -> + I processing v CR
  - No significant difference between MR and CR on participant endorsements
  - CR decisions take considerable time to complete
  - MR decisions should be more practical
- *Results from pilot test*:
  - Participant endorsement of decisions by MR preferred over CR ($t(98) = 0.35$, p. n.s.)
  - Number decisions MR >> CR ($\chi^2(1) = 4.83$, $p < .05$)
  - Judges preferred MR v CR ($\chi^2(1) = 4.12$, $p < .05$)
  - Time for both groups held constant



Organizational Performance Metric (MAGTF Metoc): dynamic *i* -> U Tradeoffs

- **Planning (Δ*K*):** (Observation => static *I*): The amount of complexity agreement; Common Data Exchange Format.
- **Execution (Δ*v*):** (Implementation; enaction => dynamic *I* flow): N, the number of participants seeking this tool as a solution process; *N*'s for acceptance => ~ consensus.
- **Energy (Δ*E*)**: The number of steps in a computation; computational complexity
  - Innovations (intellectual, technology) -> comparative advantage
- **Time (Δ*t*)**: the amount of time to compute or reach a solution (Murray Gell-Mann); time complexity

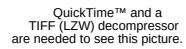
Galois lattices

- 2 agents: A is opposed to “aim” and “reasons” of a topic; B is opposed to its “reason” and “means”
  - A context can be defined and shown as:
    - A verifies: “aim” and “reas”
    - B verifies “reas” and “means”
- We can compute the Galois lattice of the conflict
- At the top, both disagree on “reas”, but at the bottom neither disagree about “aim”, “reas” and “means” simultaneously -> an area for exploration

GL of negations among 2 agents

A “aim” “reas”

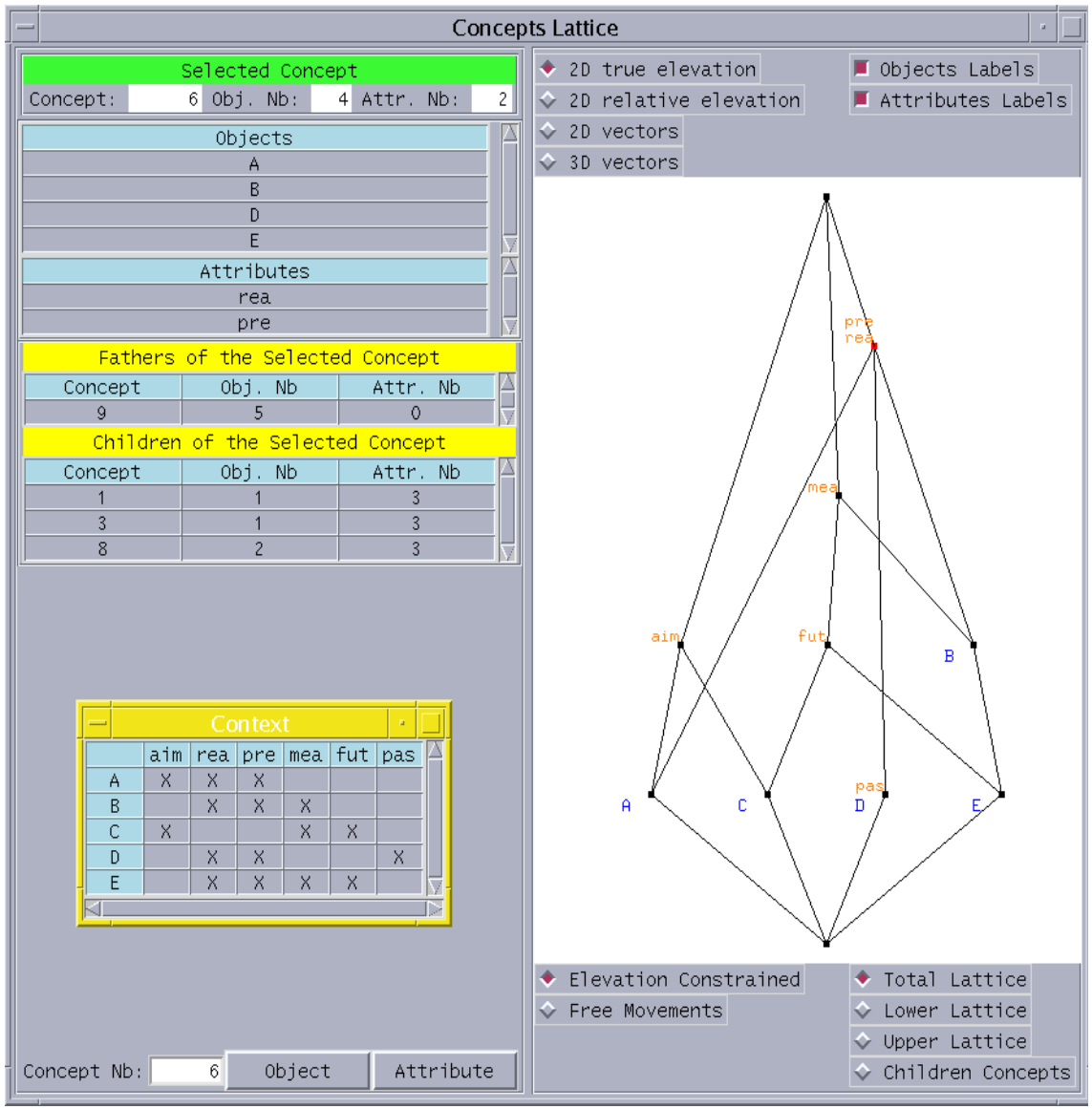
B “reas” “means”



GL of negations among multiple agents

- A aim rea pre
- B rea pre mea
- C aim mea fut
- D rea pre pas
- E rea pre mea fut

Result: C is neutral to arguments on "rea" and "pre"



Conclusions

	MI	MPU
Valued	**Understanding**	**Prediction**
Not Valued	**Prediction**	**Understanding**

- Consensus-seeking is inefficient, reduces agent diversity, responsibility
- MR's "truth-seeking" is efficient
  - –Increases Learning (Dietz et al., 2003)
  - –ISPR pierces "stories" by scientists (Trustnet, 2004)
- DOE-EM policy promotes anti-science, risk perception, and an uneducated citizenry regarding its nuclear missions and cleanup; however, its execution -> "grand field experiment
- **CR versus MR = "microscope" into dynamic interdependence**

Additional Reading

Lawless, W.F., Bergman, M., Louca, J. & Kriegel, N.N. (2006, forthcoming). A quantum metric of organizational performance: Terrorism and counterterrorism. Computational & Mathematical Organizational Theory.

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Lawless, W. F., & Grayson, J.M. (2004). A quantum perturbation model (QPM) of knowledge and organizational mergers. Agent Mediated Knowledge Management. L. van Elst, & Dignum, V. Berlin: Springer-Verlag (pp. 143-161).

Lawless, W. F., & Schwartz, M. (2002). "The social quantum model of dissonance: From social organization to cultural evolution." Social Science Computer Review (Sage), 20(4), 441-450.

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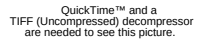
Lawless, W.F., Castelao, T., & Ballas, J.A., (2000a), Virtual knowledge: Bistable reality and solution of ill-defined problems, IEEE Systems, Man, & Cybernetics, 30(1), 119-124).

DRAFT: AAAI-Spring 2007 Symposium at Stanford on Quantum Interaction: CFP deadline October 27



- The organizers of this symposium are interested in bridging a theory of Quantum Mechanics (QM) and field practice and combining AI and QM. In considering whether to submit a paper for this symposium, we encourage speculative works, works in progress, and completed works that articulate a clear relationship with AI.
- QM is emerging out of physics into non-quantum domains such as human language (Widdows & Peters, 2003), cognition (Aerts & Czachor, 2004; Bruza & Cole, 2005), information retrieval (Van Rijsbergen, 2004), biology, political science and AI (e.g., Rieffel & Pollack, 2000).
- The QM model has already been applied to Game Theory (Eisert et al., 1999), political science (Arfi, 2005; Wendt, 2005), social science (Lawless et al., 2006), and brain models (Ezhov, 2001; Hagan et al., 2002; Stapp, 2004).
- This symposium will bring together researchers interested in how QM can be applied to solve problems with AI in non-quantum domains more efficiently or to address previously unsolved problems with AI in these other fields.
- Contact: keith@dcs.gla.ac.uk, p.bruza@qut.edu.au, lawlessw@mail.paine.edu