Adversarial collaboration: An overview of social quantum logic

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Abstract

Collaborative decision-making (CDM) to solve problems is an aspect of human behavior least yielding to rational theory. To simplify, early game theorists assumed that logical conceptions of cooperation and conflict in static configurations could represent the actual choices made by humans in an interaction, leading to the first stable solution of mutual competition (Nash equilibrium). Later, a second stable solution of mutual cooperation was found by Axelrod to evolve in extensive form. But unary maps underdetermine reality, R; cooperation in the field to solve ill-defined problems produces suboptimal solutions; and a rigorous logical map from multiple individual preferences to a single group preference is not possible. More problematic for multiple agent systems or computational autonomy, as information (I) completeness produces knowledge (K), as the number of interactants approach an N of *100* or more, or as agents depart from cooperation, computability decreases significantly. In contrast, adapting quantum logic to the interaction while difficult to understand produces a robust model of decision-making even as N increases. The evidence suggests that adversarial collaboration is superior.

Overview of research

Based on the social quantum relations (Lawless et al., 2000a), action information uncertainty, Δa, and observation information uncertainty, ΔI (where $I = -\sum p(x) \log_2 p(x)$), are conjugate:

$$\Delta a \Delta I \approx c \qquad (1)$$

Counterintuitively, equation (1) predicts that uncertainty in observational information must increase to solve ill-defined problems. Typical examples are the practice of science at the cutting edge where pro-con positions are posed, prosecutors and defense lawyers arguing in the courtroom, and conflict occurring during CDM. Evidence from the field is reviewed in item one:

1. In 1996, the Department of Energy (DOE) collected environmental remediation (ER) and waste management decision-making data from Citizen Advisory Boards (CAB) across its military nuclear weapons complex in the U.S., including the Savannah River Site in South Carolina (SAB) and Hanford in Washington (HAB), the two sites with the largest ER and waste management cleanup budgets (about \$1b in 1996). Today, having vitrified over 1000 canisters of nuclear weapons reprocessing wastes and having closed two of its 51 reprocessing waste storage tanks, SRS is the leader across the DOE complex (Lawless et al., 2000b). By comparison, Hanford has completed none in either category. Contrasting decision-making on both boards, SAB is significantly more adversarial ($\Delta I \to \infty$), yet its members trust each other more (see Table 1).

Table 1: T-tests between SAB and HAB for 1. demographics; 2. survey items on perceptions of respective DOE sites; and 3. survey items on internal decision processes (probability significances: two asterisks imply $p<.01$, one asterisk implies $p<.05$; no asterisk means not significant) (Lawless et al., 2000a).

1. More Minority members	2.9 **
2. Site heeds advice	4.7 **
Concurs with Site	5.3 **
Site progressing	1.6
Trusts Site	1.6
3. Respects other members	-2.1 **
Likes consensuses	-3.3 **
Trusts other members	0.6
Members share ideas	3.2 **

Equation (1) can be revised to an equation based on time uncertainty, Δt, and energy uncertainty, ΔE:

$$\Delta t \Delta E \approx c \qquad (2)$$

Equation (2) predicts that to reduce time uncertainty during the production of scientific K or technology, to improve physical health, or to determine a defendant's guilt in the courtroom in an important case, E uncertainty becomes unbounded. See item two:

2. From a theoretical perspective, I to observers external to an interaction increases under competition and decreases under cooperation. Considering K as the absence of uncertainty ($\Delta I \to 0$), cooperation uses existing K and least energy, E, to best solve well-defined problems (social stability); in contrast, competition generates K with E for the best solution of ill-defined problems (creative destruction). The results

from a study of 15 nations (the nations were selected by May, 1997, for his study of graduate education) indicate that the more economic freedom allowed and *E* expended, the more scientific wealth, technology and the better physical health that accrued (Table 2). In contrast, unrestrained cooperation is associated with social loafing, asymmetric *I* (e.g., spying, terrorism, command economies, monopolies), and corruption.

Table 2. Correlation matrix (truncated) for 15 nations between Scientific Wealth (SW), Health (*H*), Energy expenditure, *E*, personal computers per 1,000 capita (pc's), internet web hosts per 10,000 capita (web), Economic Freedom (EF), and Corruption Perceptions (CPI) (probability significances: $p < .01$ for $r > .65$; $p < .05$ for $r > .5$) (from Lawless & Castelao, 2001).

RCI	1.0				
H	-.72	1.0			
E	.73	-.66	1.0		
pc's	.93	-.70	.78	1.0	
web	.61	-.37	.74	.71	1.0
EF	.88	-.79	.70	.84	.48
CPI	.81	-.72	.73	.89	.60

In complex environments, CDM should make users more familiar with the uncertainties associated with automation tools (Helmreich, 2000). See item three:

3. The next study considered the effect of collaborative decision-making (CDM) versus adversarial decision-making. The Federal Aviation Agency has implemented CDM to improve convective weather forecasts (e.g., thunderstorms, tornados, hail) for commercial aviation (Table 3). Experts produced the best convective forecasts over the near term, followed by CDM then numerical models. CDM was less efficacious probably to increase safety margins and passenger comfort, but probably also because virtually no conflict occurred during CDM. CDM improved the facility of using automated forecasts.

Table 3. Better convective weather forecasts cover less area, have greater PODy (probability of being observed), lower FAR (false-alarm ratio), and Bias near one (the tendency to over or under predict) (see Lawless, 2002).

Forecast Product	Human/ Automated	Area covered	Ave. PODy	FAR	Bias
CDM	H	5.2%	.28	.84	1.9
Expert-1h	H	2.3%	.28	.70	1.0
Expert-6h	H	14.9%	.04	.92	6.1
NCWF	A	0.5%	.09	.41	0.1

4. Future research. The difficulty with human research is that surveys give only static information. Social influence occurs outside of the individual rational perspective tapped by surveys (Lawless, 2001). In an attempt to build on a rational, social quantum model of emotion, we compared paired repetitions of nine short neutral phrases from one subject speaking in a regular and angry voice (phrases similar to "beat about the bush"). Pitch frequencies were consistent for either normal or angry voice (the average for normal voice was 127 Hz, with SD 5 Hz; for angry voice 208 Hz, with SD 9 Hz). Speech samples were analyzed 100 at a time in sequence. After segmenting each pitch cycle for spectral analyses, one overall spectral pattern for each uttered phrase was generated. Results indicated a peak spectrum located in the low frequency region for normal voice but angry speech did not have a peak spectrum in the low frequency region. Pitch on average increased significantly for angry compared to normal voice ($t(8) = 24.8$, $p < .000$). CDM research with more subjects will be conducted.

Acknowledgements. The author thanks J.A. Ballas and G. Kang, ITD, NRL, Washington, DC, where most of this research was conducted with funds from ONR through an ASEE grant.

References

Helmreich, R.L. (2000), On error management: lessons from aviation, British Medical J., 320, 781-5.

Lawless, W.F. (2001), The quantum of social action and the function of emotion in decision-making, AAAI Fall Symposium (Emotion) North Falmouth, MA.

Lawless, W.F. (forthcoming, 2002), Collaborative decision making in METOC. Cognitive elements of effective collaboration, ONR, San Diego, CA.

Lawless, W.F. & Castelao, T. (2001), University as Decision Center, IEEE Techn. Soc., 20(2), 6-17.

Lawless, W.F., Castelao, T., & Ballas, J.A., (2000a), Virtual knowledge: Bistable reality and the solution of ill-defined problems, IEEE Systems, Man, & Cybernetics, 30(1), 119-126.

Lawless, W.F., Castelao, T., & Abubucker, C.P., (2000b), Conflict as a heuristic in the development of an interaction mechanics, in C. Tessier, L. Chaudron, & H.J. Muller, Conflicting agents, pp. 279-302, Boston: Kluwer.

May, R.M. (1997), The scientific wealth of nations, Science, 275, 793-796.