Review of: "Occupation from a perspective of complementarity - Part 2 - Proposals for situating a complementarity perspective in occupational science"

William Lawless[1]

1 Paine College

Potential competing interests: No potential competing interests to declare. None

With this review of Turnbull & Barnard's (TB) occupation perspective of complementarity, my goal is to open a line of dialogue between occupational science and our discipline of what may become a new occupation: autonomous human-machine teams and systems.

First, the TB article seems to be based on the monadic principle of a 1:1 relationship between an individual's cognition and behavior, what I have often described as over stating the belief in individuals, loosely justified by Shannon's (1948) theory of information's requirement of independent pieces of data for the transmission of a coded signal between two points that can be reconstructed into letters and speech; e.g., the telephone has grown up to become a cell phone, internet, and iPad (which I use daily and to write this review). Conant (1976) was one of the first researchers to extend Shannon's theory to a computational model of an organization. Civilization and the study of ethics based on individualism seems to have operated reasonably well until now with Shannon's theory as the foundation, including in the social sciences, where Skinner's reinforcement is still contributing to innovation by driving ChatGPT.[1] But there are reservations to be expressed, including with ChatGPT (Chomsky et al., 2023); with the social sciences seemingly trapped by invalidated concepts (Nosek, 2015) and biases that have until now been untreatable (Paluck et al., 2023); and with interdisciplinary applications fraught with disappointment (Cummings, 2015), especially when these reservations are applied to my field of research: autonomous human-machine teams. There, the successful applications based on individualism seem to be restricted to trust (Mittu et al., 2016), discussed later.

Second, to better establish this review, TB address the value of knowledge without defining it. Our team uses knowledge to mean the absence of uncertainty. To make it more relevant, we assume that knowledge about a topic means the absence of information from chaos (qeios) in what is widely accepted to be true about a matter. The Journal "Qeios" claims to be "the starting point of all knowledge"; I accept that claim, if in turn its readers accept that the disorder is resolved by "knowledge." An example is Conant's (1976) application of Shannon's (1948) theory of information to organizations where he illustrated that when we predict the time for sunrise tomorrow morning, knowledge exists when there is no longer surprise in the arrival of sunrise at the time predicted.

Third, the authors raise the topic of intersubjectivity. For that, we like to treat Khaldun's (ca. 1400)*"asabiyyah"* as a superordinate belief orthogonal to the occupations or beliefs of followers. Injecting Khaldun is important because in our

theory of complementarity or entanglement, orthogonality is the critical phenomenon in our model of the duality between the occupation of an individual who is transformed into a teammate and the team's productivity.

Fourth, Bohr (1955) borrowed the term of complementarity from William James (1890): "…in certain persons, at least, the total possible consciousness may be split into parts which coexist but mutually ignore each other, and share the objects of knowledge between them. More remarkable still, they are complementary." (p. 204) The ignorance expressed by James captures perfectly the loss of information which we discuss in the next paragraph. However, my favorite comment about Bohr's generalization of Heisenberg's uncertainty principle by an outsider was by Pais (1991), whom I paraphrase here. Bohr's example illustrated by Pais was of the different information collected by an athlete and a sportscaster, which TB calls "earlier Bohr" (p. 3). Bohr's point was that what the sportscaster observed of the athlete could not reconstruct the reality experienced by the athlete, making their separate interpretations of reality orthogonal and complementary, a profound insight, but while explored by the authors, they seem to look past it to satisfy their need to have individualism in their model.

Fifth, Bohr's goal with complementarity was to generalize and apply Heisenberg's uncertainty principle and the principle of causality (Bohr, 1937) to the unity of life (Bohr, 1955), what TB calls "revised Bohr" (p. 3). But what is complementarity? The authors allude to the entirety of a context, important for human-machine teams (Lawless et al., 2019). Having written extensively about Bohr (Lawless, 2022c) and Schrödinger (1935), our team treats complementary and entanglement in a fashion that leads to suggestions, which TB have avoided (p. 14). In our theory, complementarity, interdependence and entanglement mean that a loss in the degrees of freedom has occurred between two or more elements of a system, producing a loss of information, the maximum loss occurring at orthogonality (e.g., a good example is the different reality perceived by the husband and wife in their interdependent roles; or by the cook, waiter and checkout clerk functioning interdependently in a 3-person restaurant). From the National Academy of Sciences: The "performance of a team is not decomposable to, or an aggregation of, individual performances" (Endsley, 2021, p. 11). That statement by the Academy is also profound, and the first direct evidence in support of our theory by outside scientists (Lawless et al., 2023). To drive this point home, when the elements of a team, system or occupation are no longer independent, they are dependent on each other. Dependency causes a loss in information, thereby injecting randomness into the formation of a team or an organization constructed of occupations operating in complementary pairs. A counter example is the Uber self-driving car and its operator involved in the first fatality of a pedestrian (Lawless, 2022b). In this fatal accident, the Uber car and its operator were operated independently of each other, not as teammates dependent on each other. When the pedestrian jaywalked into their path (well outside of the pedestrian crosswalk that the car was train to recognize), the car struggled to identify the moving object; meanwhile, the operator was distracted by her digital device and not paying attention until the tragedy unfolded.

Sixth, to return to Turnbull & Barnard's project. As we move into the age of human-machine teams, how are we to apply ethical"principles to practical moral problems" in the science of this new occupation? Do we want deontological or consequentialist rules for machines? Rules by Kant or Asimov (1950)? Or, for now, can we make an assumption: since humans cause more accidents than machines, let us assume that machines may save human lives. TB offers as a guide the need to capture all of the information possible from the entirety of a situation (p. 15). I like their guidance, but they end

with a problem-solving that entails the perspectives of four static aspects of a situation: social-active, individual-active, social receptive, and individual receptive. These serve, it seems to me, in a limited fashion like still photographs of the complementarity that is occurring in the activities of an occupation. Instead, I looked to the definition of occupational science, which is to orchestrate occupations consisting of form, function, and meaning to produce well-being. Not in order, searching for “meaning” when information is being or has been lost is itself somewhat of a lost cause; e.g., witness the struggles that quantum physicists, practicing in our most successful and predictive science, have in reaching a consensus on what the quantum theory means; e.g., Steven Weinberg(2017a) offered to spend his last years by resolving what the quantum theory meant, only to be lambasted on all sides by his physicist colleagues (Weinberg, 2017b). The "form" we have postulated is the structure of the optimum team or system created when it forms into a single, perfect unit (guided by Khuldun’s asabiyyah at a superordinate level). A perfect unit is able to “function” or operate at its maximum productivity; e.g., witness that the opposite occurs when a couple who are getting divorced spend their time and energy ripping their team’s structure apart, leaving little energy to be productive parents. Getting divorced captures poor form and function; for the best run systems, they should produce well-being in an occupation and across a society.

But, and seventh, in a poorly-run team or system, an individual may feel that the decisions for the team or system are unjustified. In that case, the individual could "blow the whistle," creating an opportunity for the ethical belief of an individual to bring about positive change in an organization.[2] In an organization that is being poorly run, if a machine can save human lives, it should. In our first book (Mittu et al., 2016), we generalized the concept of trust into a bidirectional phenomenon with an example of complementarity: once a machine in an occupational role as part of a human-machine team knows how to play its role, it knows when a human in the same team is dysfunctional. For example, the Germanwings copilot who committed suicide and killed all of his passengers and crew mates in 2015 (as have others, such as a China Eastern Airliner). If the plane had been trained to takeover from a dysfunctional pilot and safe itself until it could have been guided to a safe landing by flight officers on the ground, the plane would have saved passengers, crew and itself. United States Air Force fighter pilots have such a system functioning in their most advanced fighter aircraft—when the pilot passes out from pulling too many G’s, the plane takes over until the pilot recovers consciousness (Sofge et al., 2019).

I close by concluding that complementarity is a powerful concept and a tool to design the structure of an autonomous human-machine team in a way that produces maximum productivity as part of a complementary tradeoff between form and function.

References:

Asimov, Isaac (1950). "Runaround". *I, Robot* (The Isaac Asimov Collection ed.). New York City: Doubleday. p. 40.

Bohr, N. (1937), Causality and Complementarity, Philosophy of Science, 4(3): 289-298. Retrieved 2/28/2021 from http://www.jstor.org/stable/184445

Bohr, N. (1955) Science and the unity of knowledge, In L. Leary (ed.), The unity of knowledge, pp. 44-62, New York: Doubleday.

Chomsky, N., Roberts, I. & Watumull J. (2023, 3/8), “The False Promise of ChatGPT,” New York Times, retrieved 3/8/2023 from https://www.nytimes.com/2023/03/08/opinion/noam-chomsky-chatgpt-ai.html?action=click&module=Well&pgtype=Homepage&section=Opinion

Conant, R. C. (1976). "Laws of information which govern systems."IEEE Transaction on Systems, Man, and Cybernetics **6**: 240-255.

Cummings, J. (2015). Team Science Successes and Challenges. National Science Foundation Sponsored Workshop on Fundamentals of Team Science and the Science of Team Science (June 2), Bethesda MD.

Endsley, M.R., et al. (2021). Human-AI Teaming: State-of-the-Art and Research Needs. The National Academies of Sciences-Engineering-Medicine. Washington, DC: National Academies Press. Retrieved 12/27/2021 from https://www.nap.edu/catalog/26355/human-ai-teaming-state-of-the-art-and-research-needs

James, W. (1892/1950), The Principles of Psychology, 2 vols. (1890) Dover Publications.

Khaldun, I. (about 1400/2015) The Muqaddimah. An Introduction to History—Abridged Edition, F. Rosenthal (Tr.), Edited by N. J. Dawood, Princeton University Press.

Lawless, W.F. (2022b), Toward a physics of interdependence for autonomous human-machine systems: The case of the Uber fatal accident, 2018, Frontiers in Physics. Section Interdisciplinary Physics, https://doi.org/10.3389/fphy.2022.879171

Lawless, W.F. (2022c), Interdependent Autonomous Human-Machine Systems: The Complementarity of Fitness, Vulnerability & Evolution, Entropy, 24(9):1308. doi: 10.3390/e24091308.

Lawless, W.F., Mittu, R., Sofge, D.A. & Hiatt, L. (2019), Editorial (Introduction to the Special Issue), “Artificial intelligence (AI), autonomy and human-machine teams: Interdependence, context and explainable AI,” *AI Magazine,* 40(3): 5-13. https://doi.org/10.1609/aimag.v40i3.2866.

Lawless, W.F.; Sofge, Donald A.; Lofaro, Daniel; & Mittu, Ranjeev (2023), Editorial: Interdisciplinary Approaches to the Structure and Performance of Interdependent Autonomous Human Machine Teams and Systems, Frontiers in Physics, eBook, retrieved 3/1/2023 from https://www.frontiersin.org/articles/10.3389/fphy.2023.1150796/full?&utm_source=Email_to_authors_&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers_in_Physics&id=1150796

Mittu, R., Sofge, D., Wagner, A. & Lawless, W.F. (2016) The intersection of robust intelligence and trust in autonomous systems, Berlin: Springer.

Nosek, B. (2015), Estimating the reproducibility of psychological science, Science, 349 (6251): 943; retrieved 2/24/2023 from https://www.science.org/doi/10.1126/science.aac4716

Pais, A. (1991), Niels Bohr's Times: In Physics, Philosophy, and Polity. Oxford, UK: Clarendon Press.

Paluck, E.L. & Green D.P. (2009), Prejudice Reduction: What Works? A Review and Assessment of Research and Practice. Annual Review of Psychology, 60:339-367, retrieved 1/23/2023 from https://doi.org/10.1146/annurev.psych.60.110707.163607

Schrödinger, E., 1935. “Discussion of Probability Relations Between Separated Systems,” *Proceedings of the Cambridge Philosophical Society*, 31: 555–563; 32 (1936): 446–451.

Singer, P. (2023, 3/16), ethics. The Encyclopaedia Britannica, retrieved 4;3/2023 from https://www.britannica.com/topic/ethics-philosophy

Shannon, C.E. (1948), A Mathematical Theory of Communication, The Bell System Technical Journal, 27: 379–423, 623–656.

Sofge, Donald (Referee), Mittu, Ranjeev (Con Bet) & Lawless, W.F. (Pro Bet) (2019), AI Bookie Bet: How likely is it that an AI-based system will self-authorize taking control from a human operator? AI Magazine, 40(3): 79-84.

Weinberg, S. (2017a, 1/19), The Trouble with Quantum Mechanics, The New York Review of Books, from http://www.nybooks.com/articles/2017/01/19/trouble-with-quantum-mechanics

Weinberg, S. (2017b, 4/6), Steven Weinberg and the Puzzle of Quantum Mechanics, replies by N. David Mermin, Jeremy Bernstein, Michael Nauenberg, Jean Bricmont, and Sheldon Goldstein, et al. In response to: The Trouble with Quantum Mechanics from the January 19, 2017 issue; The New York Review of Books, from http://www.nybooks.com/articles/2017/04/06/steven-weinberg-puzzle-quantum-mechanics/

[1] https://openai.com/blog/chatgpt

[2] In 1983, I was a whistle blower when I worked for the Department of Energy as its radioactive waste manager at the Savannah River Plant in Aiken, SC.