October 2023

Motivating a Terminological Clarification in the Account of Representation Between Computational and Dynamical Paradigms

Jamale Nagi
info@ubiquitypress.com

Follow this and additional works at: https://digitalcommons.cwu.edu/ijurca

Res Cogitans (2014) 5:77-84
Nagi: Motivating a Terminological Clarification in the Account of Repre...
2155-4838 | commons.pacificu.edu/rescogitans

Motivating a Terminological Clarification in the Account of Representation Between Computational and Dynamical Paradigms

Jamale Nagi
Portland State University

Abstract

Debate in philosophy of cognition between computatationalists and dynamists often are found to be taking past one another. This is largely due to inconsistency within the dynamic camp regarding whether or not there are representations; and for those that do affirm them, clarifying how a representation is to be conceived and used under a dynamical system paradigm. Having been equipped with an understanding of a dynamic conception of representation may prove resourceful for giving a dynamic account for cognitive tasks in a 'representation-hungry' problem domain, largely thought only to be explained through a computational cognitive model.

The Watt Governor: Computational and Dynamic versions

The big engineering problem during the industrial revolution was how to deliver a smooth, continuous, source of power. More specifically there was a desire to transfer the turning action of the steam piston into a revolving motion of the flywheel. Because of the variations, depending on the particular workloads and etc., the speed of the flywheel would often be in flux. In order for the speed of flywheel to be regulated, a throttle valve was employed to control the amount of steam entering the pistons. Originally, some unfortunate human was tasked with constantly making the appropriate adjustments to the throttle valve.

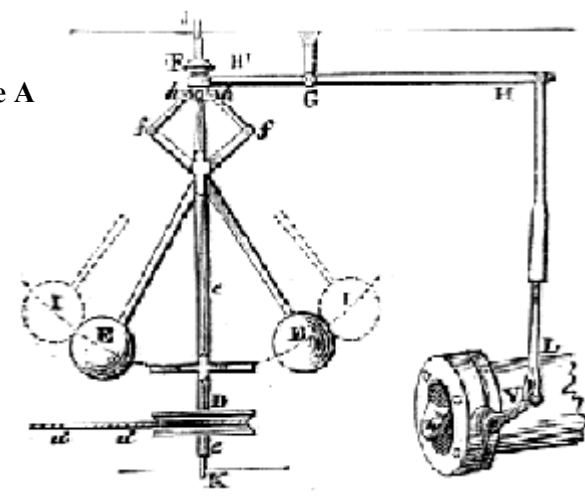## The Computational Governor

As an alternative from employing a human to govern the throttle valve, van Gelder suggests one could approach the problem by breaking the overall task into subtasks, one could then see how to devise subcomponents that each handle a particular part of the overall task. Van Gelder offers the various subtasks. 1) Measure the speed of the

flywheel. 2) Determine whether there is a difference between the actual speed and desired speed. 3) If there is no difference then return to task 1, if there is a difference, the governor must make the appropriate changes to the throttle valve. To this end, the governor will have to measure the current steam pressure and calculate the needed alteration. Next, determine the needed throttle valve adjustment, then 4) make the appropriate changes and return to step 1 (Van Gelder, What Might Cog. 347-348). Each of the tasks above, van Gelder suggests could be implemented by a physical devise. So one can think of the governor as comprised of multiple assembles that measure speed and steam, calculate discrepancies, and make adjustments. All of which is controlled by a central command to see to the sequencing of operations. Van Gelder calls this the computational governor.

The Watt Governor

The suggestion above would have been successful for an automated steam engine; however this was not the method James Watts devised for solving the problem. Van Gelder's suggestion above required more advanced calculating devices that would have been unavailable during that time. Watt's solution comprised of attaching a spindle into the flywheel, thus making its rotational speed mechanically related to that of the flywheel. He also attached, via hinges, two arms to the spindle, each bearing a metal ball on the end. So as the spindle rotated at a higher rate the two arms would move outward, via centrifugal force, and due to the hinges move upward (See figure A)[1]. This process was connected to the throttle valve. Thus as the wheel speed increased, the arms connected to the spindle would rise, closing the throttle valve; whereas when the wheel decreased in speed the arms would lower, causing the throttle valve to open to allow more steam to the pistons. In this manner, the steam engine could maintain a consistent speed with an elegant swiftness (Van Gelder, What Might Cog. 248-249).

Figure A

Van Gelder claims the differences between the two governors has fruitful implications for cognitive science. The computational governor it is constructed in such a way that it achieves its goal by implementing an algorithm that involves use of representations across the subcomponents. For example, the first task is to measure the

[1] This image was taken from: http://maybach300c.blogspot.com/2012/07/1-introduction-to-control-systems.html

current speed of the flywheel to obtain a representation of the engine speed. This representation, in concert with other representations will produce, via computation, an output, namely an adjustment to the throttle valve—if needed. Van Gelder points out that such a system is homuncular. In other words, each subcomponent interacts, via representations, with another forming an interdependent cluster. With representations playing a central role of the computational governor, the greatest contrast would be to consider the non-representational construction of the Watt governor (Van Gelder, What Might Cog. 351).

Van Gelder maintains, on the Watt governor the arm angle on the spindle is intimately related to the engine speed, but not by way of representation. To support this claim he gives four reasons. First he proposes a criterion to tell whether or not a system contains representations by asking if there is any useful explanatory power in appealing to representations to explain the system. In other words, can one make more sense of how the system works by employing representational talk? If one cannot, then why think that there are representations (Van Gelder, What Might Cog 352).

The second reason consists in stressing that even if the arm angle is causally correlated with the engine speed, mere correlation does not give rise to representation. If one were to think so, then representations would be rendered useless for any explanatory power, being that everything can be seen in correlation in one way or another with something else. His third reason, which shores up the second, is that the supposed correlation between the arm angle and engine speed only occurs when the system has reached a stable equilibrium point. However, the actual engine speed may drop suddenly, while the angle arms move at a relatively slower pace according to gravitational acceleration. Therefore, there is in fact no simple correlation between the angle arm and engine speed (Van Gelder, What Might Cog. 353).

The fourth reason—and what van Gelder feels is the most substantial—why the Watt governor is not representational is that once the relationship is fully comprehended, between the arm angles and engine speed, the conceptual framework of representations does not apply. It is the wrong conceptual tool for the job. He contends that since the angle arms are directly related to the throttle valve, and the throttle valve determines the amount of steam in the piston the engine speed is always determined by, and determining the angle of the arms. Hence, there is a continuous co-determining relationship in contrast to the discrete states in the homuncular system of the computational governor. Van Gelder explains that this relation is captured by the mathematical language of dynamics—namely, differential equations. For example, according to van Gelder, this particular formula:

$$\frac{d^2\theta}{dt^2} = (\eta\omega)^2 \cos\theta \, \sin\theta - \frac{g}{l} \sin\theta - r \frac{d\theta}{dt}$$

where θ is the angle of the arms, η is a gearing constant, ω is the speed of the engine, g is a constant for gravity, l is the length of the arms, and r is a constant of friction at the hinges, explains how change in the arm angle is changing, in relation to the current arm angle, in the manner it is changing already, and the engine speed (Van Gelder, What Might Cog. 353,356).

In review, van Gelder sees a computational system as one with cyclical discrete states and interdependent subcomponents that communicate with one another via representations in a state setting manner i.e. many variables can remain the same throughout state transitions. For instance, consider the algorithm above, in step three if no change is needed the variables will remain in the same state returning to step one. Such a system is homuncular. On the other hand, dynamic systems are without discrete intermediate states; rather the system is coupled continuously where input is seen as a continuing influence on the direction of change and the output as an ongoing influence of something else. For example consider the dynamic interaction above regarding the angle arms and the engine speed of the Watt governor—two systems co-determine one another's change (Van Gelder, What Might Cog. 357 & The Dynamical Hypothesis 621-622). Therefore, since there are no discrete states, or communication via representations, nor a need to employ representational talk to explain the Watt governor, Van Gelder concludes that governor to be non-representational.

Is the Watt Governor Representational After All?

Philosopher William Bechtel contends that contrary to van Gelder both governors are representational, and addresses all four of van Gelder's reasons above, maintaining that the angle arms stand in for, that is to say represent, the speed of the engine. Bechtel doubts a system can be said to be representational or not by simply considering if people describe how the system works by using representational terms. Rather, what is important is if the system identifies states which stand in for other states and are used by the system precisely since they stand in. He points out the van Gelder's own account appeals to the angle of the arms standing in for the speed of the flywheel, noting that the arms fell when the speed of the flywheel decreased and rose when it increased. Thus, Bechtel points out in order for us to understand why this mechanism works one has to understand how the angle arms stand in for the speed of the flywheel.

Figure B
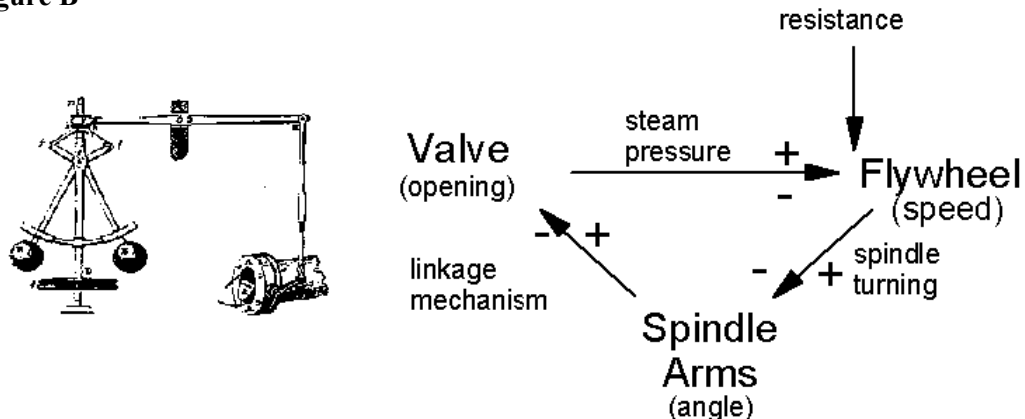
Bechtel contends the Watt governor is composed of three separate components (see Figure B)[2], all of which operate according to different engineering principles. The throttle valve, which determines the steam pressure, coupled with the resistance occurring from the work done by the engine, determines the speed in which the flywheel rotates. The physical principles acting here are, namely, steam pressure and mechanical resistance. Recall from above, that the spindle, with the two angle arms, was attached to the flywheel, where the spindle speed determines the angle of the arms via centrifugal force; and the angle arms are mechanically linked to the throttle valve. Once the three components are separated and correctly associated with their particular principles in which they work, one is in a position to appreciate how the angle arms relate to the other two components. Bechtel now asks one to consider why the spindle was needed in the first place. The answer is that while the flywheel has a speed there was not a way to open and shut the throttle valve. Thus the spindle was needed to encode information regarding the speed in such a way that could be capitalized by the throttle valve. Therefore, Bechtel contends that since the governor is so simple people just see the connection directly, but if one did not know how the governor worked the first thing that would draw attention would be how the angle arms register the speed of the flywheel (Bechtel, 301-303).

As far as van Gelder's second claim, Bechtel agrees that correlation between things is not enough to infer representation, and insists the on importance of use in determining representations. In regards to the third reason offered by van Gelder, and one we will return to later, Bechtel objects that just because the angle of the spindle arms can lag behind the speed of the flywheel does not by itself show the angle arms to not be representational. Furthermore, he claims advocates of representation allow that when an

---

[2] This image was taken from an online version of the same article cited. It can be found online at:
http://mechanism.ucsd.edu/research/REPRESENT.html

effect represents its cause there can be many interim steps in creating the representation (Bechtel, 303-304).

In regards to van Gelder's final claim for rejecting representation, Bechtel is unsure how the complex and subtle relationship of the Watt governor is so much so, that it cannot satisfy the stand-in function of representation. He maintains that "something can stand in for something else coupled to in a dynamic manner, and *by being so coupled* figure in determining a response that alters the very thing being represented" (Bechtel, 304 emphasis in the original).

The Dynamical Representation of the Watt Governor

Bechtel's objections are useful to draw out a dynamical conception of representation. First of all the supposed intermediate steps of the angle arms are not steps at all. Although there is change, it is in continuous fluctuation and thus no discrete states stand in for anything. These continuous perturbations in the angle arms constitute the subtle complexly that precludes the standing in function of computational representation.

Where representation does occur, according to a dynamic system theorist (DST), is during an equilibrium point (Van Gelder, The Dynamical Hypothesis, 622). In the case of the Watt governor, when the angle arms are correlated with the engine speed a system state of equilibrium has been achieved across the system. In this case, the equilibrium point can be thought of as a dynamic system state. Suppose this ideal system state were to continue on for such a time that the actual materials composing the Watt governor were altered—worn in such a way, or etc—so that the system, if stopped and restarted, would tend toward the previous system state. The force driving the system to such a state would function like an attractor basin.

Some Problem Domains for Dynamical Representation

A different type of critique leveled at the DST does not so much object to their claim that that some aspects of cognition may be non-representational, but rather that the problem domain of non-representation exhibited by the Watt governor is not applicable for many cognitive tasks. Philosophers Andy Clark and Josefa Toribio generally agree with all of van Gelder's four reasons for thinking the Watt governor is non-representational, but strongly object to the general conclusion that representational analyses are not sufficient to account for the full understanding of the pairing of dynamical systems such as agents and environment (Clark & Toribio, 418). The insurmountable problem according to Clark and Toribio is that non-representationalism exhibited by the Watt governor does not seem to address 'representation-hungry' problem domains.

A 'representation-hungry' problem domain for Clark and Toribio is one where 1) the problem involves reasoning about absent, non-existent, or counter-factual states of affairs; or 2) the problem requires the agent to be selectively sensitive to parameters whose ambient physical manifestations are complex and unruly (Clark & Toribio, 419). In regards to the former, it would include things like planning one's schedule in advance to make time to watch a sporting event, or deciding to buy stocks if a certain threshold is met. These particular tasks, prima facie, rely on some inner faculties that are not consistently informed by environmental inputs. Therefore, whatever the particular faculties are should be considered representational.

In regards to the latter, consider an ensemble of jelly beans dumped out on a table. Furthermore, suppose that one's friend prefers juicy pear over and above all the other flavors. Those particular jelly beans are considered to have value attributed to them that is not inherent to the physical structure of jelly beans per se. Therefore, one would selectively steer clear of the juicy pear jelly beans (JPJB) not because of any raw environmental triggers, but rather from the ability to infer the importance of them to one's friend. Clark and Toribio state it is difficult to conceive of a system that could perform this discrimination without appealing to one that could consume a plethora of superficially different inputs under a common code, then define further those inputs according to stored information related to the abstract content, namely being liked by one's friend, but this process involves computational representations (Clark & Toribio, 420).

A Modest Answer to the "Representation-Hungry" Challenge

In response to the latter scenario, the DST could give an account for the learning JPJB were valued by a friend without appeal to a computational use of representation. DST holds that cognition is not bounded to the brain, but is embedded within an environment. In other words, they hold that the brain, nervous system, and environment are all coupled together, mutually altering and informing one another. In this way, the learning process of non-physical property attributed to the JPJB is not achieved through some computational algorithm, but through a simultaneous coupling of dynamic systems that when reach an equilibrium point is achieved, representation occurs, standing in for ones friend's preference for JPJB. Therefore, the discrimination of JPJB from the other flavors on account of the value attributed to them can be achieved without the use of computational representations.

The difficulty arises in explaining how one continues to remember ones friend prefers JPJB even when not coupled with the same the same environmental inputs. This problem is along the same lines as reasoning about absent, non-existent things, and counterfactuals. It could be the case that when one recalls their friend's affinity for JPJB it is due to some environmental inputs that match up, in such a way, that an attractor basin responsible for JPJB knowledge is sufficiently engaged causing an

equilibrium point when activated. In other words, other combinations of environmental inputs could be coupled to activate the same attractor basin responsible for the JPJB knowledge. For example, say one component of the mechanical linkage in the Watt governor was switched out with another slightly smaller—or larger—given the rest of the linkage the ideal system state should be still tended toward. There may not have to be an exact replication of prior environmental factors to bring about the memory of some previously learned thing.

The same may be said about thinking of non-existent objects or counterfactuals. An equilibrium point could be developed for unicorns along the same lines as learning about a non-physical property of JPJB. The same kind of story may be said about the counterfactual "if the 49ers won the NFCC, then they would have won the Superbowl." Namely, just because one experiences mental content about possible events or non-existent objects, it doesn't follow there are tokens in the head being manipulated that instantiates that content. It could very well be dynamic mechanisms that supply the content one is aware of. After all, Clark and Chalmers state some tasks of cognition in which one is not directly aware of, such as: The retrieval of memories, language processing, and skill acquisition (Clark & Chalmers, The Extended Mind). Given the account above of a dynamical representation of mental content, it seems being conscious of non-existent objects or counterfactuals could be added to Clark and Chalmers' list.

Works Cited

Bechtel, W. (1998). "Representations and Cognitive Explanations: Assessing the Dynamicist's Challenge in Cognitive Science." *Cognition Science* , 295-218. http://dx.doi.org/10.1207/s15516709cog2203_2

Clark, A., & Chalmers, D. (1998). "The Extended Mind." *Analysis , 1* (58), 7-19. http://dx.doi.org/10.1093/analys/58.1.7

Clark, A., & Toribio, J. (1994). "Doing Without Representing?" *Synthese* , 401-431. http://dx.doi.org/10.1007/BF01063896

Van Gelder, T. (1998). "The Dynamical Hypothesis in Cognitive Science". *Behavioral and Brain Sciences* , 615-665.

Van Gelder, T. (1995). "What Might Cognition Be If Not Computational." *Journal of Philosophy* , 345-381. http://dx.doi.org/10.2307/2941061