Rethinking Human and Machine Intelligence under Determinism

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Abstract
This paper proposes a metaphysical framework for distinguishing between human and machine intelligence. Specifically, it posits two identical deterministic worlds -- one comprising a human agent and the other comprising a machine agent. These agents exhibit different types of information processing mechanisms despite their apparent sameness in a causal sense. By postulating the distinctiveness of human over machine intelligence, this paper resolves what it refers to as “the vantage point problem” – namely, how to legitimize a determinist’s assertion of determinism by placing the determinist within the universe.

Keywords: determinism; computationalism; simulation; state description; counterfactuals

Introduction

When a determinist asserts that the universe is deterministic, this requires assuming a hypothetical vantage point from which to describe the universe. At first sight, it seems reasonable to say that such a vantage point should be located somewhere beyond the universe. For instance, Wittgenstein (1922) notes that “the philosophical I” is a “metaphysical subject” that is “not a part of the world” (p. 75). Determinism is a philosophical judgment imposed upon the world. Accordingly, the determinist’s reasoning mind may have to be separated from the world. However, the determinist herself is a part of the world. According to Danielsson (2023), since “[w]e cannot stand outside the world,” “we always look at the world from the only vantage point that exists: from within. (Chapter 1)”

The above peculiar relationship between the two (i.e., the determinist vs. universe) can cause confusion. The determinist is a finite being located within space and time. Then, how could she justify the significance of her assertion of determinism, which is a view that seems to require attainment of a God’s-eye perspective? This issue will be referred to as the “vantage point problem” in this paper.

To address the problem, this paper proposes to discuss two different types of deterministic worlds. If readers patiently follow this paper’s arguments to the end, they will see how it establishes a plausible model that allows a determinist to validly claim our universe as deterministic while remaining a part of it.

1. Deterministic Knowledge

This paper will use the following key definitions:

(1) **Deterministic knowledge** (D knowledge): A totality of facts associated with all the past, present, and future events in a deterministic world.

(2) **Deterministic world**: A world where events are deterministic. There is metaphysical significance in considering a case of providing D knowledge to a cognitive agent of this world.[1]

Definition (1) is similar to Carnap's (1947) "one state-description" (he notes that this idea was inspired by Wittgenstein) (p. 10). Specifically, it "describes the actual state of the universe" and "contains all true atomic sentences and the negations of those which are false." However, Carnap primarily devised this concept in relation to a semantical system for linguistic analysis. Meanwhile, D knowledge relates to descriptions of a deterministic world. In this regard, these two notions are different. Nevertheless, following Carnap, we will assume that D knowledge is an entirety of atomic sentences that describe a deterministic world.

Definition (2) introduces a seemingly contradictory idea. If D knowledge were provided to the agent, it suggests that she could gain knowledge about her future. However, if she did attain such knowledge, the D knowledge would no longer be valid because it fails to describe one particular event: her attainment of the knowledge. To address this apparent contradiction, this paper will examine reception of D knowledge in a *metaphysical* sense only.[2]

Now let us define two deterministic worlds.

(i) An original world like ours that comprises a human agent.

(ii) A simulated world that replicates every aspect of the original world and comprises a machine agent emulating the human agent in a causal manner.[3]

According to Schwartz (2012), determinism is the view "that [possible] worlds cannot be the same up to a point and then diverge" (p. 216). However, in our thought experiment, it *is* possible that the deterministic worlds (i) and (ii) are computationally identical up to a particular point and then diverge when D knowledge is provided to them. If one contends that the human mind cannot be fully reduced to an algorithm, it becomes necessary to assume that such a divergence is possible.

For further discussion, this paper will use concepts of computationalism to investigate the characteristics of information processing exhibited by both agents. According to Beraldo-de-Araújio, the essence of computation is "symbolic manipulation" and concerns "mapping function between two sets of symbols" (Polak & Krzanowski, 2019, p. 6). The human agent's symbolic manipulation, for instance, may take place through neural activities in the brain. Meanwhile, the machine agent

[1] Vihvelin (2023) proposes "[leaving] open the metaphysical possibility of time travel to the past" (p. 1). This concept is philosophically worth considering, even though it is unlikely to materialize in reality. Note that her proposal implicitly involves the idea of providing D knowledge to an agent in the past.

[2] We assume that the cognitive agent receives only a "small breadth" of D knowledge that is associated with the agent. The entirety of D knowledge would be too immense to be processed by any agent.

[3] Müller (2014) indicates that there can be two different physical processes P_1 and P_2 that perform the same computation C (p. 9). Similarly, the original and simulated worlds are computationally the same but ultimately different.

performs symbolic manipulation by processing machine-readable symbols. By slightly changing Beraldo-de-Araújio's definitions on p.6, this paper defines computation as follows.

(a) A process is a function $P: I \rightarrow O$ such that its domain I is a set whose elements are called input *events* and its co-domain O is a set whose elements are called output *events*, while both I and O are subsets of a physical world. For all $x \in I$, $y = P(x)$ ($y \in O$) is a corresponding output event.

(b) A computer is a function $C: S \rightarrow T$ from a set of input *symbols* S to a set of output *symbols* T, such that $C(\overline{x})$ is outputted by computing $\overline{x}$. ($\overline{x}$ is a symbolic representation of x.) A process $P: I \rightarrow O$ is computational if P is generated by a computer C.

In the simulated world, we suppose that the mind is a "classical von Neumann computer" and that "its representation-bearers [are] data structures" (Frankish & Ramsey, 2012, pp. 31-32).[4] This world is intentionally designed to avoid being based on a "connectionist" model.[5] Specifically, it may not be feasible for the connectionist model to accurately emulate the human agent due to its highly stochastic nature.[6] Such a feature might hinder accurate realization of a scripted scenario. Although the classical model may be much less sophisticated, it can at least robustly emulate human behaviors in hindsight if all the relevant information is available.

1.1 Type 1

If the D knowledge specific to the simulated world is provided to its agent, the agent would process reception of the D knowledge simply as one of the existing potential input events. This suggests that the agent executes rigid processing, as it cannot process in any other way an input that it was not capable of processing. This world is trivially deterministic in that it is governed by a predefined type of D knowledge (i.e., Type 1) that *dictates* how things should occur.

See the following mappings.

$I = \{x_1, x_2, \ldots, x_n\}$

$O = \{y_1, y_2, \ldots, y_n\}$

Since this is a fully deterministic world, only one predetermined event from the input set is destined to occur. The pairs other than the actual input-output pair are included to illustrate counterfactual cases for the sake of a real-world-like appearance. These cases are also included in Type-1 D knowledge. Now, suppose that reception of D knowledge occurs immediately before a particular event in the input event set does. Then:

$x_D = x_k$ (x_D is reduced to x_k.) $\quad 1 \leq k \leq n$

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[4] A representation-bearer is a means through which an object being represented is thought/perceived by an agent. See Frankish & Ramsey (2012, p. 9).

[5] Connectionism suggests that "individual neurons do not transmit large amounts of symbolic information" and that "they compute by being appropriately connected to large numbers of similar units" (Feldman & Ballard, 1982, p. 208).

[6] Testing whether a connectionist-based AI could think like humans may require a different approach like Schneider's (2019) ACT test (p. 54)."

x_D = Reception of D knowledge
$y_D = y_k$
y_D = Response to reception of D knowledge
To illustrate the triviality of the simulated world, let us consider a hypothetical scenario involving a clinical psychologist named “Millicent” (or simply “Millie”). She loves coffee but often hesitates whether to drink it. One morning, she decides to have a coffee anyway while watching a seminar video through a tablet device. The following *event* mappings are established for her in atomic-sentential form:
x_1 = The seminar tires me.
x_2 = The coffee does not convince me of insomnia.
x_3 = The coffee convinces me of insomnia.
y_1 = I stop watching.
y_2 = I keep drinking.
y_3 = I stop drinking.
However, since the world is deterministic, only one particular event such as x_1 would have been configured to occur. Meanwhile, in a metaphysical sense, it is possible to assume that specific descriptions in the D knowledge could be provided to her immediately before x_1 happens. Suppose that her tablet displays not only the above mappings but also a short history of her activities in the morning and the events to unfold throughout the day. How would she respond?
From a humanistic perspective, there must be a distinct mental representation corresponding to the event of “I see the descriptions.” However, Millie’s rigid processing mechanism would only be able to interpret the sight of the display as one of $\overline{x}_1$ to $\overline{x}_3$. Recall that Millie’s mind follows the classical computer model whose representation-bearers are data structures. Since she only executes rigid processing, a bit structure corresponding to her symbolic representation of the event would most probably be translated to a particular bit structure corresponding to one of $\overline{x}_1$ to $\overline{x}_3$. Suppose that it is interpreted as $\overline{x}_3$. Then, her processing mechanism would output $\overline{y}_3$, which should be accompanied by y_3. In other words, she would probably stop drinking her coffee in response to receiving the D knowledge. This result is not surprising because only the predefined sets of inputs/outputs were configured for the simulated world.
1.2 Type 2
If the D knowledge specific to the original world were provided to its agent, the agent would process reception of the D knowledge as a different input event than all the other previous potential input events. This means that the agent’s processing mechanism exhibits emergent processing, as it can distinctly identify a particular input event that was not supposed to happen. Further, it is possible (rather than necessary) that the D knowledge only *reflects* every physical event across time. Unlike Type 1, this type of D knowledge (namely, Type 2) does NOT include counterfactual cases. Also, this knowledge is compatible with the block universe theory.
In the block universe model, “[w]hether past, present or future, all events ‘lie frozen’ in the four-dimensional block, much like the scenes from a movie are fixed on the film roll” (Thyssen, 2020, p. 6). If one were to see the events of the universe like fixed scenes on a film roll from an omniscient viewpoint across time, she might be able to extrapolate to a certain extent counterfactual cases in relation to those events.

However, the scenes themselves do not include such information. In that sense, Type-2 D knowledge only mirrors the physical events.

Despite its assertion that the past, present, and future all coexist, the block universe theory does not demand absolute causality. Polkinghorne (2007) notes that "[b]elievers in the block universe are not forced to commit themselves to a deterministic account of its causal structure" (p. 977). Nevertheless, we assume that *emergence* of a new output in response to D knowledge reception ("x_{n+1}") is necessary in a metaphysical sense, considering that the agent's processing mechanism is assumed to be governed by causality. However, the *content* of the new output may be deterministic or non-deterministic. This is highlighted by the question mark in the mappings below. The pairs other than the actual input-output pair are provided as dummies whose contents are unknown (which means that the counterfactual cases are unknown). In addition, "x_{n+1}" is included in parentheses to illustrate its distinction from the other dummies.

$I = \{x_1, x_2, \ldots, x_n, (x_{n+1})\}$

$O = \{y_1, y_2, \ldots, y_n, (?)\}$

$x_D = x_{n+1}$ $y_D = ?$

If the Millie scenario happened in the original world, she might have been struck to the core and asked, "Am I living in a Matrix?" by emergently interpreting her reception of D knowledge.

But how can we be certain that the real Millie would respond differently from her simulated counterpart? Recall from the paper's first footnote that contemporary metaphysicians (e.g., Vihvelin (2023)) accept the metaphysical possibility of time travel to the past. Time travel would not simply suggest the displacement of one's body. It would also mean that the time traveler could bring some of the accumulated knowledge about the world to the past. In this case, it would be hard to imagine that an agent in the past would show only a robot-like reaction to the knowledge of her future.

1.3 Type 3

Now assume that the original world is thoroughly deterministic in a *causal* sense. Then, one can entertain the idea that its agent's decision-making processes are strictly deterministic in a metaphysical as well as physical sense. Specifically, the agent should produce a new output (whose content is deterministic) in response to receiving D knowledge of Type 2. This hypothetical situation would generate a derivative version of D knowledge (namely, D'). Then, the agent should produce another output in response to receiving D', thereby generating another derivative version of D knowledge (namely, D''). To aid in understanding this somewhat complex scenario, let us go back to the Millie story. With regard to the Millie of the original world, D' knowledge might state as follows:

"Millie responds to D knowledge. She speaks, "Am I living in a Matrix?"

D'' knowledge might state:

"Millie responds to D' knowledge. She speaks, 'I might need to take some medication to calm my caffeine-induced paranoia. Or maybe this world that I'm living in was monstrously rigged, and I must somehow survive by figuring out how I first reacted to… I don't know, but it seems like this situation that I'm in happened already once before, and I must figure out whatever this evil gadget had said in the first place. Let me think… Whatever action I take right now, was that also predetermined?'"

See the following formal mappings:

$I = \{x_1, x_2, \ldots, x_n, (x_{n+1}), (x_{n+2}), \ldots \}$

$O = \{y_1, y_2, \ldots, y_n, (y_{n+1}), (y_{n+2}), \ldots\}$

$x_D = x_{n+1}$ $y_D = y_{n+1}$

$x_{D'} = x_{n+2}$ $y_{D'} = y_{n+2}$

… …

The above mappings may develop indefinitely.[7] All these potentially infinite counterfactual cases are included in Type 3.[8] Further, it can be said that this type of knowledge *is generated by* an inherent configuration of the world.[9] For instance, Tegmark (2008) argues that it is "plausible that our universe could be simulated by quite a short computer program" (p. 18). Based on the idea that "our universe *is* mathematics" (p. 1), he maintains that its realization only requires storage of "all the 4-dimensional data" (i.e., all the "[encoded] properties of the mathematical structure that is our universe") (p. 18). He states that a "complete description" of a mathematical structure is "a specification of the relations between the elements" of the mathematical structure (p. 18). As such, the 4-dimensional data primarily relate to the abstract realm of mathematics. If his argument is true, we would not need any type of D knowledge (consisting of verbal descriptions in atomic-sentential form) to simulate a universe. Rather, D knowledge would be a byproduct of the mathematical structure and its specification.

2. The Vantage Point Problem

This section explores how to address the "vantage point problem" using the concept of D knowledge. Let us first look into two philosophical cases where this problem has not been properly addressed.

(1) Tegmark[10] (2008) asserts that "[t]here exists an external physical reality completely independent of us humans" and that "[o]ur external physical reality is a mathematical structure" (p. 1). However, despite presenting convincing arguments, he still fails to address the vantage point problem. In footnote 3 on p. 5, he notices the problem of how a mathematician should derive, through (i) a mathematical structure alone, (ii) an empirical domain and (iii) "a set of correspondence rules

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[7] Similarly, Sterelny (1990) notes that the "ability to think about the world as it is and as it might be, to think indefinitely many and indefinitely complex thoughts" may be a "necessary condition on having intentional states" (p. 29).

[8] When considering the infinite counterfactual cases, we see that no predefined type of D knowledge (i.e., Type 1) can exist that dictates a non-trivial world.

[9] This configuration may be unidentifiable as demonstrated in the Kantian antinomies (Kant, 1998, pp. 470-495).

[10] Tegmark is a determinist. He supports Einstein's dictum that "God does not play dice" (p. 10).

which link parts of the mathematical structure with parts of the empirical domain." He hints at a possibility of achieving this by introducing a "car" analogy. Specifically, "given an abstract but complete description of a car (essentially the locations of its atoms)," "someone" that wants "practical use of this car" might "be able to figure out how the car works and write her own manual" by "carefully examining the original description." Simply put:

"Someone" → Mathematician

Car → Universe

Description of the car → Mathematical structure of the universe

Practical use of the car → Empirical domain of the universe

Knowledge of how the car works → Correspondence rules linking the mathematical structure with the empirical domain

While the mathematician is a part of the universe, that "someone" is not a part of the car. Therefore, the car analogy fails. The analogy would have been more accurate if the "someone" had a complete description of *both* herself and the car.[11] Tegmark's case is one instance illustrating a common mistake made by scientists as well as philosophers – namely, the confusion that arises from the vantage point problem.

(2) Dennett (2003) notes that "confusion [over determinism] arises when one tries to maintain two perspectives on the universe at once" (p. 93). One perspective is the "God's eye" perspective, and the other is the "engaged perspective of an agent within the universe." His description of the former perspective coincides with the Parmenidean view of the universe. He adds that "[f]rom the timeless God's-eye perspective nothing ever changes," as "the whole history of the universe is laid out 'at once.'" Dennett appears to give equal weights to both perspectives but cautions against assuming them at the same time. He does not provide a philosophical scheme where both perspectives can coexist. Specifically, he does not reveal how it is possible for the agent *within* the universe to assert determinism from a provisional God's-eye perspective.

The above two cases illustrate the ongoing struggle of scientists and philosophers to reconcile the discrepancy between a human agent making a declarative statement (i.e., a deterministic worldview) about the universe at large and the universe where the agent belongs. It is believed that this paper has resolved this issue to a certain extent. Unlike machines, human intelligence is capable of emergently processing -- to use a bit of an oxymoron -- even "otherworldly but comprehensible" knowledge (i.e., D knowledge). By definition, D knowledge is an entirety of verbal descriptions

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[11] Even if she had all the information regarding her mind/body as well as the car from a materialistic viewpoint, she might still fail to explain how her bodily composition gives rise to consciousness. Even a complete mathematical formulation of the neural correlates of consciousness may not fully elucidate its nature. Such an "epistemological limitation" may be a necessary feature of consciousness, as "the transcendental standpoint is in a sense irreducible, for one cannot look 'objectively' at oneself" (Žižek, 2012, p. 239).

encompassing the whole universe. This type of knowledge is inherently inaccessible; therefore, it can be considered to exist in an "otherworldly" realm. Nevertheless, it is deemed "comprehensible" from the human agent's perspective, as evidenced by its capacity to provide a non-trivial response to D knowledge. This has a metaphysical implication that the human agent could potentially view the universe from a vantage point situated in a realm beyond the universe despite actually being a part of the universe. However, for machine intelligence, D knowledge is neither "otherworldly" nor "comprehensible." In fact, there is no type of information at all that can be genuinely comprehended by machine intelligence. This is illustrated through the triviality of responses it might generate with regard to D knowledge in subsection 2.1.

Further, the same level of triviality could be said to be exhibited by a hypothetical agent whose declaration of determinism should be assumed to be inseparable, in a pancomputational[12] sense, from all the other events of the world. Specifically, in a world without a qualitative distinction between the two (i.e., espousal of determinism and the other physical phenomena), the agent (possibly a machine one) would have no motivation in the first place to assume a higher "vantage point" from which to view the world. Roughly speaking, in such a world, no scholarly debate on determinism would have any meaning. If our universe is to be depicted differently from that world, a determinist's declaration of determinism should by necessity stand out by acquiring a particular metaphysical meaning amidst all the events of the universe. This is achieved by granting a privileged status to the determinist regardless of the truthfulness of her argument. She deserves the status because of her inherent capacity to comprehend D knowledge.

Finally, note that this peculiar dynamic between the determinist's philosophical mind and the universe can be best described through a dialectic circle in Maybee (2020, Section 1). Before the determinist decides on the determinacy of the events of the universe, these events must first be placed within her scope of thoughts. In other words, they should become the objects of her speculative investigation. Then, as she declares determinism, she realizes that the entire process (from her investigation up to the declaration) is also part of the deterministic scenario of the universe. Subsequently, she concludes from a transient God's-eye perspective that every time she declares determinism, this would have also been predetermined. In hindsight, she realizes that her conclusion was also predetermined.

The above process continues,[13] thereby generating the dialectic circle. It expands as the determinist's mind and the objects/events of the universe continue to encircle each other in an alternating manner. This type of circle provides a more nuanced illustration than the image of "eye" of the "metaphysical subject" encapsulated within "the field of sight" in Wittgenstein (1922, p. 75), as well as a different image that one may newly draw by placing the eye outside the field of sight.

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[12] According to pancomputationalism, "everything is a computing system" and "minds are computing systems too" (Piccinini, 2007, p. 95).

[13] This type of infinite progression is believed to be a central feature of philosophy, as seen in examples such as Kripke's "Kripkenstein," Derrida's "différance," the Liar Paradox, and Lao Tzu's Taoism.

3. Conclusion

The main ideas of this paper can be outlined as follows.

(1) Deterministic knowledge

- Type 1
  - Dictates the world.
  - Includes finite counterfactual cases.
- Type 2
  - Reflects the world.
  - Includes no counterfactual cases.
- Type 3
  - Is generated by the world.
  - Includes infinite counterfactual cases.

(2) Deterministic worlds

- Trivially deterministic world
  - Its agent executes rigid processing.
- Non-trivially deterministic world
  - Its agent executes emergent processing.

Based on the above conceptual scheme, this paper has sought to distinguish human from machine intelligence by allowing for hard determinism. In accordance with this scheme, it attempted to justify a determinist's assertion of determinism by placing the determinist within the universe.

However, this paper may face several challenges from readers. First, one might point out that the paper relies only on metaphysical speculation and lacks empirical support. However, many philosophical ideas are inherently speculative, aiming to look beyond the realm of empirical science. Despite their purely speculative nature, they can meaningfully influence the empirical world. For instance, this paper's framework can be taken as a normative model for human vs. machine intelligence. Under this model, we can imagine measuring the level of enhancement in a connectionist-based AI by studying its response to a history of its replica provided as a certain kind of "D knowledge."

Second, one may argue that the "vantage point problem" is not really a problem. She may have no difficulty accepting the idea that a determinist can describe the universe from a viewpoint situated within the universe. She can conveniently appeal to the causality principle to support determinism. However, causality itself does not tell us very much about *her* particular status as an intellectual being. If she conflates herself with mindless machines in accordance with pancomputationalism, her concern for the truth of determinism becomes insignificant. Philosophical truths are dead issues to mechanical beings. What this paper has done is illustrate a subtle difference between human and machine intelligence by assuming that both adhere to causality.

Third, one could suggest that this paper seems to beg the question by assuming from the beginning that the original and simulated worlds are already different. Indeed, this is a notable limitation of the paper. Nevertheless, the author believes that it provided one original instance of a logical possibility where machines fall short of human intelligence.

This paper has additional limitations. The conception of D knowledge, for example, may be deemed questionable by quantum physicists. They argue that describing physical events through exact spatial/temporal coordinates on the quantum level is impossible in principle. Additionally, the paper cannot explain the phenomenon of qualia or a sense of agency and free will. These problems require further study.

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References

REFERENCES

Carnap, R. (1947). Meaning and Necessity. University of Chicago Press.

Danielsson, U. (2023). The World Itself: Consciousness and the Everything of Physics. Bellevue Literary Press.

Dennett, D. C. Freedom Evolves. Penguin Books, 2003.

Feldman, J. A., & Ballard, D. H. (1982). Connectionist Models and Their Properties. Cognitive Science, 6(3), 205-254.

Frankish, K., & Ramsey, W. (Eds.). (2012). The Cambridge Handbook of Cognitive Science. Cambridge University Press. https://doi.org/10.1017/CBO9781139033916

Kant, I. (1998). The critique of pure reason (P. Guyer & A. W. Wood, Eds. and Trans.). Cambridge University Press.

Maybee, J. E. "Hegel's dialectics." In The Stanford Encyclopedia of Philosophy, edited by E. N. Zalta, Winter 2020 edition. Stanford University, 2020. https://plato.stanford.edu/archives/win2020/entries/hegel-dialectics/

Müller, V. C. (2014). Pancomputationalism: Theory or metaphor? In R. Hagengruber & U. Riss (Eds.), Philosophy, Computing and Information Science (pp. 213-221). Pickering & Chattoo.

Piccinini, G. (2007). Computational Modelling vs. Computational Explanation: Is Everything a Turing Machine, and Does It Matter to the Philosophy of Mind? Australasian Journal of Philosophy, 85(1), 93–115.

Polak, P., & Krzanowski, R. (2019). Deanthropomorphized Pancomputationalism and the Concept of Computing. Foundations of Computing and Decision Sciences, 44(1), 45-54. https://doi.org/10.2478/fcds-2019-0004

Polkinghorne, J. (2007). Space, time, and causality. Zygon, 41(4), 975-984. https://doi.org/10.1111/j.1467-9744.2006.00792.x

Schneider, S. Artificial You: AI and the Future of Your Mind. Princeton University Press, 2019.

Schwartz, S. P. A Brief History of Analytic Philosophy: From Russell to Rawls. Wiley Blackwell, 2012.

Sterelny, K. (1990). The representational theory of mind: An introduction. Basil Blackwell.

Tegmark, M. (2008). The Mathematical Universe. Foundations of Physics, 38, 101-150. https://doi.org/10.1007/s10701-007-9186-9

Thyssen, P. The Block Universe: A Philosophical Investigation in Four Dimensions. Doctoral dissertation, KU Leuven, Humanities and Social Sciences Group, Institute of Philosophy, 2020.

Vihvelin, K. (2023). Determinism, Counterfactuals, and the Possibility of Time Travel. Philosophies, 8, 68. https://doi.org/10.3390/philosophies8040068
Wittgenstein, L. Tractatus Logico-Philosophicus. Project Gutenberg, 1922. https://www.gutenberg.org/ebooks/5740
Žižek, S. (2012). Less Than Nothing: Hegel and the Shadow of Dialectical Materialism. Verso.