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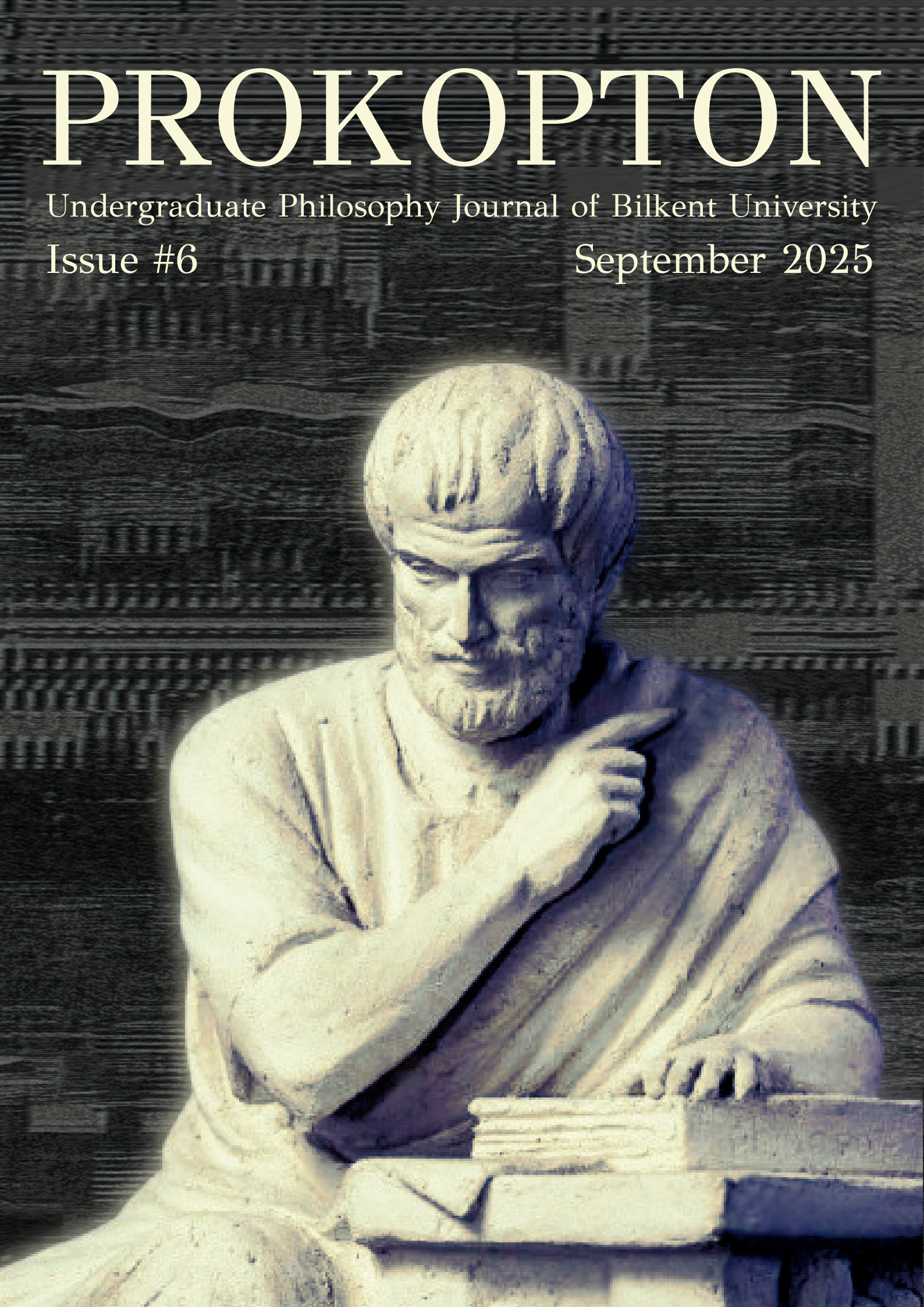

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Beyond the Linear Model: A Holistic Approach to Funding Equitable and Sustainable Innovation

Asmin Elif Karaçöp | Bilkent University

Introduction

Linear model of innovation is a framework that describes the sequential process where basic scientific research leads to applied research, technological development, and economic growth. This paper analyzes the dual-edged nature of this model, which has facilitated significant industrial advancements while also causing long-term societal and environmental challenges. It seeks to answer the research question: how does this dual-edged nature inform the debate on the funding of scientific research? To do so, the paper first outlines the theoretical critiques of the model's simplicity and market-driven priorities, drawing on Godin (2005) and Mirowski (2011). It then supports these critiques with empirical case studies of innovations like tetraethyl lead (TEL), chlorofluorocarbons (CFCs), and asbestos. Building on this analysis, I argue that the linear model should be replaced by a more holistic framework that integrates sustainability and equity. A key implication of this shift is that government funding of scientific research is preferable to reliance on the private sector. Governments, as the entities ultimately responsible for mitigating negative externalities, are more inclined to prioritize long-term public welfare in funding, advertising, and distributing scientific innovations.

The Linear Model of Innovation: Historical Origins and Critiques

In this section, the historical origins and fundamental flaws of the linear model will be identified through the work of two key critics. First, Benoît Godin's historical analysis reveals the model's oversimplification of the innovation process. Second, Philip Mirowski's critique highlights its instrumentalization for geopolitical and market-driven ends, often at the expense of societal good. Together, their work exposes the model's inherent inability to address complex global challenges. By tracing the historical evolution of the linear model, this analysis underscores its limitations in addressing the broader impacts of innovation.

For starters, Benoît Godin's historical construction of the linear model, in *The Linear Model of Innovation: The Historical Construction of an Analytical Framework* (2005),

highlights its origins and development as an analytical framework for understanding innovation. He argues that the linear model oversimplifies the innovation process by presenting it as a straightforward progression from basic research to applied research and ultimately to marketable products or outcomes. According to Godin, this narrative fails to account for the iterative, dynamic, and non-linear nature of innovation, where feedback loops and interactions between different stages often play a critical role.

The model's adoption as a dominant framework emerged partly because of its utility in policy-making and resource allocation, particularly in promoting basic research as the foundation for technological advancements. However, Godin underscores that this framework overlooks the complexities of societal needs, institutional dynamics, and the multifaceted relationships between research and application. By focusing exclusively on causality and economic benefits, the linear model neglects the broader societal and ethical dimensions of innovation.

Philip Mirowski (2011) builds on this critique by tying the linear model to Cold War-era science policy, as discussed in his book *Science-Mart: Privatizing American Science*. Mirowski argues that the institutionalization of the linear model during the Cold War was driven by geopolitical imperatives, particularly the race for industrial and technological dominance between the United States and the Soviet Union. Governments and institutions embraced the model as a justification for public investments in scientific research, emphasizing its potential to produce tangible outcomes that could strengthen national security and economic competitiveness.

Mirowski critiques this approach for its instrumental focus on innovation as a tool for power and profit, often at the expense of broader societal implications. The prioritization of research with immediate industrial or military applications marginalized other fields of inquiry and neglected the ethical, social, and environmental consequences of technological advancements. This critique exposes the inherent bias in the linear model towards market-driven outcomes, which can perpetuate inequalities and fail to address the root causes of societal challenges.

Both Godin and Mirowski highlight the linear model's failure to integrate societal and ethical considerations into the innovation process, with Godin focusing on its structural oversimplifications and Mirowski emphasizing its instrumental role in market-oriented research. The model's reductionist view of innovation fails to consider the iterative, collaborative, and interdisciplinary processes that are often essential for solving global issues like climate change, health crises, and social inequality. Furthermore, the focus on causality and economic benefit may lead to the

exclusion of marginalized voices and alternative approaches to innovation. While Godin underscores the model's lack of complexity and Mirowski highlights its market-driven priorities. Building on the critiques of Godin and Mirowski, which the following section will empirically substantiate, I argue for a holistic perspective on science funding, advocating for government-led research initiatives.

The Dual-Edged Nature of Innovation: Case Studies

The theoretical critiques raised by Godin and Mirowski are starkly illustrated by historical examples of innovations developed under the linear model paradigm. While this model spurred industrial growth through groundbreaking innovations, it often neglected broader societal and environmental considerations. By examining government policies, funding patterns, and the outcomes of specific innovations, this paper will eventually posit that the linear model incentivized short-term economic gains at the expense of long-term sustainability.

The linear model of innovation has driven significant industrial growth through groundbreaking technologies like tetraethyl lead (TEL), chlorofluorocarbons (CFCs), and asbestos. These innovations, funded and commercialized largely by private entities, provided substantial economic benefits and revolutionized industries such as automotive, refrigeration, and construction. However, the long-term societal and environmental costs of these innovations have been severe. TEL contributed to widespread lead pollution, harming public health, particularly of children. Similarly, CFCs, while initially celebrated for their role in refrigeration, caused significant ozone depletion, leading to increased risks of skin cancer and environmental damage (Edelmann, 2015). Lastly, Asbestos, widely used for its fire-resistant properties, resulted in devastating health crises, including lung cancer and mesothelioma (Paluch, 2025).

These cases reveal a recurring pattern: the linear model of innovation often fails to integrate precautionary measures, assess risks, or consider the broader implications of technological advancements. Governments, as the entities ultimately responsible for addressing these negative externalities, bear the financial and societal burden of cleanup, healthcare, and regulation. This responsibility provides governments with a strong incentive to prioritize sustainability when funding and overseeing scientific research. The presumption that innovation inherently benefits society overlooks critical factors, such as health crises, environmental degradation, and the economic costs of remediation. The model's narrow focus on economic gains has historically led to unintended consequences that outweigh the initial benefits.

To address these issues, future innovation frameworks must adopt a systems approach that integrates sustainability into every stage of research and development. Policymakers and funders should emphasize long-term goals and align incentives with societal and environmental well-being, moving beyond the limited scope of the linear model. By learning from the unintended consequences of TEL, CFCs, and asbestos, we can refine innovation frameworks to balance economic growth with the public good, ensuring a more responsible approach to technological progress.

A Holistic Approach to Science Funding

As demonstrated above, the theoretical limitations and empirical failures of the linear model necessitate a shift toward a more holistic framework for innovation. This framework would integrate sustainability, equity, and ethical considerations at every stage of research and development, thus, moving beyond a narrow focus on market-driven outcomes. A primary implication of adopting this holistic approach is the reaffirmation of government's central role in funding and guiding scientific research.

Government funding for initial research in developing new technologies is essential due to the public good nature of such research. Early-stage research often exhibits characteristics of public goods—it is non-excludable and non-rivalrous, meaning that the benefits cannot be confined to those who invest in it. As a result, private firms are often unwilling to allocate sufficient resources to foundational research because they cannot fully capture its benefits and may face free-rider problems. By providing funding, governments ensure that critical research is conducted, enabling the development of foundational innovations that private firms can later build upon and commercialize.

Moreover, technological innovations, while valuable, frequently come with negative externalities, such as environmental degradation, societal disruption, or health risks. For example, industrial innovations might lead to pollution, or new technologies like artificial intelligence might create privacy concerns (Clark, 2003). Governments, as regulators, are already equipped to address these externalities through policies and enforcement mechanisms. By being involved in the research and development stages, governments can proactively design regulations and safeguards to minimize risks. This ensures that emerging technologies are developed responsibly and align with societal values, thereby reducing the likelihood of harmful consequences (Douglass, 1999).

Empirical analyses support this view. Carlos Henrique de Brito Cruz (2024) examines research funding organizations and their alignment with the UN Sustainable

Development Goals (SDGs). He demonstrates how public funding mechanisms can effectively prioritize research that promotes equitable and sustainable development. For instance, government initiatives often emphasize capacity building, inclusivity, and interdisciplinary approaches, which are critical for addressing complex global challenges like poverty, education, and clean energy.

Similarly, the South African Department of Science and Innovation's (2021/22) report on government funding highlights the strategic benefits of public investment in research. The report showcases how government-led frameworks have supported technological advancements and societal progress by prioritizing research areas with high social impact, such as renewable energy and public health. These efforts mitigate the negative externalities often associated with market-driven innovation, such as environmental exploitation and socioeconomic inequality.

The high-risk, long-term nature of developing new technologies further necessitates government involvement. The private sector often avoids investing in areas where profitability is uncertain or where the timeline to returns is lengthy (Clark, 2003). Government funding helps absorb some of this risk, enabling innovation in fields that might otherwise remain unexplored. By sharing the financial burden of early-stage research, governments encourage private sector participation in subsequent stages, thus, facilitating the commercialization of socially beneficial technologies that might not otherwise attract investment.

Governments also play a critical role in creating the infrastructure needed for the commercialization of new technologies. Beyond funding research, they can establish ecosystems that foster innovation by building infrastructure, offering tax incentives, and supporting early adopters of new technologies. This comprehensive involvement bridges the gap between research and market readiness, ensuring that innovations transition smoothly from laboratories to real-world applications. Without such support, the commercialization process may become fragmented, limiting the societal impact of technological advancements.

Lastly, a holistic approach recognizes that government funding aligns technological progress with long-term societal benefits. Governments can prioritize funding for research that addresses pressing global challenges, such as climate change, clean energy, and healthcare. By steering innovation toward these critical areas, governments ensure that new technologies contribute meaningfully to societal well-being while mitigating potential risks. This strategic involvement ensures that

technological advancements are not just economically beneficial but also serve the public good, addressing both current and future societal needs.

It is important to note that this argument presents a normative view of government's role based on its unique responsibility for public welfare. Governments *should* fund this research because they *are* the entities ultimately tasked with managing its consequences. While not all governments consistently prioritize sustainability, the institutional mandate and accountability mechanisms inherent in democratic governance make it the most suitable entity to fund research within a holistic framework.

Conclusion

In conclusion, by tracing the limitations of the linear model through theory and case studies, this paper has argued for its replacement with a more holistic framework. This framework integrates sustainability and societal equity at every stage of the research and development process. A critical component of this shift is a reaffirmation of government's role in funding science, as its responsibility for the public good aligns with the long-term, risk-aware perspective that holistic innovation requires. Therefore, a vital question for future research and policy is: *How can innovation frameworks be concretely designed to operationalize sustainability and equity?* Addressing this question will ensure that technological advancement truly serves the public good and mitigates the unintended consequences of past advancements.

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Cardinality Criterion for the Integrated Information Theory

Ahmet Oğuz Yemenici | *Bilkent University*

Abstract

The Integrated Information Theory of Consciousness (IIT) is one of the most prominent theories in neuroscience. In this paper I offer a mathematical criterion to test out the theory's soundness. The theory (IIT 3.0) posits a mathematical object that can be generated in neural systems, called: *maximally irreducible conceptual structure* (MICS), while the latest version (IIT 4.0) employes a different mathematical structure called Φ-structures. Both of these versions later claim that every instance of a phenomenal conscious experience is *identical* to a MICS/Φ- structure. That is to say, the distinguishing features of a conscious experience from others, are in fact, nothing over and above the distinguishing features of a given MICS/Φ-structure to other MICSs/Φ-structures. This entails that the number of all possible and actual conscious mental states of a person is equal to the number of all possible and actual MICSs/Φ-structures that can be generated by that person's neural system. I argue that the cardinality of the class of all possible conscious mental states for a person, is at least countably infinite. Then on that basis, I argue that for IIT to be true, it needs to predict that the cardinality of the class of all MICSs/Φ-structures of a person should be greater or equal to countably infinite.

Introduction

IIT's main program is to detect the essential properties of every conscious mental state and axiomatize them (Tononi, 2015). The theory later turns these axioms into mathematical postulates to define a kind of mathematical construct that has the characteristics of conscious mental states (Albantakis et al., 2023, p. 3-5). One of the key claims of the theory states that the physical substrates which realize this type of mathematical construct generates consciousness (Albantakis et al., 2023, p. 5). In that way, theory hopes to achieve a quantized model for conscious experiences.

The essential properties that are axiomatized by IIT, to be a conscious mental state are: *existence*, *intrinsicality*, *information*, *integration*, *exclusion* and *composition* (Albantakis et al., 2023, p. 5). The *existence* axiom simply states that the conscious system exists. In some sense, it should be able to both affect and be affected by objects. The *intrinsicality* axiom is about the domain of this cause-effect potency, that is to say, the conscious system should be able to form cause-effect relations *intrinsically*. The next axiom is the axiom of *integration.* The axiom holds that conscious experiences are unitary. In a sense, it states that there can be only one conscious state at a time. (i.e., the composition of the experience cannot be divided into smaller pieces that are also conscious states themselves.) The *information* axiom states that every conscious mental state is unique. There is always a distinguishing feature between two seemingly similar mental states. The *exclusion* axiom is about the *borders* of conscious experiences. In this lexicon, the axiom states that a conscious experience has a specific content and nothing more. And the last axiom, *composition*, concerns simply with the fact that there is a structure to conscious experiences. For example, in spatial experiences there is a left and a right side of the sight.[1]

The key aspect of the IIT for this paper is the identity claims of the theory. The former version of the theory, IIT 3.0, holds that every conscious experience or *quale*[2] is identical to a mathematical structure called *maximally irreducible conceptual structure* (MICS), also named as *quale sensu lato* (Tononi, 2015).

1 The six axioms and their correspondent postulates hold relatively small importance to the content of this paper. Therefore, this brief paragraph will be all that is dedicated to them. More detail can be found in the bibliography.

2 *Quale* denotes spesific and individual mental states (e.g., tasting Döner, having paizzn or seeing a red apple for the first time) (Tye, 2021).

MICSs are mathematical forms which qualifies physical substrates to be realizers of conscious experiences. The physical substrates in question might be neural systems or any other physical entity that can generate MICS. For example, the particular conscious mental state of person *A*, tasting döner while listening traffic noise at 7:34 pm. 14 July 2023, is identical to a specific MICS that is generated by person *A*'s neural system. If there was even a minute change that makes relevance to the experience, maybe less seasoning in the döner, then the conscious experience would be different as well as the MICS. It is important to note that the identity relation IIT 3.0 draws, is between conscious experiences (*qualia*) and MICSs. The identity is not between the conscious experience and the physical substrate of the conscious agent (Tononi, 2015). Thus, the theory commits that a particular döner tasting experience and the brain state which generates the relevant MICS, are not identical; the experience and the MICS's itself are.[3]

The latest version of the theory, IIT 4.0, holds *Φ-structures* to be identical with conscious experiences, not MICSs (Albantakis et al., 2023, p. 29). This version names the physical substrates that generate the Φ-structures as, *complexes*. In other terms, *complexes* which generate certain kinds of cause-effect structures are Φ-structures. IIT 4.0's notion of Φ- structures are similar to the IIT 3.0's notion of MICS, for the fact that they are both held identical to the conscious experiences. However, IIT 4.0 has a nuance in its identity claim: "IIT proposes an explanatory identity: every property of an experience is accounted for in full by the physical properties of the Φ-structure…" (Albantakis et al., 2023, p. 6). That is to say, a particular Φ-structure and its correspondent conscious mental state are identical in the sense that, every property of the mental state is captured and accounted by a correspondent property of the given Φ-structure.

Metaphysical Implications

IIT 3.0 endorses a metaphysically necessary connection between conscious mental states and their correspondent MICSs, for they are numerically identical. In other terms, a specific conscious mental state *X* cannot fail to exist as long as its correspondent MICS exists and vice versa. This picture also entails there to be a modal relation between these two:

[3] Due to this reason, IIT bypasses some objections that arise from holding mental states identical to brain states

(1) The number of all possible and actual conscious mental states of a person *A* that has the neural system *N*, is equal to the number of all possible and actual MICSs that can be and are generated by that neural system *N*.

The above modal claim is similar to this: The number of all possible and actual water molecules is equal to the number of all possible and actual H_2O molecules, for they are identical. The same is also the case for IIT's claim. This fact makes these two classes' cardinality equal.

IIT 4.0 on the other hand, offers a different type of identity claim: explanatory identity (Albantakis et al., 2023, p. 5-6). I take it that, the IIT 4.0 theorists want to subscribe a more moderate kind of identity that is not as strong as numerical identity. In the context of IIT 4.0, explanatory type identity seems to propose a one-to-one mapping between features of a conscious mental state and its unique Φ-structure. The said identity relation seems to resemble with a map of a territory. However, the map is so detailed that the map and the territory has the same complexity and details. It's as if, for each property of the territory, there is a property in the map. To illustrate it, let's say that conscious mental state *K* has the properties $P1 = \{F1, \dots Fn\}$ and correspondent Φ-structure has the properties $P2 = \{G1 \dots Gn\}$. IIT 4.0 does not want to endorse an identity between these two classes that would entail properties to be identical respectively such as $F1 = G1$, $F2 = G2 \dots Fn = Gn$. Rather, it employes a function to link class P1 to class P2, so that every property of conscious state *K*, will be accounted by correspondent properties in the class P2. Just like in IIT 3.0, we can make a modal claim of this sort for the IIT 4.0 as well:

(2) The number of all possible and actual conscious mental states of a person *A* that has the neural system *N*, is equal to the number of all possible and actual Φ- structures that can be and are generated by that neural system *N*.

We can make this claim because there is one-to-one match between conscious mental states and their unique Φ-structures. Just like we can say that the number of all territories and the number of their unique, equally detailed maps are equal. Therefore, in terms of cardinality, both versions of the theory have something in common. That is:

(3) The number of all possible and actual conscious mental states of a person *A* that has the neural system *N*, is equal to the number of all

possible and actual MICSs/Φ-structures that can be and are generated by that neural system *N*.

The Argument for The Criterion

IIT's soundness has been an issue of dispute. Critics tried to formulate objections regarding various aspects of the theory. Some objections stirred up the allegedly problematic methodology of the theory concerning the bridge between the axioms and postulates. Some others issued so claimed absurd consequences of the theory (Aaronson, 2014). A community even labelled IIT as pseudoscience (Fleming et al., 2023). Despite the objections, IIT is still considered to be a worthwhile option by many neuroscientists and philosophers.

I will offer a criterion based on the consequences of the theory's identity claims. The criterion is focused on the number of possible conscious mental states of an average conscious agent and the number of MICSs/Φ-structures for that agent, with the intend to compare them. If these two numbers do not match, then the identity claim of the IIT will be shown to be false. This conditional is all there is to the criterion that I propose. Here are some definitions and argument for the criterion:

Definition 1.) *N* is the neural system of the agent *A*.[4]
Definition 2.) *B* is the class of all MICSs/Φ-structures that can be and are generated by *N*. Definition 3.) *C* is the class of all possible and actual conscious mental states of *A*. Definition 4.) *P* is class of all atomic propositions.
Remark: *C* contains conscious mental states from possible & actual worlds only in which
N is the one and only neural system of *A*.

[4] "*A*" stands for any arbitrary conscious agent, whose complexity regarding conscious mental states are average. "*N*" stands for the *complex*, (i.e., physical substrate which realizeses consciousness.) *N* is *A*'s neural system or *complex*, in the sense that consciousness generated by *N* is directly available for only *A*.

The argument:

(4) If IIT is true, then the cardinality of *B* is equal to the cardinality of *C*.
(5) Cardinality of *C* is not smaller than $\aleph_0$.
(6) Therefore, for IIT to be true, the cardinality of *B* must not be smaller than $\aleph_0$.

The conclusion (6) is the criterion that is said to be presented. It posits that cardinality of class
B not being smaller than $\aleph_0$, is a necessary condition for IIT to be true.

Justification for The Premises

The first premise follows from the identity claims and the previously mentioned entailment of the theory: (3). Since theory claims that there is an equality between the number of MICSs/Φ-structures and conscious mental states of a person, the class of all of the former, should not be smaller than the class of the all of the latter. This is a rather straightforwardly extractable claim, considering the previously made explanations for the identity claims of the theory.

However, the second premise requires further external support. It basically posits that the class of all possible and actual conscious mental states that an average person can experience, has the cardinality not less than $\aleph_0$. That is to say, there are at least infinitely many possible conscious mental states available for an ordinary person. This claim can be supported with reference to atomic propositions. The feature of being the most basic/simple structures subject to truth bearing, makes them a great candidate for multiplying possible conscious mental states. This simplicity regarding the content, enables ordinary conscious agents to think about them without any cognitive hardship or constraints. If we were talking about compound propositions, we would hesitate to say the same due to complexity of semantic content.[5]

[5] Large compound propositions are complex contentwise. One can plausibly say that some complex compound propositions constructed by infinite conjunctions or dijunctions, cannot be thought by any conscious agents, let alone ordinary average ones.

It seems intuitive that there is a possible world for every atomic proposition, in which they are consciously being thought by an ordinary conscious agent, say previously defined *A*. In other words, there is no atomic proposition which cannot be subject to conscious thought of *A*.[6]

This entails that there are at least as many possible conscious mental states for *A* as there are atomic propositions. Thus, the class *C* has the same or bigger cardinality than the class *P*, the class of atomic propositions that is. It is known that the class of all atomic propositions, *P*, has the cardinality of $\aleph_0$ in first order logic. Therefore, we can hold that *C*'s cardinality is not less than $\aleph_0$ (i.e., the second premise).

Another way to justify the second premise might involve with sensory originated conscious states: visuals, sounds, tastes, etc. We can say that there are infinitely many different possible scenes or compositions including various sensory elements that can be presented to the conscious agent *A*. with these set ups, *A* would consciously experience all these different sensory compositions. For example, one sensory composition might be: "*A* is eating yoghurt in a freezing winter day, on top of a building with traffic noises coming beneath." There would be a unique conscious mental state, experienced by *A* for this scene. It seems *prima facie* that we can change this composition with little minute changes such that we can create very big amount of different sensory compositions. In fact, we don't even have to stict to the normal everyday sensory inputs. Since, we are dealing with metaphysical possibilities, we can construct compositions with bizarre "alien" sensory inputs. One such bizarre composition might be: "*A* is hearing a metaphysically possible sound *D*, while being touched by a metaphysically possible object *T*, with the metaphysically possible surface texture *G*." In this composition, *A* would experience a completely different conscious experience than the normal everyday ones. Thus, the thought is: there are infinitely many sensory compositions of which, *A* can experience unique conscious experiences for. That amounts to saying that there are at least infinitely many conscious experiences available to *A*.

[6] I assume that the thesis of cognitive phenomenology is true (i.e., there are conscious phenomenal experiences for entertaining cognitive activities/propositional attitudes.

Objection From Cognitive Limits

A critic might try to question the second premise (5). The objection is mainly grounded in the cognitive limits of average persons. Due to the argument's heavy reliance on the average persons and their mental states, critics may hope to question what are the cognitive limits of such persons and whether those limits permit the argument to work? Here are two assumptions that a critic may hold to object to the argument:

(7) An average person *A* can only consciously think of/comprehend propositions that are below a finite threshold in terms of semantic content load.

Let's accept that this threshold is up to one thousand letters/characters, that is to say, an average person cannot consciously comprehend propositions whose natural language translations have more than one thousand letters. Actually, the precise number does not matter, as long as it is finite. The next assumption is more controversial:

(8) The majority/more than half of the propositions that an average person *A* can possibly consciously think of, can be uniquely translated into natural language (i.e., English).

The assumption basically states that most of the propositions that can be thought by an average conscious agent *A*, are translatable to English.

With (7) and (8), the critic might proceed with a permutation to show that the number of the majority of the propositions that an average person *A* can consciously think of is finite. Let's hold (8) and translate the majority of the propositions that can be consciously thought by average person *A*. In light of (7), we know that no translated proposition has more letters than one thousand. Then how many propositions can be translated? We know that the number cannot be bigger than 26^{1000}. Because, we know that there are only one thousand letter slots (the limit mentioned in (7)) and 26 total letters in English. The first slot can be filled with any of the 26 letters and any other slot as well. With permutation, we can calculate the total number of variations. The result would be: 26^{1000}. In fact, most of the strings produced would be meaningless bundles of letters.

With this calculation we can infer that the number of the majority of the propositions that an average human *A* can consciously think of, is smaller than a

finite number. If the number of the majority/more than half of these propositions is smaller than some finite number, then the number of all of them must also be smaller than a finite number. Therefore:

(9) Average person *A* can only consciously think of finite number of propositions.

This claim undermines the justification of the second premise (5), because in the justification, it is stated that every atomic proposition can be consciously thought by an average person *A*. Since, the number of atomic propositions is infinite, the justification for (5) and the claim (9) contradicts.

Possible Reply

It can be argued that the average person *A* with having the same neural system *N*, exists in some class of possible worlds, which has infinite cardinality. In some of them, *A* is a villager and in others, *A* lives with aliens due to abduction. All these different sceneries *A* is faced to, causes different phenomenal experiences within his mind. Let's say that each world in the class makes *A* experience a totally unique experience, such that there are no two worlds which are equal in terms of experiences they provide to *A*. Since there are infinite number of worlds in which *A* resides, there are infinitely many distinct possible phenomenal mental states of *A*. Let's try to depict each of these experiences with propositions such that for each experience there is a unique proposition:

(10) "I experience Γ right now."

"Γ" is a variable for every phenomenal conscious state that *A* can possibly experience. Thus, there are infinite versions of the proposition (10) in which *A* can possibly believe or think about. However, none of the versions could be written down due to the private, ineffable nature of phenomenal conscious experiences. Therefore, there are at least infinite number of propositions, which can be consciously thought by *A* and are untranslatable to English. That would mean that the conjunction of assumptions (7) and (8), namely the thesis that the number of conscious mental states of *A* is a finite number, is at least intuitively false.

Conclusion & Last Notes

The question whether IIT complies with the criterion seems to be answerable on empirical basis. However, I suspect that the number of MICSs or Φ-structures that can be *realized* by an average human is a very large finite number, yet finite nonetheless. The biological make-up of neural system seems not to be able to generate infinite number of different relevant mathematical structures. After all, MICSs and Φ-structures are mathematical forms that are *realized* by states of the neural system (i.e., *complexes*). An average person's neural system, however, cannot produce infinite number of different neural states/*complexes*. Therefore, the neural system of a human cannot be the *realizing* substrate of infinite number of mathematical structures (i.e., MICSs and Φ-structures). Due to these reasons, I foresee that the IIT would fail the criterion.

In this paper, I explained the identity claims of Integrated Information theory, along with the basic features of it. My intention was to provide a criterion or a necessary condition that the theory needs to fulfill for being true. I focused mainly on the identity claims of the theory, for they are the subject to the criterion that I propose. It is shown that both versions of the theory, 3.0 & 4.0, entail there to be an equality between the number of conscious mental states of a person, and the number of mathematical entities (i.e., MICS/Φ-structures) of that person's neural system. The criterion is dedicated to test whether these two numbers were equal. If they are shown not to be equal, then it would be concluded that the theory is false. In order to support the criterion, I presented an argument entertaining a comparison of cardinality between classes of relevant kinds. Then, I tried to justify the premises with relying on: cognitive phenomenology and metaphysically possible sensory compositions' unique conscious mental states. Later on, I considered an objection concerning the cognitive limits of average conscious agents and intends to object to the second premise (5) of the argument. I proposed a line of thought which utilizes possible phenomenal experiences of an average conscious agents, in order to demonstrate the falsity of the consequence of the objection.

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I Do Not Exist, Never Existed, and Shall Never Exist

Ümit Ege Atakan | Koç University

Introduction

In problematizing the existence and identity of material objects, it has often been assumed that individual objects combine to form composite objects. However, is it necessary that composition always occurs? "The Special Composition Question" (SCQ) problematizes the very presumption of composition and claims that it is *not* a brute fact. Accordingly, it asks about the conditions in which composition occurs. It is the question for any individual object, when is it the case that there is a composite object such that the former composes the latter? (Ney, 2023, p.100). To avoid denoting individual objects the property of being a collection, Peter Van Inwagen (1990) introduces the plural variables and uses "∃ xs" (there exist some xs) instead of ∃x. When formalized in first-order predicate logic, the question becomes as follows: "For any xs, when is it true that ∃y (the xs compose y)?" (Ney, 2023, p.100), which is to be answered in the following form: "∀xs∃y (the xs compose y iff the xs . . .) where the ellipsis (. . .) is filled in by the condition required to get any xs to compose something" (Ney, 2023, p.100). This will be the context in which I will formulate and support my own non-existence.

Once the SCQ is asked there are several theories and answers available to us. Some of them are called the moderate views, others called the extreme views, as well as there is Inwagen's organist view. The arguments for and against each view need a detailed discussion worth an entire paper.[1] In this paper, I will only discuss Inwagen's organism and Unger's nihilism in relation to the SCQ. In the first section, I will introduce Inwagen's organism as well as mereological nihilism and offer Inwagen's criticism of nihilists. In the second section, I will offer my arguments against Inwagen's counterargument based on *sorites and paraphrasing*. In doing so, I will be able to explain Unger's nihilism as well. The third section will consider potential objections to my objections against Inwagen, which can be named arguments from epistemicism and—following Churchland's (1981) terminology—folk psychology, respectively. There, I will show why they fail to refute my arguments. In the end, we will see that *I do not exist, never existed, and shall never exist.*

[1] Roughly, the moderate views are the *Contact, Fastening, Cohesion*, and the *Fusion* views, whereas the extreme views are the mereological universalist and nihilist views (see Ney, 2023, pp. 100-109; Van Inwagen, 1990).

I. Inwagen and Mereological Nihilism: Do Xs Ever Compose Y?

What is Inwagen's organism? According to Inwagen, "(∃y the xs compose y) if and only if the activity of the xs constitute a life" (Van Inwagen, 1990, p.90). Why this is an organism, one may ask. Mainly because the term "life" refers to a biological composite object, we call organism (Van Inwagen, 1990, p.83). What follows is that for atoms to compose an object they must be doing a complex activity, which somehow results in life, in a functioning biological organism. In any other way, the mereological simples do not compose an object. However, if ordinary objects do not exist, how are we to make sense of our referring proper names, and accordingly, of our given language? Inwagen offers the paraphrasing method: if we paraphrase our ordinary propositions that commit us to the existence of things we do not want our ontology to commit to, then we would be able to talk about those things within our language without necessarily committing to them. Suppose the following proposition: "There are two cars in front of me". Now we should ask, are cars living organisms? No. Therefore they do not exist. Yet, the above proposition seems to commit us to their existence. What to do? Here is a potential Inwagen paraphrase: ∃xs∃ys(((C$_w$xs [xs are arranged car-wise] ∧ Ixs [the xs are in front of me]) ∧ (C$_w$ys [ys are arranged car-wise] ∧ Iys [the ys are in front of me])) ∧ xs ≠ ys). Here what we have accomplished is not to commit to cars but to things arranged car-wise.

Now I turn to mereological nihilism. What is mereological nihilism (henceforth, nihilism)? According to nihilists, only mereological simples exist and no simple come together—unless they are one, since they compose themselves—to compose another composite object (Ney, 2023, p.105). Hence the SCQ formulation appears as follows: "(∃y the xs compose y) if and only if there is only one of the xs" (Van Inwagen, 1990, p.73). It is important to see here that nihilists do not reject any existence once and for all (Schaffer, 2007, pp. 175-76; Sider, 2013, p.2). They are not claiming nothing exists, not even Peter Unger. What they are saying is that no arrangement of xs (if they are more than one) is beyond their p-wise arrangement: *there is nothing new in the picture.* Now, Inwagen is of course not happy with this because, after all, nihilism would imply the non-existence of even living organisms. He offers a counterargument against this nihilist view. It goes as follows:

> [P1] I exist. [P2] I am not a mereological atom. Therefore, [C1] At least one object exists that is not a mereological atom. Therefore, [C2] Nihilism is false. (Van Inwagen, 1990, p.73, as cited in Ney, 2023, p.106)

Now, if a nihilist would like to argue against the conclusion(s), she should argue against at least one of the premises above (given that the argument is valid). Arguing

against the second premise would lead us to some kind of substance dualism, which is outdated and also, I think, is not interesting. Accordingly, throughout the paper, I will be dealing with his first premise and show why it should be rejected. This way I can reject the conclusion as well.

II. Against Inwagen's "I Exist": Sorites and Paraphrase

First Objection: My Existence Reduced to Absurdity

Why does Unger think that he or any other human being does not exist? The answer lies in the sorites paradox. He uses the sorites *method* of decomposition to reduce our existence to absurdity (via the indirect method of supposing that he does exist and then arriving at inconsistencies/absurdities) (Unger, 1979). The absurdity achieved via indirect method will allow him to conclude that he does not exist. Before though, we should understand what sorites paradox is. The sorites paradox is a paradox based on the vagueness of composition and has two versions: "sorites of accumulation" and the "sorites of decomposition". I begin with the first one.

Now, consider again that I have a "composite car" in front of me, (if we believe in science and physics) we will say that it is "composed" of atoms. Suppose that a hundred billion atoms coming together "compose" a car. Hence it follows that just one atom can never give rise to a car. We go a step further. If one atom cannot give rise to a car, it seems, neither two atoms coming together can give rise to a car. Accordingly, if not two then not three, and if not three then not four, and so on. This means though that "if a hundred billion minus 1" atom cannot give rise to a car then neither can "hundred billion" atoms coming together. Therefore, a hundred billion atoms coming together cannot give rise to a car. This conclusion seems false, despite the premises being true.

Now to the second version I turn: *sorites of decomposition*, as articulated in Unger (1979). Decomposition has the same logic, only with the difference that now we start from the car and go backward: if a hundred billion atoms "compose" a car, then also "hundred billion minus 1" atoms do, and "if hundred billion minus 1" atoms do compose a car, so does "hundred billion minus 2" atoms, and so on. This means however that, in the end, we arrive at: "if two atoms 'compose' a car, so does one atom" and the conclusion: "one atom 'composes' a car", which is false despite the premises being true. Now, what Unger does is to apply these paradoxes to his own existence. He detects two presuppositions in the sorites paradoxes, which are according to him unscientific to object: first, that any physical object consists of atoms and a finite

number of them, and second, that removal of one or a few without replacement (in certain conditions that do not destruct the thing) should not make a difference in the that thing's existence (Unger, 1979, pp. 237-38, p.243). In addition to these, when he adds the indirect supposition of his own existence "I exist", it gives rise to inconsistency (Unger, 1979, p.243). Hence, we should reject it and say: *I do not exist.* All put in a premise form, we have:

> (1) I exist. (2) If I exist, then I consist of many cells, but a finite number. (3) If I exist (and consist of many cells, but a finite number), then the net removal of one cell, or only a few, in a way which is most innocuous and favourable, will not mean the difference as to whether I exist. (Unger, 1979, p.243)

Suppose that (as Inwagen argues) I exist, then I am made of cells and again of a finite number (and given that cells are made out of atoms, for the sake of argument we can use cells and atoms interchangeably). Now apply the sorites of decomposition: if I remove one cell out of me, I still do exist, if I remove two, I still am around. If three, still I am not going anywhere. This means that however at some point I will miraculously turn out to not exist (Unger, 1979, p.245). At some point, the removal of only one cell or a few would result in my non-existence (Unger, 1979, p.245).[2] Is this plausible? I do not think so. The same applies to accumulation as well: one cell does not compose me, and neither do two cells. Nevertheless, at some point miraculously the addition of one more cell (or a few) would result in my coming into existence out of non-existence. Can the addition of one cell would make such a difference? No. What decomposition and accumulation show is that I *did* not exist in the first place (Unger, 1979, p.245). So, we reject our first premise via an indirect method. When we accept Inwagen's "I exist", we end up with inconsistencies. Therefore, *I do not exist.*

Second Objection: I Do Not Exist But Arranged Me-Wise

Another refutation I would like to employ is with regard to a potential paraphrase of Inwagen's premise "I exist". Now, we can rewrite this in the first-order predicate form as follows: $\exists xs(\mathbf{MN}_{w}xs$ [xs are arranged MN-wise]).[3] Inwagen by

2 Note that the conclusions of the sorites paradoxes are always false, and that is why they are paradoxes in the first place. In our case, the conclusion is "one cell composes me", which is false. That is why I say I miraculously turn out to not exist, which would have been the true conclusion of a sorites case. Unger uses the sorites method to demonstrate how absurd is the supposition of his existence, he is not replicating the paradox in his argument.

3 MN is short for "My Name". In the original draft, I used my name in place of MN. Throughout the paper, to preserve anonymity, I will use MN instead of my name.

postulating "I exist" actually puts forward the presuppositions of his own theory as a refutation. The premise "I exist" already implies that a living thing is something that exists. It is almost like saying, "if 'I' is a living thing, then it exists". However, this conditional is what the nihilist rejects in the first place. After all, for the nihilist, although the antecedent may be true, the consequent is false ($T \supset F$). What follows is that Inwagen and nihilists differ in their presuppositions. Inwagen's reasoning is circular. He cannot simply posit "I exist" as a counterargument to nihilism, he needs to show why we should accept his presupposition in the first place. In other words, he must show why I cannot formulate "I exist" as an "MN-wise arrangement of xs".

III. Refutations of Potential Objections: I "Still" Do Not Exist

I anticipate two objections to my objections. With regards to the sorites argument one may argue against the third premise by saying that the premise has an implicit presupposition: there is "no critical point" where the addition or removal of one cell makes a difference and so everything is gradual (Unger, 1979, p.239). That is why, they would argue, Unger claims that if we accept our own existence, at some point we should expect a miracle such that suddenly we come into existence out of non-existence or become non-existent out of existence. However, there is no miracle. Ontologically speaking, there may be a breaking point where the addition or removal of one cell makes a difference, although we can never know it. This would be a counterargument from epistemicism against Unger (and me thereof).[4] Now how to respond to it? If epistemicism is true, then at some point *ontologically* just a minus or plus one cell should make a difference. This would imply, for instance, that at the *six billion and hundredth* cell I exist, and yet at the *six billion and ninety-ninth* cell, I do not exist. Is this plausible? Not at all. The problem we face when we posit our existence is not about *knowing the n-th number* at which I decay into non-existence, it is just that it is *nomologically impossible* that "one unit change" in atoms/cells makes any difference in a world governed by our physical laws.

Now I turn to the second possible objection, which I think is a strong one: if we paraphrase "I exist" as "xs arranged p-wise", how are we to give an account of propositional attitudes such as "I believe that p" as well as statements like "I think that p" and "I feel that p". In other words, If the "I" does not exist, how are we to explain the fact that we think, believe, and feel, and so on? Fair enough. However, I do not think we are at an impasse. Paul Churchland (1981) shows us that our folk psychology is misguided and when we use propositional attitudes such as "I believe" we are

4 Epistemicism claims that vagueness results from ignorance, that is from us not knowing the existing critical boundaries and not from the fact that there is no breaking critical point in the physical world (Ney, 2023, p.110).

actually referring to neurophysiological and electrochemical firings occurring in our brain and nothing else, and accordingly, our folk psychological language can be revised (eliminated) to coopt with the scientific developments in neuroscience (Churchland, 1981). He argues that statements including propositional attitudes are in "logical form" not different than those scientific laws and so a paraphrase of the former in the language of the latter is always possible (see Churchland, 1981, p.82). Now, in a way by combining Churchlandean paraphrase and Inwagen's method, I can paraphrase "I" "believe", "feel", and "think" in a similar fashion.

I offer the following: "I believe that there is a car" can be paraphrased as "in the MN-wise arranged xs, there are some ys, which are arranged in a way to give rise to belief-wise electrochemical firings that are about the car-wise arranged zs". In the first-order predicate logic, I have thus the following: $\exists xs \exists ys \exists zs((((MN_w xs$ [xs arranged MN-wise]) $\wedge$ ($B_w ys$ [ys arranged belief-wise]) $\wedge$ ($Ib_w yse_w xs$ [belief-wise arranged ys are *in* MN-wise arranged xs]) $\wedge$ ($C_w zs$ [zs arranged car-wise]) $\wedge$ ($Ab_w ysc_w zs$ [belief-wise arranged ys are about car-wise arranged zs]) $\wedge$ ($xs \neq ys \neq zs$)))). I can extend this paraphrase to all "conscious-wise" states (such as I think that…, I feel that…, etc). What I accomplish by doing thus is to combine mereological nihilism and eliminative materialism in a way to account for "conscious-wise" states. It is important to keep in mind that neither nihilists nor eliminative materialists deny there is some "conscious-wise" activity happening (Sassarini, 2021, pp. 7987-88). What we are rejecting is that the simples compose a complex and *not* that the simples exist. So, why can't we say that some simples' being arranged together give rise to a certain "conscious-wise" activity, if we hold that those arranged simples do not compose anything?

In a slogan form: *The grounding relation between the fundamental and derivative is different from the composition relation between the xs and the y* (Ney, 2023, pp. 208-209; Schaffer, 2010).[5] That is, belief states, thinking states, or feeling states can be grounded on the neurons' particular arrangement only as belief-wise, thinking-wise,

5 The explication of this argument by itself needs an entire paper. Here, suffice it give an example to demonstrate why I think this is so. Think of the explanatory gap between the physical and the phenomenal feel. The gap says that the properties of the latter cannot be explained by those of the former. Now, phenomenal properties are grounded on the physical (at least in this physicalist account that I am pursuing in this paper, we should take this for granted). That is, the physical is the fundamental level and the phenomenal is the derivative level. However, if we claim that the grounding relation between the fundamental and derivative levels is also a composition relation, then the derivative becomes an "entity" different from the fundamental. It becomes an "emergent" entity. However, consistency-preserving principle between fundamental and derivative entities tell us that if a derivative entity has the property X, it should not be the case that the property X cannot be a priori derivable from the fundamental

and feeling-wise arrangement, *without being* beliefs, thoughts, and feelings per se. Now, one may further argue here that if some simples are "giving rise" to something such as the belief-wise state, then this means that *from some arrangements come into existence new entities such as neurons.* After all, without neurons, no belief-wise, thinking-wise, or feeling-wise arrangements could have occurred. Thus, there are derivative entities even though there are no fundamental entities. Further, the argument could say due to the consistency required between the fundamental and derivative levels, there should be fundamental entities as well, from which the properties of derivative entities are a priori derivable. Well, had there been derivative entities, then this criticism would have been valid, but I do not see why we should commit to neurons in the first place. There is no need to postulate neurons as derivative entities. There are no neurons, only neuron-wise arranged particles. They are at most *derivative arrangements* grounded on *fundamental arrangements*. Hence, nowhere in the hierarchy ladder composition occurs, and so the consistency between the fundamental and derivative levels is preserved.

I think finally we can freely deny our own existence. I do think that nihilism is still very strong and as far as I am concerned no evidence shows *why and on what grounds* should we call the "p-wise" arrangement of particles compositions per se.[6] There seems to exist objects, you and I, but actually we are nothing more than simples arranged together. One final time "I" declare: *I, MN, do not exist, never existed, and shall never exist!*

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level, which is precisely the case when we talk about phenomenal consciousness. Yet, if we say grounding does not necessitate composition, then we do not have derivative "entities" but only derivative "arrangements" which are not "emergent" entities different than those at the fundamental physical level. Hence, there is no consistency problem to begin with: they are the same simples (the fundamental and the derivative) only in different arrangements. Also, Jonathan Schaffer in Schaffer (2010) argues that whole-part relation is one thing, and the prior-posterior relation is another. So—even if we assume that composition occurs—it may be the case that something is a part of a whole that is responsible for its composition but not fundamental and similarly a whole that is composed but not derivative: his "priority monism" is set out to demonstrate this.

6 For a detailed analysis of the impossibility of a priori ruling out nihilism as false, see Schaffer (2017).

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Virtual Reality and the Phenomenon of Presence

Kaan Tuncay Erdaş | *Bilkent University*

Introduction

Contemporary virtual reality (VR) research highlights technological possibilities and philosophical complexities. Despite advancements, the theoretical understanding of VR experiences is often hindered by oversimplifications of key concepts like presence and immersion. These concepts are central to the VR experience but remain inadequately addressed within a physicalist framework. This article identifies the conceptual gaps between presence and immersion and explores how these gaps might prevent understanding of these concepts. By applying a Husserlian phenomenological lens, I aim to resolve these confusions and provide a framework for understanding the structure of presence. Unlike empirical methodologies, phenomenology focuses on the a priori structures of consciousness, offering a nuanced distinction between immersion and presence with significant implications for theory and practice.

The paradox of VR lies in users engaging with virtual environments as if they were real while remaining aware of their artificiality (Sanchez-Vives and Slater, 2005, p.1). Presence enables users to inhabit virtual spaces meaningfully despite this paradox. However, much of the literature misinterprets presence as either equivalent to immersion or a mere perceptual illusion, lacking the precision of phenomenological analysis. This paper distinguishes immersion from presence by analyzing immersion through the concept of horizons and presence through embodiment and intentionality.

The contribution of this paper is twofold. First, it critiques the conceptual inadequacies in the literature rooted in physicalism. Second, it proposes an alternative framework for theorizing presence using Husserlian phenomenology. Following a review of psychological literature on presence and immersion (§1), I will analyze VR through Husserlian concepts of intentional acts and their features (§2). In §3, I will explore the phenomenological relationship between immersion and horizons using Hopp's theory of conflicting horizons and a Husserlian analysis of image consciousness. Finally, §4 will argue that embodiment and immersion together constitute the structure

of presence.

This phenomenological approach contributes to theoretical discourse and practical applications in VR by deepening the understanding of VR's impact on consciousness. It offers a new perspective on presence. Therefore, it will enhance comprehension of how VR affects the nature of consciousness and immersive experiences.

§1 Literature Review

Virtual Reality (VR) immerses users in computer-generated environments by replacing sensory inputs with digital data (Heim, 1998,p. 2). Using head-mounted displays (HMDs) and motion-tracking devices, users interact with three-dimensional spaces, perceiving visuals, sounds, and spatial awareness in real-time (Heim, 1998, pp. 220-221; Slater et al., 2022, p. 2). Real-time graphics dynamically adapt to user movements in order to enable active navigation and manipulation of virtual objects. Presence, a key concept in VR, refers to the subjective experience of "being there" in a virtual environment while physically in the real world (Coelho et al. 27-28). It arises through two perspectives: the rationalist view, which sees presence as an illusion of non-mediation enabled by technological advances like realistic visuals and real-time feedback (Coelho et al. 28-29; Slater et al., 2022, p. 2), and the psychological view, which considers presence a natural human ability evolved through biology and culture, allowing users to perform actions in virtual worlds similar to real life (Coelho et al. 29-30; Nilsson et al. 122- 125). Immersion, closely linked to presence, describes being absorbed in a virtual environment and losing awareness of the physical world. It has an objective dimension, defined by technological factors like rendering quality and tracking accuracy (Sanchez-Vives and Slater, 2005, p. 4), and a subjective dimension, where users feel profoundly involved and focused on the virtual world (Hovhanisyan et al., 2019, p. 231). While immersion emphasizes technological and experiential absorption, presence captures the phenomenological sense of inhabiting the virtual world. For example, a puzzle game in VR may create immersion through task engagement, but realistic sensory feedback enhances presence, making users feel they inhabit the space. Together, these concepts form the foundation for understanding VR experiences.

§2 Husserlian Concepts

According to Husserl, intentionality is defined as the fundamental property of consciousness. Intentionality refers to the property of being directed toward an

object. Every act of consciousness, such as perceiving something, is always about something. The act of perceiving is considered an intentional act. According to the Husserlian analysis of intentional acts, the four properties of these acts enable us to distinguish between types of conscious and intentional experiences, such as perception, image consciousness, phantasy, memory, and so forth. In subsections, I will explain Husserlian terms "originary," "direct," and "positing."

2.1 Originary vs. Non-Originary Acts

The Husserlian term "originary" refers to an intentional act linked to the immediate nature of perception. Husserl describes originary acts as those in which an object is given "in the flesh" or "in person (Hopp, 2017, 134)." Originary perception thus involves the experience of the object in its entire presence. Non-originary intuition, on the other hand, refers to modes of apprehension where objects are not directly given but are instead re-presented, as in acts of memory or phantasy. Even though non-originary acts can lack originary perception, they might not involve the kind of mediation found in image consciousness. For example, you see a tree in front of you; thus, you perceive the tree in the flesh. Meanwhile, you can imagine the same tree without relying on any medium. Therefore, originary acts are linked to a sense of presence.

2.2 Positing vs. Non-positing Acts

Positing and non-positing acts of consciousness involve asserting the presence of an object as actual or not (Behnke). Consider the act of preparing a party for your friends. You are curious whether the party will succeed or everyone will enjoy themselves. Here, you engage in a non-positing act. If you have a good reason to believe that the party will be successful, firmly believing it will be a successful party is a positing act.

2.3 Direct vs. Indirect Acts

Perception involves a direct apprehension of an object. When one perceives an object, one approaches the object without mental intermediaries. Intentional acts of perception are directly oriented towards the object itself. Meanwhile, indirect perception involves a mode of consciousness in which the perception of an object is indirect through the presence of another entity. For example, while you see an image, you see the image subject in favor of the image object. I will explain this experience in detail later in the image consciousness section.

2.4 Adequacy and Horizons

The adequacy of an object relates to its completeness in intuitive experience. An adequate intuition implies that the object is fully and perfectly given, leaving no further knowledge to be discovered. Physical objects, viewed from different angles, influence perceptual experiences by revealing richer details (Hopp, 2017, pp. 141-142). For instance, a sunset's appearance varies from afar versus up close, illustrating Husserl's idea that inadequate modes of givenness are inherent to spatial objects (Hopp, 2020, pp. 136-138). The more adequately an object is given, the less suitable it is for depiction in an image. Pain, as a sensation, exemplifies adequacy since it lacks unperceived parts. However, images inherently involve unperceived aspects. Horizons, intrinsic to perception, encompass intentions toward parts of objects that are not immediately visible or determined (Hopp, 2020, p. 139). Internal horizons concern an object's hidden or further-determined aspects, like perceiving a table's full texture. External horizons, meanwhile, involve the object's position within its surroundings and its relation to the broader environment (Hopp, 2020, pp. 141-142). Objects cannot be fully perceived without internal horizons, and without external horizons, internal horizons lack context. Together, horizons shape our perceptual experiences, connecting visible and invisible aspects of objects to the world around them.

2.5 The Conditions of Image Consciousness

According to Husserl, image consciousness involves the simultaneous intuitive consciousness of three different objects: "image subject," "image object," and "physical image" (Hopp, 2017, p. 131; Mion, 2018).

2.5.1 Physical Image

The physical image is the physical medium in which the image object is presented (Hopp, 2017, pp. 132-133). It is the physical form in which the image appears, such as a printed photograph, a painting on canvas, marble, or a digital image on a screen. The physical image serves as the medium through which the viewer perceives the image object. Seeing a painting of the Galata Tower hanging on a wall, we are at the level of focusing on the physical material (canvas) of the picture.

2.5.2 Image Object

The image object is the visual content that points to the image subject (Hopp, 2017, pp. 132-133). Thus, the visual structure of the painting conveys information about the image subject. In the example of a painting of the Galata Tower, the image object would be the visual depiction of the Galata Tower. In perceiving a Galata

Tower photograph, I am, besides the "image object," intuitively conscious of the "physical image." In the first place, it seems that through physical images, one can see the depicted object in the image (Hopp, 2020, p. 20). Thus, it covers all the ways it can be perceived through sensory experience. Aspects like its material, texture, and spatial orientation can be explored through physical interaction or observation. However, the image object goes beyond the physical characteristics of the image (Hopp, 2020, p. 20). It includes the mental representations and interpretations that individuals attribute to the image. While exploring the physical image further through actions like turning it over or examining its texture may reveal more about its physical properties, it does not necessarily uncover additional aspects of the image object itself.

2.5.3 Image Subject

Remember the picture hanging on the wall. In this picture, the image subject would be the Galata Tower itself. The image subject is what the image is about or what it depicts (Hopp, 2017, pp. 132-133). According to Husserl, the image subject appears in and with an image. The difference between an image object and an image subject is that an image object is a two- dimensional representation of a scene (Hopp, 2020, p. 20). It is distinct from the actual scene it depicts.

2.5.4 Features of Intentional Experience

According to Husserl, perceptual experiences have some features that differentiate them from other intuitive conscious experiences. The Husserlian term "originary" refers to the direct and immediate nature of perception where the perceiver is directly aware of the object without intermediary representations (Hopp, 2020, pp. 29-30). Therefore, originary perception involves experience where the object is directly present to us as it is (Kinkaid, 2020, 6). However, when we look at the Galata Tower photograph, the tower is not presented physically. Thus, image consciousness is non-originary. Secondly, indirect perception involves a mode of consciousness where the perception of an object is indirect through the presence of another entity. In image consciousness, the experience of the image subject is indirect since it is perceived through the image object (Hopp, 2017, pp. 135-136). Lastly, positing consciousness involves asserting the presence of an object as actual. In image consciousness, positing can refer to the belief or assumption that the image subject depicted in the image exists or has a certain quality (Hopp, 2017, pp. 136-137). It can be either present or absent in the experience of images, depending on whether the viewer takes the image to represent reality or simply as a visual representation.

These four intrinsic features explain the conscious side of image consciousness; however, the emergence of image consciousness depends on resemblance and perceptible conditions to be met (Hopp, 2017, p. 138). The image object must resemble the image subject. The second condition is that we must perceive them differently.

2.5.5 Resemblance

Experiencing resemblances in image consciousness refers to the similarity between an image object and an image subject (Hopp, 2017, p. 138). The resemblance between the representation of the image and the depicted image becomes perceivable through spatial relations such as shape and texture. According to Husserl, the critical point of resemblance is that the image must match the overall structure and shape of the depicted subject (Hopp, 2017, p. 138). Therefore, we can recognize the image subject within the images.

2.5.6 Perceptible Difference

However, a perceptible difference between the image object and the subject is also necessary. If the image object and image subject totally resembled one another, we would experience straightforward perception rather than image consciousness (Hopp, 2017, p. 139). The condition of resemblance enables the connection between the image object and the subject; the perceptible difference introduces distinctive characteristics that set them apart. These characteristics may add variations to the visual experience (Hopp, 2017, p. 139). These variations include colors, shapes, or other contextual elements. Suppose you are holding a photograph of a flower in a grayscale. The lack of color in the photograph contrasts with the vivid color of a real flower. This lack of color is a perceptible difference. Although the photograph of the flower lacks colors, the image object may still capture the shape and form of the flower accurately. Therefore, resemblance creates a connection between the object and the subject. In the next section, I will explain the Husserlian analysis of immersion and how immersion comes from reducing the conflict of horizons in image consciousness

§3 Husserlian Analysis of Immersion

3.1 Conflicting Horizons

Hopp uses Husserl's concept of conflicting horizons to explain how image consciousness involves a conflict between different perceptual apprehensions (Hopp, 2017, pp. 145-147). This conflict is essential for image consciousness to occur.

Husserl identifies two types of conflict in image consciousness. The first conflict is between the image object and the physical thing. The reason for this conflict is that one perceives them differently. The physical thing is perceived as real in the immediate environment, whereas the image object is "irreal." Even if it is perceived, it is not real in space or time, outside or inside of my consciousness (Husserl 23). For example, the physical support of an image as a real object can be moved, viewed, touched, or smelled. However, you cannot smell or touch the image object because it does not have the same spatial and temporal properties as physical supports.

The second conflict is critical for understanding how image consciousness occurs. It involves the same intuitive content or visual appearance conflicting with each other in two distinct perceptual apprehensions (Hopp, 2017, pp. 145-147). Perceptual apprehension refers to the way sensory content is understood. The same sensory content (e.g., color and shapes) provides us with the image object through one perceptual apprehension, while another apprehension reveals the image subject. We see the image subject (Galata Tower) as existing in a different space from our perceived environment. In contrast, the image object is present or in the flesh in our immediate environment. Since the image subject is not physically present, you cannot interact with it in the same way as the image object. This distinct perceptual apprehension emphasizes that the image object is present and tangible while the image subject is detached from the immediate physical environment.

From a horizontal perspective, the internal and external horizons of the image object and subject lead to phenomenological conflict due to their inadequacy (Hopp, 2017, pp. 147– 148). For example, you see the Nighthawks in the museum. In this picture, we see a depiction of a night diner. In the place, there are two men and women drinking coffee with the server in the coffee shop. The physical thing of the painting is made of canvas, and you perceive this painting in your environment(museum). You can move closer to the image and change your angle to examine its detail. Through these acts, you will fulfill the horizons related to the image object. However, the image subject remains fixed even if you change your angle; it will only reveal more details about the picture since a few men and women are not present in the flesh or your environment. In other words, moving closer to the picture does not bring you closer to the coffee shop. Changing the angle around the painting does not change your view of the scene. Therefore, the horizon of the image object can be fulfilled by shifts in perspective and movements; the image subject does not share the same spatial and perceptual relations with the image

object. Therefore, if the image subject had the same spatial and perceptual properties as the image object, you could start walking around the corner of the café. Image consciousness is, therefore, distinct from perceptual experience.

3.2 Phenomenological Explanation of Immersion

Immersion in VR can be analyzed using the Husserlian concept of horizon because it provides a sense of "beyond" or potentialities. First, I will explain the simulated depth and environment from a horizonal perspective. In this, I will explain the user's dynamic interaction with virtual objects and the continuity of the virtual space. I will bring the "flow" concept from psychology in VR to understand the concept of immersion from an interdisciplinary point of view. In the second part, I will identify the similar phenomenological aspects of conflicting horizons in VR and image consciousness in order to explore immersive experiences phenomenologically. Therefore, I will show why immersion is a structural part of the presence in VR rather than being identical to the presence or an entirely different unrelated concept.

Immersion in VR can be analyzed through the Husserlian concept of horizon, which emphasizes the "beyond" or potentialities within perception. Simulated depth and spatial relationships in VR create an external horizon akin to real-world perception. From the user's perspective, the virtual environment extends beyond their immediate field of vision, offering depth and layered interactions (Slater et al., 2022, p.2-3). This dynamic space encourages exploration and engagement, aligning with Husserl's notion of horizons emerging through perception and action. For instance, interacting with a virtual object, such as picking up a glass, reveals unseen details as perspectives shift. Like a table or surroundings, the glass's relationship to its environment represents an external horizon enriched through dynamic interaction.

Husserlian horizons are not static but are fulfilled incrementally as users perceive and explore. Similarly, VR maintains a sense of spatial and temporal continuity, reinforcing the perception of a unified, navigable space (Weibel and Wissmath, 2011, pp. 2-4). Even when only parts of the environment are rendered upon approach, VR creates the illusion of a continuous, immersive world. This mirrors the phenomenological idea of horizons, where objects are perceived in parts rather than as a whole, driving active exploration. The incompleteness or "inadequacy" of virtual horizons ensures users remain aware of unfulfilled potential, fostering an immersive experience. By maintaining this phenomenological uncertainty, VR aligns with the structure of perceptual horizons,

where immersion becomes an integral part of presence rather than an entirely distinct concept.

3.3 Conflicting Horizons in Other Media

This section will examine other media or immersion-involved experiences, such as reading books and watching films. While you are reading a book, you are in the experience of narrative immersion (Nilsson et al. 113-114). This type of immersion includes the ability to alternate the reader's attention to physical reality into the fictional world created by the author. For example, you are reading a book about the adventure of a guy in the world of elves and orcs. Well-written plots with a precise sequence of events and conflicts in the fiction will help the readers to maintain the reader's focus on adventure. Visualization of the sequence of events, the descriptions of the views, and the characters enable readers to be immersed in a fictional world. Therefore, while following the adventure, you are disconnecting from physical reality. You will focus your attention intensely on the main character's adventure. Therefore, even if it lacks a high level of sensory stimulus regarding technological capacities, you feel immersed in the fictional world.

While watching the movie Interstellar in IMAX, you constantly get sensory feedback from the theatre. The higher sensory feedback, such as auditory and visual, you feel like a witness of the story even if you are not in their physical world. The image object and subject constantly move, and the higher sensory feedback closer to you feel immersed in their reality. However, the conflicting horizon in the image subject and object can be seen as similar in the image consciousness since images are given to you constantly. However, the big difference is that constant visual and auditory feedback from the scene allows you to disconnect from physical reality and get closer to the world of the film.

Being deeply drawn into Interstellar stories, characters, and events will produce a sense of being part of the cinematic world. While the story unfolds through the movie, the technological capacity of the IMAX format advances this experience by giving sensory and auditory inputs to make viewers feel as if they are part of the interstellar journey. Thus, in this sense, you feel immersed in the cinematic universe. However, since it is similar to image consciousness, you will not feel the presence in the cinematic universe because the universe of Interstellar is not in your immediate environment.

In the following section, I will explore the conflicting horizons in VR to present a clear phenomenological aspect of the immersive experience.

3.4 Conflicting Horizons in Virtual Reality

The concept of conflicting horizons in image consciousness can be quite revealing for understanding immersive experiences in virtual reality. First, in virtual reality, the user is between two realities. The first reality is the physical environment they are physically in. The second is virtual reality, the computer-generated environment in which they interact. This dual experience does not create conflicting horizons. In virtual reality, we can posit two interpretations of sensory content (visual, auditory, and sometimes tactile)—one for virtual and one for physical environments. For example, the user is confronted with a virtual table in the virtual world. When moving around the virtual table, a user moves as if there is a physical table in the room. Even though he knows he is not in the physical environment, he sees a virtual table. This situation resembles the conflict found in image consciousness, where the "image object" (representation) and the "image subject" (depicted object) are in conflicting perceptual relations.

However, this conflict is also different from traditional image consciousness. It allows users to interact spatially with virtual objects in a coherent way. Users can move around these objects, see them from multiple perspectives, and interact with them in the same way as with real objects. This kind of spatial interaction deepens immersion by allowing virtual objects to become part of the user's perceptual space as if they were physically present. This situation is significantly different from image subjects, where no matter how we look at an image of an object (such as the Nighthawks), we only see different aspects of the image and do not have access to the "real" object beyond the representation. You cannot move around an image of the Nighthawks and see different aspects of the actual coffee shop. Instead, you can see different aspects of the image object. In other words, you do not feel immersed in the reality of the image. As a result, the horizon of a virtual reality object—unlike an image—can be filled, allowing users to explore and perceive it spatially. The user sees the table as a reality and acts accordingly. The external horizon in the physical world does not conflict with the inner horizon in the virtual world since the stimulation of the physical world is less than the stimulation of the virtual world. Therefore, you feel disconnected from the physical world and become engaged and immersed in a virtual environment.

Immersion, as I understand it, constitutes two interrelated dimensions within the VR. On the one hand, it is a feature of the VR system designed to integrate the user into the VR world. On the other hand, it is also related to the user's subjective response to the VR environment. From a phenomenological perspective, the essence

is that it reduces our sensory connection with the physical world and allows us to alternate our sensory connection with the virtual world. Equating immersion in VR with technology does not mean that immersion in VR cannot be evaluated through a subjective experience. Indeed, the subjective experience of immersion can be experienced in many different types of media.

Consider the immersive experiences we experienced in different media types in the previous section. At the same time, the sensory feedback we get while reading a book is minimal. The reader may still undergo an immersive experience formed by imagination and engagement with the novel. Moreover, we get a different set of immersive experiences in cinema thanks to the technological apparatus-such as cinematic screen and sound systems – that can advance the sensory input. Thus, while immersion derived from reading a book can be an example of a subjective experience, the technological apparatus of the cinema objectively increases our immersive state. Overall, the technological and subjective sides of immersion influence the state of being immersed in another world. In the following section, I will explain the concept of flow to understand absorption from physical reality. Therefore, the difference between presence and immersion will be clearer.

3.5 Flow and Immersion

"Flow" describes a mental state where individuals are fully immersed in a virtual environment, experiencing high concentration, clear goals, and a loss of self-consciousness (Weibel and Wissmath, 2011, pp. 2-4; Mütterlein, 2018, pp. 1048-1409). In this state, the user's attention is entirely focused on the virtual world, with distractions from the physical environment minimized or absent, enhancing immersion. Users often feel highly engaged and motivated, losing track of time—a key indicator of an immersive experience (Weibel and Wissmath, 2011, pp. 2-4). This is facilitated by VR technology, which provides clear goals and immediate feedback. Actions within the virtual world, such as navigating or interacting with objects, elicit instant responses, reinforcing user engagement and focus. As the activity itself becomes inherently rewarding, the sense of immersion deepens. Immersive experiences align with the perceptual horizon as technological advancements make the simulated environment increasingly realistic. When users' intuitions about unseen aspects of the virtual world are fulfilled, their level of immersion and sense of flow intensifies. In general, the concept of flow helps conceptualizing immersion as the

subjective experience of feeling surrounded by the environment and engaged with the activities within the virtual realm, even if you are in physical reality. Fundamentally, it refers to being deeply engaged in virtual activities. Meanwhile, presence stands user's perception of being present in the virtual environment itself. For a user to feel present in that environment, the user must be immersed in the activities within that environment. Now, I will present immersion as a structural part of the experience of presence in the following subsection.

3.6 Immersion as a Structural Part of Presence in VR

At the point of conflicting horizons, the phenomenological approach to immersion has this to say. It reveals that immersion is not an isolated feature of presence but a structural element necessary for experiencing presence. As in our perception of the real world, horizons allow us to grasp the totality of things and suggest that more lies beyond what is currently visible. Virtual reality offers similarly rich horizonal intentions. Thus, it supports users in exploring virtual space in ways consistent with the internal logic and rules of the virtual world.

These horizons often conflict less with the boundaries of the physical world, such as the user's awareness of the physical room around them. In virtual reality, the user's horizons are rich. The richness provides continuity and keeps the user engaged with the feeling that there is more to explore. The horizon of the virtual environment has less conflict with the horizon of the physical world compared to image consciousness. The consistency of the virtual environment allows users to prioritize the virtual horizon over the physical horizon momentarily.

In conclusion, the user feels immersed in the virtual environment through a head- mounted display that generates high-resolution visuals, spatial audio, and haptic feedback. These multisensory inputs allow users to interact with and feel surrounded by the environment. This absorption helps you feel like you are in virtual rather than physical reality. Thus, we can conclude that immersion is necessary to create a sense of presence, but it is insufficient. For example, you are playing a race simulation game with poorly designed car physics and mistimed sound effects. The lack of realism and consistency will prevent immersion since it is difficult to achieve the state of "flow." Lack of flow will negatively affect the feeling of being in virtual gameplay. Conversely, even with highly immersive technology, you might not feel fully present in the virtual environment due to external distractions such as daily worries. Thus, we can conclude that even if you feel immersed in virtual reality, the sense of presence needs the mental focus and coherence of virtual experience.

§4 Husserl and Embodiment

In Husserl's view, awareness of embodiment is key to understanding how we perceive and awareness of ourselves concerning embodiment, which is key to understanding how we perceive and have an awareness of ourselves in relation to the world (Carman, 1999, 206). The body is an intermediary tool to enable embodiment. Husserl understands the body as a unique entity with a function. The body bridges our conscious experiences and the physical world (Carman, 1999, 217). It is neither part of our consciousness nor entirely different from other physical objects. This unique function plays a role in localizing our sensations (Carman, 1999, 211). Husserl considers these sensations fundamental to our sense of self and bodily awareness. Therefore, the body is an intermediary that supports the conscious experience; however, it does not constitute it (Carman,1999, 224).

Husserl explains the concept of bodily intentionality as playing a role in the perception of and interaction with the world (Carman, 1999, 208). The main idea of intentionality is that our bodily movements and sensations are directed toward the environment. Therefore, it is not merely an object among the other physical objects but essential for perceiving and understanding the world (Carman, 1999, 218). For example, when we reach out to touch a glass of wine to drink, our body does not perform mechanical action. Instead, it is directed toward a glass of wine. This intentional aspect of it is not the distinct aspect of conscious experience.

According to A.D Smith, our perceptual consciousness arises from the spatial relationship between objects and our sense-organs (Smith 2005 134-135). For example, while seeing objects at different distances from our eyes, one will understand objects as three- dimensional objects. For example, you consider picking a glass of wine from the table. As you move your hand toward wine, your perception will set according to the spatial relationship among your hand, the glass, and your sense organs. While holding it, you see the glass from a specific perspective. In the meantime, you feel its smooth surface and the weight of the glass in your hand. The interaction between you and the object is about perceiving it as a three- dimensional object existing in space (Smith, 2005, pp. 140-141). Your movement of sense organs toward an object makes perception distinct from mere sensation, such as feeling, by gaining different perspectives on objects.

The embodied nature of perception reveals the object and your bodily presence through shared spatial interactions (Smith, 2005, pp. 134-135). While holding the glass of wine, you experience the pressure of the glass when the glass touches your hand. The pressure indicates the presence of external objects, such as

glass. Therefore, it reveals the glass as distinct from your body. Anstoss is the experience of encountering the pressure that reveals the glass as an external object (Smith, 2005, pp. 103-104). This interaction illustrates how our perceptual consciousness is formed through bodily activity and the external environment.

Transforming the embodiment in physical reality to virtual reality will enhance the sense of embodiment and, as a result, our sense of presence. For example, you are climbing a virtual replicate of the mountain of Everest. The system must have coherent motion tracking to set our visual perspective while reaching the rock. Therefore, the user achieves a coherent sense of spatial awareness. To achieve tactile connection with virtual objects, the haptic feedback must simulate the rough texture and pressure of the rock while climbing. Feeling the resistance of the rock allows you to understand it as an external object and your body in the same spatial domain. Therefore, users understand and interact actively rather than passively with the virtual environment. As a result of understanding embodiment and integrating these actions into the virtual realm, our perceptual consciousness gradually becomes similar to real life.

§5 Presence as Phenomenon

In this section, I defend that presence arises when embodiment and immersion work in harmony. Embodiment refers to integrating bodily interaction with the environment, while immersion is about being surrounded by a virtual environment. For example, when climbing a mountain, you get high-resolution graphics that match your movement at the exact moment of climbing. Meanwhile, you will get the sound of your steps and the sound and feel of the wind as the spatial sound of the virtual environment. Meanwhile, your subjective interaction with the environment will measure the value of your reactions. At the same time, the change of sound and image every time you hit your pickaxe will enhance your objective immersive quality. In this way, your interaction with the physical world will gradually decrease, and your interaction with the virtual world will increase. During climbing actions, the haptic feedback you receive through your avatar's body will put objects in a different spatial dimension to your body. The sensory feedback you get with each step will change your angle to the object before you, and you will be more integrated into the virtual world. These two phenomena will facilitate your active interaction with the virtual environment, and you will get an experience close to what we experience in the real world.

However, this interaction will not require defining presence in the literature as an illusion. I think presence cannot be reduced to a psychological trick or a

sensory manipulation. Instead, it is a fundamental mode of how consciousness positions itself concerning its physical or virtual environment. As we have seen in the psychological literature, a sense of presence is also part of our relationship with the physical world (Riva et al. 207-211). Immersion allows this part to move from one world to another. Consciousness relates to the world through embodied and enveloping dynamics as long as it receives sensory feedback in an ontologically different world. This makes presence a fundamental feature of experience rather than an incidental by-product of technological mediation.

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Interview:

Alireza Fatollahi

Dr. Alireza Fatollahi is an assistant professor at Bilkent University. He received his PhD in philosophy from Princeton University. His main areas of interest are philosophy of science and early modern philosophy. He has published in *Canadian Journal of Philosophy, Episteme, Philosophy of Science, Pacific Philosophical Quarterly, Synthese*, and *European Journal for the Philosophy of Science.*

What do you think about the famous division of philosophy of science: Popper or Kuhn?

I take it you're alluding to two different approaches to philosophy of science, each represented archetypically by one of these figures. Popper emphasizes the normative side: asking questions like, what must an epistemic enterprise look like to count as science? He aims to sketch an ideal picture of science, even if we never fully attain it. Kuhn, by contrast, insists on describing how science actually works and emphasizes its human and social dimensions. I think philosophy of science risks being either quixotic or reduced to pure history if it takes only one of these sides. We don't want a utopian account of science that is unattainable for human beings. But as philosophers (rather than historians) of science, we also don't want simply to recount what has happened. We want to explain the striking fact – or at least the strong intuition – that science is, epistemically, the best humanity has to offer. In other words, a normative account of why science works can succeed only if it is genuinely informed by how science works.

We observe that scientists are fond of Popper for explaining scientific method. Do you see a reason why?

I've always been puzzled by Popper's popularity among non-specialists, though I didn't realize he was especially admired by scientists. Among philosophers of science today, it's hard to find anyone who thinks Popper has much to offer. Yet outside the field he is often treated as central – as if he were to philosophy of science what Aristotle is to philosophy more broadly. This can't be because of the depth of his ideas: they are now widely regarded as simplistic. So I think the main reason probably is that his signature idea – the importance of falsifiability – is both easy to

grasp and easy to endorse. If you don't have time to wrestle with the complexities of a philosophical account of science, it provides a ready-made view that feels satisfying. In fact, when it comes to easily accessible views, the options are rather limited: (i) Popper, (ii) some version of positivism, or (iii) fundamental skepticism about science's rationality. All these are highly implausible (or so it seems to me), but they are the obvious off-the-shelf choices unless one engages more deeply with philosophy of science.

As a philosopher working on philosophy of science, how has getting a BSc degree on physics affected your perspective on your work?

It has helped me but not in the way one might expect. I use statistical tools in my work, but I actually learned them during my philosophy studies, not as a physics major. To be honest, I wasn't a very strong student during my undergraduate years. I was preoccupied with existential questions and had little time or energy left for physics. Still, one experience from studying physics has been deeply influential in my current research. Even though I attended the top physics program in Iran and had professors with excellent training, I was struck by what seemed to me as a lack of critical engagement with the theories they taught us. Of course, not everyone was the same, but most physicists I encountered were primarily concerned with applying the theories rather than questioning their foundations. Questions that appeared to me as pure physics questions were quickly dismissed as "philosophical." Thus, insofar as my experience was concerned, Kuhn's description of scientists as puzzle-solvers felt remarkably accurate. This raised for me a set of enduring questions: What is the proper aim of science? Was I simply naïve to want to understand the meaning behind the equations of quantum mechanics? Are scientific theories just "black boxes" that matter only insofar as they work? Later, when I turned to the history of science, I realized that things had not always been this way. Figures like Leibniz and Newton approached physics in a manner much closer to my own instincts than to those of my professors. That discovery planted the first seed of what has become central to my research. Put very simply, I believe science has always had at least two principal aims that sometimes clash: (i) explaining why nature works the way it does, and (ii) predicting new phenomena. Yet the history of science suggests a gradual but decisive shift: whereas once explanation was, by far, the most important goal, prediction has gradually come to dominate over explanation. This doesn't mean scientists don't care about explanation today. But if theory A offers slightly better predictive success while

theory B provides far deeper explanatory insights, I suspect most scientists would favor A. This is what one might call the tyranny of data. Much of my research today revolves around this general idea.

You completed your PhD on early modern philosophy.
Do you see the philosophers from the early modern era
capable of answering contemporary questions of philosophy?

My dissertation was in contemporary philosophy of science, although I've always had a serious interest in early modern philosophy, and my research is increasingly shifting in that direction. When it comes to answering contemporary questions, I think no conceptual framework is better suited than the contemporary one. One of Kuhn's central insights is that paradigms tend to ask precisely those questions they can answer. In that sense, early modern philosophy is not equipped to address contemporary problems more effectively than contemporary philosophy itself. But that doesn't mean the history of philosophy is irrelevant. On the contrary, engaging with early modern thought – or other historical periods for that matter – offers us a perspective from outside our current conceptual framework. And this perspective has at least two major benefits. First, it deepens our understanding of our present situation. For example, my own research on the goals of science was shaped by studying historical sources. Without that background, I could not have articulated my vague sense of a tension between two intrinsic aims of science: explanation and prediction.

Second, the history of philosophy brings back into view questions that still matter to us but that we've (largely) abandoned because answering them would require a shift in our current conceptual scheme. Let me give you an example. As you know, Spinoza's magnum opus is called Ethics. However, ethics for Spinoza (and his contemporaries) was that part of philosophy that was concerned with the good life. By contrast, contemporary ethics tends to focus on moral obligation. Personally, I think this shift has been an unfortunate development in the field. The older conception strikes me as both more interesting and more fruitful. And ethics is just one case. If you look closely, many of the most stimulating discussions of some of the topics traditionally associated with philosophy (art, romantic love, friendship, authenticity) are now being carried out by historians of philosophy and mostly in dialogue with historical figures. Alexander Nehamas's work is a particularly good example of this. So for me (and for many others who work in history of philosophy),

history is not just about tracing the past. It is about reopening questions that are more interesting than the ones contemporary philosophy currently sets for itself.

One of your research focuses is simplicity. Do you see simplicity as a reliable or sufficient criterion of truth for scientific method?

Before answering your question, let me clarify what I mean by simplicity. Take the family of parabolic functions: $y = ax^2 + bx + c$, where a, b, and c are adjustable parameters. Changing the parameters yields different parabolas – for example, (1, 0, 2) yields $y = x^2 + 2$, while (3, 5, 13) gives $y = 3x^2 + 5x + 13$. Scientific theories often suggest a family of hypotheses but leave certain parameters to be fixed by data. We can call the number of adjustable parameters of a model its *degree of complexity*. For instance, if a theory says that x and y are linearly related, without specifying the exact linear function, the model has two adjustable parameters. We have strong statistical results that, other things being equal, the fewer adjustable parameters a model has, the likelier it is to be true and the more accurate its predictions will be. Simplicity understood as paucity of adjustable parameters is linked to truth, predictive accuracy, and (as I argue in my latest work) explanatory power. Now, to your question: simplicity alone is not sufficient. But I believe (though this is controversial) that the combination of simplicity and consistency is sufficient. My view is that all other theoretical virtues can be reduced to these two. So yes, I regard simplicity as a highly reliable indicator of both truth and predictive success. That doesn't mean that truth is more likely to be simple. It means that, other things being equal, the simpler theory is the more promising candidate.

How do you see mathematical elegance regarding this issue? Is it possible that physics theories with mathematical elegance to be superior to ones without?

The case of elegance is a bit tricky. Typically, there is a correlation between mathematical elegance and simplicity understood as paucity of parameters. In that sense, elegance can serve as a proxy indicator of truth: elegant theories tend to be simpler, and simpler theories tend to be more reliable. But I don't think elegance has any *independent* or *sui generis* epistemic value. Its role is derivative: elegance is valuable when, and because, it signals simplicity.

Does the simplicity work the same for different scientific fields? For instance, does the complex nature of biology differ from physics, a more fundamental science? Is it applicable to social sciences?

The statistical results suggesting that simplicity is a reliable indicator of truth and predictive accuracy rely on minimal assumptions that, I suspect, hold across almost all scientific fields. If a field studies more complex causal relations, as the social sciences do, then the competing theories will themselves be more complex. What matters is not simplicity in some absolute sense but relative simplicity. To illustrate: other things being equal, the difference in predictive accuracy between two polynomials of degree 98 and 100 is equal to the difference between polynomials of degree 1 (linear) and degree 3 (cubic). So the fact that a field deals with more intricate phenomena doesn't change the basic epistemic role of simplicity. That said, complexity does make a difference in practice. Human beings have limits: there's only so much complexity we can handle. Often, we simply don't consider highly complex relations at all. So if the truth in a given domain happens to be very complex, we may never arrive at a theory that captures it with the elegance and power of, say, Newtonian mechanics in its proper domain. One of my hopes is that advances in AI will help us overcome this limitation, by vastly expanding the range of candidate theories we can generate and by making it possible to work with complex functions as easily as we now handle simple ones.

Do you belıeve that simplicity-focused research promise a solution to the crisis physics finds itself in? Do you believe that a theory of everything is possible?

I'm afraid my research on simplicity has little to offer here. The present crisis in physics is not philosophical; it is data-driven. The problem is that we currently lack a unified theory that can adequately accommodate the data we have about the physical universe. Only the discovery of such a theory can resolve the crisis. But there is no guarantee that such a theory exists, let alone that we will find it. Nor is there any philosophical guarantee that a "theory of everything" is possible. One of the lessons that the history of science teaches us is that our intuitions are not always reliable guides to truth. As much as we may wish the universe to have a single, elegant story behind it, that hope could turn out to be unfounded. For all we know, we may live in a universe that keeps its deepest secrets from epistemic agents like us indefinitely. Whether that is the case is an empirical question, not one philosophy can

decide in advance. This is not to say we should despair. A few months before Heisenberg published his paper on quantum mechanics, Pauli wrote to a friend that physics seemed so hopeless that he wished he had become a comedian and had "never heard of physics". In less than five months, when Heisenberg's new ideas appeared, Pauli thought it was once again possible to "march forward." Our current moment may be similar. Who knows?

What makes philosophy of science tempting to you?
Are there any more questions you are interested in philosophy of science?

I'm drawn to philosophy of science for two main reasons. First, science itself is endlessly fascinating. The sheer scope of what it allows us to do is astonishing. Although because we live with it every day, it can be hard to fully appreciate just how remarkable a phenomenon it is. Second, I think philosophy of science is the best kind of epistemology. Science is, epistemically speaking, the best humanity has to offer. So if we want to study our relation to truth – whether it is within our reach and how we can approach it – the best way is to study how and why science works.

There are many questions in philosophy of science that interest me, but one I'm especially focused on now is the relation between explanation and simplicity. As I mentioned earlier, I'm not sure whether science will ever produce a theory of everything. But I endorse the ambitious idea that in philosophy of science we might have a theory of everything. I suspect that the key lies in a proper understanding of simplicity and its role in theory choice. At present, explanatory power is the last major theoretic virtue that hasn't been reduced to simplicity and consistency. But I think ideas from information theory point toward a way of doing exactly that.

Another topic, which might seem a bit futuristic, is the possible bifurcation of science into predictive and explanatory branches. With the rise of powerful predictive tools (such as neural networks) that can generate highly accurate predictions without relying on explicit theories, we now face the prospect of a "predictive science" that operates without explanation. If that happens, we might need a distinct form of science devoted to explanation, one concerned with trying to give us an understanding of the world. Whether this bifurcation is realistic, and what such a division of labor would mean for our understanding of science, is a question I've been thinking about recently.

Why did you choose Bilkent as a step on your academic career?
Do you see a future for philosophy of science here?

When I joined Bilkent, its philosophy department struck me as very impressive (and it has only grown stronger since). The fact that Turkey is both geographically and culturally close to my home country, Iran, was also a major factor in my decision. As for philosophy of science, I do think Bilkent has the potential to become a real center of strength in the field, even though we are far from there yet. The key fundamental factor is having students with strong technical or scientific backgrounds who are also drawn to philosophy of science. And Bilkent has quite a few of them. That makes me optimistic about the future here.

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