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Time Can Flow in the Opposite Direction of What We Think It Does

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Abstract. Attitudes towards the future and the past differ. This difference seems easy to explain if time actually flows, and thus, has an intrinsic direction. At first, this appears to be an advantage of the dynamic view of time, according to which time really flows, over the static view of time, according to which time does not flow. However, this paper aims to demonstrate that the intrinsic direction built into the dynamic view of time can point in the direction opposite of that in which we believe that time progresses, thereby rendering the dynamic view futile for explaining why attitudes towards the past and the future differ. Therefore, this advantage of the dynamic view of time over the static view becomes invalid.
Keywords: flow of time; intrinsic direction; dynamic view of time; static view of time; empirical direction.

Laikas gali tekėti priešinga kryptimi, nei manome

Santrauka. Ateities ir praeities suvokimai skiriasi. Atrodo, kad šiuos skirtumus lengva paaiškinti, jei laikas teka, taigi, jei laikas turi vidinę kryptį. Iš pirmo žvilgsnio atrodytų, kad tai yra dinaminės laiko sampratos privalumas. Remiantis šiuo požiūriu, laikas iš tikrųjų teka. Dinaminė laiko samprata prieštarauja statiškam požiūriui, teigiančiam, kad laikas neteka. Tačiau šiuo straipsniu siekiama parodyti, kad, laikantis dinaminės laiko sampratos, vidinė laiko kryptis iš tikrųjų gali nurodyti į priešingą pusę, nei kad įprastai esame linkę manyti. Tuomet dinaminis požiūris į laiką taptų beprasmis ir nebesuteiktų galimybės paaiškinti, kuo skiriasi požiūriai į praeitį ir ateitį. Todėl šis dinaminės laiko sampratos privalumas, lyginant su statiniu požiūriu, praranda pagrįstumą.
Pagrindiniai žodžiai: laiko tėkmė, vidinė kryptis, dinaminė laiko samprata, statinė laiko samprata, empirinė kryptis

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1. Introduction

There are two kinds of direction, namely, *conventional* and *intrinsic*. The conventional direction is a direction determined by agreement; it is not determined by the direction along which something really moves. Conversely, the intrinsic direction is determined by a path in which something moves. For example, the arrow sign '→' has a conventional direction from left to right but has no intrinsic direction because nothing moves. Another example is electric current from the plus terminal to the minus terminal; this direction is conventional. However, when we refer to the electron, which moves from the minus terminal to the plus terminal in electric current, this direction is intrinsic because electrons really move along this direction. Therefore, the intrinsic direction of the electron and the conventional direction of electric current do not coincide.

There are two views about time, namely, dynamic and static. According to the dynamic view of time, the flow of time is an objective fact.[1] Most proponents of this view hold that there is an absolute, objective present moment (Deasy 2017: 378; Dowe 2009: 642; Dyke 2013: 333; Merricks 2006: 103; Olson 2009: 3; Zimmerman 2008: 212), and that 'Time passes' means that this absolute present changes (Leininger 2015; Price 2011; Tallant 2018). However, according to the static view of time, there is no absolute present. In other words, a present moment is relative to the speaker; it is not absolute but indexical, like 'here' in space. If the dynamic view is true, then time (the absolute present) must have an intrinsic direction because the absolute present really moves along the time axis (except for presentism).[2] Conversely, if the static view is true, time has no intrinsic direction but only a conventional direction. In the case of the static view, the conventional direction points to the high entropy state or direction of which we have no memories (see, for example, Farr (2022)).

This study aims to demonstrate that time can flow in the opposite direction to what we ordinarily perceive, even if the dynamic theory of time is correct and time possesses an intrinsic direction. The distinctive feature of this study is that it does not merely argue that this would follow if current physics is correct, but rather argues that even if current physics were to be revised, we would still be compelled to reach the same conclusion. More specifically, this study shows a psychological direction (the direction of what we think time flows), and intrinsic directions may diverge in either of the following cases: causation is not a primitive concept (§4), and causation is a primitive concept (§5). In the latter case, we consider the following conditions: (1) The *Growing Block Universe* theory (GBU), one of the dynamic views, assumes that the world is ontologically time-asymmetric. (2) The *Causal Power Theory* (CPT) assumes that things or actions have causal power. (3) The basic law of physics is time-asymmetric. (4) The absolute present (the flow of time) plays a role in physics theory. These conditions are favourable to the view

[1] Although some presentists insist that time does not literally pass (see Tallant (2010)), that perspective is irrelevant to my thesis because it also assumes the intrinsic direction.

[2] The standard definition of presentism is that only present things exist (Crisp 2004: 15; Hinchliff 1996: 123).

that we can recognise the intrinsic direction (for example, previous studies that argue that time has no intrinsic direction have not taken Condition (3) into account). Nevertheless, this study argues that there still remains a possibility that the intrinsic and psychological directions diverge.

The structure of this paper is as follows. Sections 2 and 3 are a preparation section for the main argument. In Section 4, I argue a case where causal direction can be reduced to other directions. In Section 5, I argue that assuming GBU and CPT does not guarantee agreement between the psychological and intrinsic directions. In Section 6, I argue that the above arguments are valid even if the flow of time plays a role in the theory of physics. Section 7 is a summary.

2. Directions of Time

To achieve the goal described in §1, this study classifies the direction of time as follows: psychological, thermodynamic, causal, and forking.[3] Furthermore, this study aims to clarify the relationship between these directions and the intrinsic one. The psychological direction refers to the direction in which we feel that time flows; from what we remember to what we do not remember. The thermodynamical direction emanates from the low-entropy state to the high-entropy state. The causal direction flows from cause to effect. The forking direction is explained by the following example. If a glass is broken, the forking direction leads from the unbroken glass to pieces of glass.[4] By classifying the directions of time in this way, the aim of this study can be restated as follows: to demonstrate that, regardless of which direction – other than the psychological one – is assumed to coincide with the intrinsic direction, it does not necessarily always coincide with the psychological direction.

The relationship between causal directions and other directions depends on which view of causation is adopted. If the view that causation is a reducible concept is considered, then the causal direction can be reduced to another one, for example, the forking direction (Dowe 2000; Horwich 1987; Lewis 1979; Price 1996; Reichenbach 1956). In this case, whether the causal direction coincides with the intrinsic one depends on whether the direction to which the causal direction is reduced coincides with the intrinsic one. However, if causation is considered a primitive concept, such as in CPT, then the causal direction coincides with the intrinsic direction. Nevertheless, this paper argues that the causal direction (and thus, the intrinsic direction) does not necessarily coincide with the psychological direction. One of the original contributions of this study lies in discussing this case (where causation is a primitive concept).

Note that this study does *not* aim to demonstrate that it is *impossible* that the psychological direction necessarily coincides with the intrinsic one; rather, it aims to prove

[3] In addition to these, some authors insist that there is the cosmological direction. The cosmological direction is the direction of expansion of the universe. Hawking (1985) insists that the thermodynamical arrow is reduced to the cosmological one (see also Greene (2004)). Although why they coincide is one of the hot issues, I do not address it in this paper. See also Stradis (2021).

[4] Although details of the forking theory vary by authors, such differences do not affect the argument outlined in this paper.

that there is no straightforward way to show that the psychological direction necessarily coincides with the intrinsic direction. In other words, this study reveals that the dynamic view does not explain the time-asymmetric attitude more easily than the static view. Therefore, as discussed in Section 3, one of the perceived advantages of the dynamic view over the static view is invalid. In what follows, I call the direction from (toward) which the absolute present moves as the 'absolute past (future)' and the direction in which we have memories (no memories) as the empirical past (future) when there is a possibility of confusion.

3. The Dynamic View Seems to Easily Explain our Asymmetric Attitude

The dynamic view seems to easily explain why attitudes towards the past and the future differ by appealing to this intrinsic direction – simply, time objectively moves from the empirical past into the empirical future; that is, the absolute future (past) and the empirical future (past) are coincident (Emery et al. 2020: §12; Prior 1959: 17; Tallant & Ingram 2018: §2). For example, we feel relieved when an undesirable event is over because the event will not reoccur, and we feel apprehensive when an undesirable event is coming because it will occur. At a first glance, this is an advantage of the dynamic view over the static view of time, which claims that time does not objectively flow.[5]

However, this paper proposes that the dynamic view of time cannot explain the difference in attitudes towards the past and the future; at least, it cannot do so in a straightforward way because if one only remembers the absolute future instead of the absolute past, and entropy increases towards the absolute past, then one would believe that the absolute future had passed and the absolute past had not arrived (in other words, one would consider the absolute future as the empirical past, and the absolute past as the empirical future). For example, assume that you suffer from a headache, and then your pain is relieved. In this situation, you must believe that your headache has passed, and thus, you feel relieved. However, suppose further that the intrinsic direction points in a direction opposite to the empirical one; thus, the headache is actually approaching contrary to your belief that the headache has passed and that you have been relieved of your feeling.

In this paper, I demonstrate that the headache scenario outlined above could happen *even if this world is intrinsically time-asymmetric*. I show that the psychological and intrinsic directions do not necessarily coincide (thus, the intrinsic direction of time is irrelevant to the psychological one).[6] In this paper, therefore, I focus only on one of the dynamic

[5] Of course, it might be possible for the static view to explain the difference in attitudes towards the empirical past and the future. However, this only shows that such attitudes do not necessarily follow the reality of time's passage; thus, both views can explain the attitudes. Therefore, dynamic views are still candidates for an appropriate model of time (to show that the static view can explain the difference in attitudes towards the past and future does not give the static view an edge over the dynamic view).

[6] I use the word, 'necessarily' not as a logical, but as a metaphysical necessity. It is difficult to explain what distinguishes logical necessity from metaphysical necessity. Both hold in all possible world. However, while logical necessity is always *a priori*, metaphysical necessity can sometimes be *a posteriori* (for example, the proposition 'water is H_2O' is metaphysically necessary, but *a posteriori*).

views of time: GBU, which argues that the absolute past and the absolute present are real, whereas the absolute future is not. Therefore, GBU is an ontologically and intrinsically time-asymmetric view. Since GBU seems to easily explain our time-asymmetric attitude, it is actually an unfavourable model for my argument; therefore, I deliberately choose GBU in this paper. For, I consider that if my argument succeeds even in GBU, then this line of argument can easily apply to other models that are ontologically time-symmetric.[7]

It has been argued that the experience of time's flow does not constitute as evidence of the reality of time's flow (Price 1996: 14–15; Prosser 2000; 2007; 2012; 2013). However, as Baron points out, such a discussion assumes the following proposition:

> [E] The flow of time makes no physical difference to the physical state of the world (Baron 2017: 613).

For example, Prosser (2007) argues as follows. Because of [E], the flow of time is an epiphenomenon of the physical state (the flow of time itself is not a genuine physical phenomenon). In addition, our consciousness (thus, our feeling of time's flow) is also an epiphenomenon of the physical state. However, epiphenomena cannot interact with each other. Therefore, the experience of time's flow does not constitute evidence of the reality of time's flows.

Nevertheless, Baron (2017) argues that, as the current theory of physics is not finalised and we have observational evidence that we really feel the flows of time, there is no strong reason to support the claim [E]. Baron's argument seems to be persuasive. However, I demonstrate in this paper that the dynamic view cannot explain our different attitudes towards the past and the future *even if the theory of physics could change into another form from the current one*. For example, I argue that even if we find a theory of physics in which the absolute present plays some role (i.e., the flow of time makes a physical difference to the physical state of the world), this does not guarantee that intrinsic and empirical directions are coincident. In other words, even if time's flow is a genuine physical phenomenon, intrinsic and empirical directions can be opposite to each other. Note that I do not insist that our feeling of time's flow does not stem from the fact that time really flows.

Finally, I address the question of why we believe that the direction in which we have memory is the past, and the direction in which we have no memory is the future (namely, why we believe that the psychological direction is coincident with the intrinsic direction) from the question why we feel that time flows from the past to the future. What I mainly focus on in this paper is the former (although the latter is briefly discussed in §5). Certainly, it can be the case that if the latter question is solved, then the former one is necessarily solved, and the dynamic view can solve the latter.

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[7] Many versions of the moving spotlight theory have recently been suggested, and some of them are ontologically asymmetric models (Cameron 2015; Deasy 2015; Sullivan 2012). However, as mentioned in the main text, I expect that if my argument holds, then the line of my argument easily applies to them. In addition, I do not treat the shrinking block universe theory, which some authors insist is as intuitive as GBU (Casati & Torrengo 2011; Norton 2015).

However, first, it is discussed in the field of philosophy of time that it is difficult to explain why we can experience the flow of time even if the dynamic view is true (discussed in §5), and there are many attempts to explain our feeling of time flow according to the static view (Baron et al. 2015; Dainton 2017). Second, the proponents of the dynamic view might insist as follows: even if it is difficult to explain why we experience the flow of time even by the dynamic view, if the dynamic view can answer the former question, then it has the advantage over the static view. Third, our feeling of time's flow might stem from the belief that we believe that the direction in which we have memory is the past, and the direction in which we have no memory is the future (thus, the assumption that the solution of the latter question may necessarily also be the solution of the former might be false). Therefore, I argue that the dynamic view cannot answer the former question.

4. In a Case where Causal Direction can be Reduced to another Direction

Let us assume a case in which causation is not a primitive concept. Some philosophical theories explain that the psychological, thermodynamic, or forking directions agree with the causal direction (Dowe 2000; Horwich 1987; Lewis 1979; Price 1996; Reichenbach 1956).[8] This means that the causal direction can be derived from the psychological, the thermodynamical, or the forking direction. Therefore, the causal direction does not necessarily coincide with the intrinsic direction unless the direction to which the causal direction is reduced coincides with the intrinsic direction.

Reichenbach (1956), Lewis (1979), Horwich (1987), and Dowe (2000) propose that the causal direction can be reduced to the forking direction; the causal direction is defined as the direction of the fork that is open. Reichenbach (1956) insists that we can never find a fork open towards the (empirical) past, a fact that is contingent. Lewis (1979: 474–475) argues that the causal direction is reduced to the counterfactual direction and the counterfactual direction is reduced to the forking direction. Horwich (1987: Ch. XII) and Dowe (2000) seem to propose that the fork asymmetry stems from a contingent initial condition, and, therefore, there is no reason for this forking direction to coincide with the intrinsic direction. Dowe (2000: 205) further accepts that the fork points in the opposite direction of most other forks in some cases, thus proving reverse causation.

Let us assume that the causal direction is reduced to the forking direction. As mentioned above, Dowe (2000: 205) argues that the fork points in the opposite direction of most other forks in some cases, thus proving reverse causation, taking the Einstein-Podolsky-Rosen (EPR) situation (Einstein et al. 1935) as an example. However, Reichenbach opposes his suggestion. Thus, let us consider another case where the forking direction points in the opposite direction. As discussed in Section 5, when stars are created, things converge

[8] Hawking (1988) shows that the psychological asymmetry can be reduced to the thermodynamic asymmetry. However, whether the thermodynamic asymmetry can be reduced to the cosmological asymmetry is controversial (Callender 2004; Greene 2004; Hawking 1985; Price 2004). Nevertheless, even if the second law of thermodynamics were fundamentally asymmetrical, asymmetry and direction would still be different concepts, as discussed in §5.

through gravitation. In this case, the forking direction points in the opposite direction of most other forks.[9] Therefore, if the forking and intrinsic directions are coincident, time flows in the opposite direction when the forking direction points in the opposite direction; however, this is not plausible. Accordingly, if the causal direction is reduced to the forking direction, the causal and forking directions do not coincide with the intrinsic direction. Furthermore, if the psychological direction stems from the causal direction, it also does not always coincide with the intrinsic direction. Some may state that the psychological direction could stem directly from the intrinsic direction, which is what I argue in Section 5.

Price (1996) argues that the causal direction could be reduced to the psychological direction, insisting that the belief that a cause precedes an effect arises from the more foundational belief that the future is open and the past fixed. Therefore, according to Price (1996: Ch. 7–8), when we do not know what happened in the past, we could believe that there is a reverse causation; the EPR situation is typical.

Consider a case where the causal direction is reduced to the thermodynamical direction. If the second law of thermodynamics was a principle that is irreducible to the other time-symmetrical law, then it seems that the thermodynamical and intrinsic directions must be coincident. Additionally, if the causal and psychological directions must be coincident, then the psychological direction must necessarily coincide with the intrinsic direction. However, we must note that direction and asymmetry are different concepts. There is no reason for time to flow from low-entropy states to high-entropy states *even if the second law of thermodynamics was a principle*. Therefore, if, as Hawking (1988) shows, the psychological asymmetry can be reduced to the thermodynamic asymmetry, this does not mean that the psychological direction necessarily coincides with the intrinsic direction.

In summary, this section examines the case in which causation is not a primitive concept. First, if the causal direction is reduced to the forking direction, then some causal directions can point in the opposite direction of most other causal directions. Thus, if the psychological and causal directions are coincident, then the former does not necessarily coincide with the intrinsic direction.

Second, if the causal direction is reduced to the psychological direction, then the psychological and intrinsic directions do not always coincide because, as Price (1996) discusses, the causal direction can be reversed (see also Dummett (1978)).

Third, we consider the case in which the causal direction is reduced to the thermodynamical direction, the psychological direction is reduced to the thermodynamical direction, and the second law of thermodynamics is a principle. Here, the point is that direction and asymmetry are different concepts. Therefore, there is no reason for the thermodynamical direction to coincide with the intrinsic direction even if the second law is a principle. Namely, there could be a case in which time flows from the high-entropy state to the low-entropy state even in the closed system.

[9] In this case, as the distribution of momentum is diverging while the distribution of position is converging, entropy is increasing.

5. In a Case where the Causal Direction is Primitive

When considering the issue of the psychological and intrinsic directions being necessarily coincident, the significant question is whether the causal and intrinsic directions are necessarily coincident. Since the occurrence of an event, E, is considered to cause the memory of E, the causal and psychological directions are necessarily coincident. Therefore, in this section, I examine the case in which causation is primitive and GBU is correct. I conclude that, even in this situation, contrary to what appears to be the case, the psychological direction does not necessarily coincide with the intrinsic direction because the causal direction does not necessarily coincide with the psychological direction. (The causal and intrinsic directions are necessarily coincident if GBU is correct.)

According to GBU, the existent area of the universe (including space and time) grows as time flows; thus, the existent area is the absolute past, the non-existent area is the absolute future, and the absolute present is the edge of the block universe. This entails that the intrinsic direction in GBU is a growing direction.

If the psychological direction could point in a direction opposite to the intrinsic (growing) direction, then the following scenario is possible: you could have the memory of an event, E, that occurs in the future (this is the situation that I would like to demonstrate to be possible in this paper). However, future objects, ideas, and events do not exist in GBU, although the cause of the memory of E is generally believed to be the occurrence of E. Therefore, in that scenario, it seems to follow that the future non-existent event E causes the present memory of E. This seems strange because it seems impossible that a non-existent event could cause anything.

Therefore, if the causal direction necessarily coincides with the intrinsic direction, then GBU seems able to explain the difference in attitudes towards the past and the future. For, as the occurrence of E is the cause of the memory of E, the occurrence of E has to precede the memory of E. This means that it is impossible for you to feel relieved even though the headache from which you will suffer has not yet come (because the fact that the headache is over causes your relief, and the cause has to precede the result).

Indeed, proponents of CPT propose that causation has an intrinsic direction that coincides with the intrinsic direction of time (Koons & Pickavance 2015; Mumford & Anjum 2011). They insist that the concept of causation is primitive and cannot be further reduced to another concept. CPT argues that things (or actions) have causal power to make other things occur. Accordingly, non-existent things (or non-existent actions) cannot have causal power, and, thus, a future event cannot make a past event happen in the GBU world. Therefore, according to CPT, the causal direction must coincide with the intrinsic direction in the GBU world. Thus, the absolute future event E cannot create the memory that E happened in the absolute past, and the intrinsic, causal, and psychological directions must coincide.

This argument seems plausible. Nevertheless, the point of this paper is that there is no ground that the causal and psychological directions coincide, even if we accept CPT and GBU (coincidence of the causal direction with the intrinsic direction). Then, how is

such a situation possible? The situation is possible if the memory of E is the cause of the event E (namely, the memory of E temporally precedes E). We consider the occurrence of E as the cause of the memory of E, because we believe the occurrence of E to be more in the past than the memory of E. However, this, in other words, shows that believing the occurrence of E causes the memory of E has no basis other than our belief that the occurrence of E temporally precedes the memory of E. Then, why do we think that the occurrence of E temporally precedes the memory of E? I believe this stems from our habit or instinct (or may be due to the thermodynamic asymmetry). In other words, this direction is merely a conventional one, because, as discussed in Section 3, physics does not tell us the intrinsic direction of time.

Some may argue that the memory of E cannot create E. However, this claim has no basis. Even if the mechanism of how event E creates memory E is clarified, this just clarifies the causal connection between E and the memory of E. Again, current physics does not tell us the direction. Of course, if a certain event, E_1, is caused by the memory of E_1, then *all* other memories of all events (of all agents in this world), E_2, E_3, …, must cause all corresponding events, E_2, E_3, …

Nevertheless, some may object, as is also discussed in Section 3, that this fact may be considered an indication that current physics is incomplete. This indication could be true. However, the point is that at least, *in the current stage*, the proponents of the dynamic view cannot explain how E causes the memory of E. Generally, we cannot explain how all things and events considered to be the cause of E_n actually cause E_n (scientists only show the causal connection between them).

Some may still state that the dynamic view can explain why we experience the flow of time. However, the reality of the flow of time does not *straightforwardly* explain our experience of this flow to the extent that the proponents of the dynamic view suggest. Assuming that we perceive only the present moment, we do not perceive the flow of time itself because the present moment has no temporal range. Some scholars reply to this criticism by arguing that the present is not an instant but consists of a certain range of time (Russell, 1996, etc.). However, this does not provide a simple explanation. Consider that an agent feels a ball is moving from a spatial point A to B. Consider also that the ball is located at A at time t_A and at B at time t_B. Consider further that the 'present' includes t_A to t_B. Now, if the agent perceives t_A and t_B *at the same time*, how can they know that the ball is moving from A to B (Paton 1929)?

Some may respond to this by stating that our inherent cognitive ability allows us to recognise them as a 'flow' rather than as 'simultaneous'. However, this being the case, the *static* view also can explain our experience of the flow of time. Of course, the ability that allows us to recognise them as a 'flow' could work only in the dynamic world; however, at least in the current stage, such a mechanism remains unknown. Again, the point is that the dynamic view does not offer a better explanation of our temporally asymmetric attitude than the static view. (Note that I am not claiming that the dynamic view can never explain the asymmetric attitude.)

Nonetheless, some scholars make the following argument (Dainton, 2000). Consider that the above ball moves from A (at t_A) to B (at t_B) passing through C (at t_C), D (at t_D), and E (at t_E), where $t_A < t_C < t_D < t_E < t_B$. Consider also that we perceive the temporal ranges from t_A to t_D, from t_C to t_E, and from t_D to t_B as the 'present', namely, there are overlaps between every 'present'. In this way, we can perceive the flow of time. However, I argue that, even in this case, the static view can also explain our experience of the flow of time, because the above line of argument can be applied to the static world. For example, if a temporal part of an agent at t_D (this part simultaneously perceives t_C, t_D, and t_E as 'present') has a memory of another temporal part of the agent at t_C (this part simultaneously perceives t_A, t_C, and t_D as 'present'), then it is not strange that the same mechanics that make the agent in the dynamic world feel time's flow could also make the agent in the static world feel it.

Of course, a more elaborate theory of how we perceive the flow of time, only applicable to the dynamic world, may be proposed in the future. Nevertheless, the point is that our experience of the flow of time cannot be explained in a straightforward manner, even in the dynamic view. Consequently, even if GBU and CPT are true, it is possible that the memory of E temporally precedes the occurrence of E. (The dynamic view at least has not offered any evidence that the occurrence of E must precede the memory of E at the current stage.) Thus, the memory of E might cause the occurrence of E. This implies that even if the causal direction coincides with the intrinsic direction, the psychological direction may diverge from the intrinsic (and causal) direction.

Still, some readers might propose a loophole against the possibility of disagreement between the causal direction and other directions (e.g., the thermodynamic direction and the psychological direction) when taking CPT. If we consider Hawking's (1985) suggestion that the thermodynamical and psychological directions are coincident, and that one thing causally creates multiple things, although multiple things cannot create one thing, then, an event E creates multiple objects and events, such as lights, sounds, and heat. This direction coincides with the direction of the thermodynamic direction. Therefore, the forking direction is grounded by the causal direction (if CPT is correct), although many scholars, such as Reichenbach (1956) and Horwich (1987), insist that the causal direction is reduced to the forking direction. Since the causal and intrinsic directions are necessarily coincident as discussed (if CPT and GBU are correct), the intrinsic and psychological directions are necessarily coincident.

However, if the forking (thus, causal) direction and the intrinsic direction necessarily coincide, all forks must point in the same direction. Nevertheless, they do not have to do so as discussed in the example of the EPR situation. Still, some may insist that Dowe's argument is false. (Note that Dowe considers that causation is not primitive, and that the causal direction is reduced to the forking direction; thus, he argues for backward causation. Nonetheless, if CPT and GBU are correct, no backward causation can exist because the causal and intrinsic directions are coincident.) However, there is another case where some forking directions point opposite to other forking directions, that is, there is a case where thermodynamical and forking directions do not coincide (as mentioned in

Section 4). For example, the process by which things come together by gravitation is also an entropy-increasing process (Carroll 2010).

Accordingly, the assumption that the forking and (primitive) causal directions will coincide is false. The intrinsic and causal directions and the psychological and thermodynamical directions are coincident. However, to connect these directions through the forking direction, the forking and thermodynamical directions must be coincident. Nevertheless, they are not always coincident; thus, the forking and causal directions are also not always coincident (because some forking directions point in the opposite direction to the other forking directions, but all causal directions must point in the same direction if CPT and GBU are correct). Therefore, this loophole is invalid.

6. In a Case where the Theory of Physics was Different

Let us summarise the argument presented thus far. I do not insist that the directions of time that we experience, namely, the psychological and thermodynamical directions, could not coincide with each other. Perhaps, these two directions coincide. In addition, I accept the possibility that if causation is not a primitive concept, then causal direction can be reduced to one of the above directions (or to a forking direction). What I insist on is that it is not guaranteed that intrinsic direction and those directions coincide (§4). In other words, the intrinsic direction is irrelevant to explaining our different attitudes towards the future and the past.

Furthermore, I insist that even if the world is ontologically time-asymmetric (as in GBU), causation is a primitive concept (as in CPT), and thus causal direction and intrinsic direction coincide, it is still possible that intrinsic and psychological direction point in opposite directions (§5). For, the memory of an event E could cause the occurrence of E, and a high-entropy state could cause a low-entropy state (namely, in this case, it is not guaranteed that causal direction and psychological direction are coincident). There are no physical or metaphysical reasons to prohibit such a scenario.

Some readers might consider that this is because the current fundamental laws of physics are time-symmetric. However, even if the fundamental laws were time-asymmetrical, dynamists would still need to clarify why the intrinsic and causal directions would coincide with the psychological directions (even if CPT is correct), because asymmetry and direction are different concepts. For example, the sign of the arrow (→) is a spatially asymmetric sign. This is intrinsic asymmetry. However, as discussed in the introduction, the direction from left to right is not intrinsic, just convention. Likewise, there is a possibility that there is no intrinsic direction even if there is an intrinsic temporal asymmetry in the world.

Suppose that the second law of thermodynamics was a basic law (this law could not be deduced from any other laws). It would then follow that the world is intrinsically time-asymmetric. Nevertheless, it still is not clear why the low-entropy state is identified with the absolute past; it is not guaranteed that the direction from the low-entropy state to the high-entropy state coincides with the intrinsic direction. Even if there were an intrinsic

temporal asymmetry in the world, the temporal direction that pointed towards the absolute past could not be determined. The only thing that the temporally asymmetric fundamental laws prohibit is the inability to observe time-reversal phenomena.

For example, (if the second law were a basic law) we would never observe phenomena where a high-entropy state changes into low-entropy state in a closed system; namely, we would never *observe* William's Doppelgänger who was dead, being born in a state of senility, and getting younger as he was growing up (Williams 1951: 468–469).[10] This is not because the intrinsic direction coincides with the psychological direction but because the thermodynamical direction and the psychological direction (both are empirical directions) are coincident. Therefore, it is possible that *all* of us are Doppelgängers; All of us were dead, were born in the state of senility, and get younger as time flows from an absolute past to an absolute future (in this case, the state of the whole world changes from high entropy to low entropy). Nevertheless, we ourselves cannot recognise this situation; we believe that time flows from a low-entropy state to a high-entropy state.

However, some still might insist as follows. The reason it seems possible that intrinsic and psychological directions point in opposite directions is that the flow of time plays no role in the theory of physics. If the future is open, and the flow of time makes some differences in the physical state, then, the intrinsic direction must coincide with the psychological direction. The 'future is open' means that the future state is uncertain or indefinite. Therefore, when a future time point becomes the present, then the indefinite changes into the definite state; this means that the flow of time makes a difference in the physical state. If a physical theory, T, describes this situation, then the flow of time plays some role in the theory of physics, T.

For example, quantum mechanics cannot predict the future in principle.[11] Although the Schrödinger equation, which is the fundamental equation of quantum mechanics, is a time-symmetric equation, quantum mechanics becomes a time-asymmetric theory combined with a projection postulate, which allows a discrete change of the physical state (i.e., the collapse of wave-function). If the wave-function completely describes the physical state of the system, the future is open.[12] In this case, the flow of time plays a role in the theory of physics.

Suppose that the wave-function of a certain physical quantity Q at a certain time point t is not an eigen-function when t is the future; this means that Q actually has no definite value (thus, the future is open) because we now assume that the wave-function completely describes the physical state. However, when t becomes the present, Q is measured, and we obtain a definite value of Q. Therefore, the flow of time has made the indefinite value of

[10] Maudlin (2002: 272–273) argues that such a person whose body were to consist of cells and other matters working in opposite time direction of ours cannot have any mental state at all because it is doubtful that it could even properly be called a living organism.

[11] Note that unpredictability in principle is not the sufficient condition of the open future, this is just the necessary condition of the open future (Morita 2022).

[12] Of course, this is one of the interpretations of quantum mechanics. For example, Morita (2022) argues that this interpretation is implausible. In this paper, I assume this interpretation for the sake of discussion.

Q a definite value. This seems to follow that intrinsic and psychological directions should coincide if quantum mechanics is complete, and this interpretation (that the wave-function completely describes the physical state, and quantum mechanics includes the projection postulate) is correct.

However, like the case of quantum mechanics, a theory supporting an open future must include discrete change. If the fundamental equation completely describing the physical process is continuous, the future state is predictable (thus, the quantum mechanics need the projection postulate). If the future is open, at the moment when an observer measures a physical quantity or the future state changes into the present state, the physical state changes from an indefinite state into a definite state; this change is discrete. Consequently, we cannot retrodict the past state, either. For, the current state does not include any information about the past due to discrete change. Therefore, if physics completely describes the physical process, an open future also implies an open past, even if they are asymmetric.

However, there is a possibility that the physical theory only describes our knowledge about the physical state even if the physical theory is complete. 'The physical theory is complete' means that any information other than that which the theory requires is unnecessary to explain the experimental data; in other words, there are no so-called 'hidden variables'.[13] Nevertheless, in this case, the above argument is also applicable. We cannot retrodict the past state from the current state since there must be discrete change at some moment between the past and the present (again, if there is no discrete change, the future is predictable under the assumption that the physical theory is complete). Accordingly, even if the absolute future is open, the intrinsic direction and psychological direction do not necessarily coincide because if the absolute future is open, then, the absolute past is also open (there is no ground to determine which direction is the absolute future).

Some may insist that such issues can be solved by introducing a metaphysical principle that the future is open while the past is definite. However, the problem is that it is not guaranteed that the empirical future is really open, and the empirical past is really definite because we have no means to confirm that intrinsic and psychological directions point in the same direction.

7. Summary

This paper demonstrates that the intrinsic direction of time, which is built into the dynamic view of time, is irrelevant to our different attitudes towards the past and the future. The GBU theory insists that future things do not exist. Thus, if objects (or actions) have the causal power to create (CPT is true), then those future things cannot make things happen. Accordingly, the intrinsic direction has to coincide with a causal direction. However, there is no basis for asserting that any given event C that people believe to be the cause of

[13] Note that I do not insist that the quantum mechanics is incomplete. There are many interpretations, such as the many-world interpretation and the modal interpretation that do not (necessarily) require that the quantum mechanical world is open future, although they accept that the quantum mechanics is complete. Actually, Morita (2022) argues that if the modal interpretation is true, the future must be determined (see also Morita (2023)).

another event E is really the cause of E, even if these two events are causally combined. Namely, E could be the cause of C (thus, E could intrinsically precede C in time). For it is possible that the psychological (and thermodynamical) directions could point in the opposite direction of the causal direction and, thus, of the intrinsic direction. These arguments are valid even if the flow of time plays a role in the fundamental laws of physics.

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