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(IN)STABILITY OF CAUSALITY-REPRESENTATION IN THE SPACE OF MULTIPLE MENTAL REPRESENTATIONS OF TIME FLOW[2]

The article examines the interconnection between time and causality. It describes an instability in causality-representation when causal relata are projected on the space of the multiple cognitive representations of time flow. Traditionally the manipulability theories of causation are taken for cases when all elements of the causal chain are given within conventional linear time flow. Within the manipulability approach to causality, the article examines how far human cognitive system contributes to variability of mental representations of cause, effect and their temporal connectedness. The paper answers the question whether and how the different time-representations affect the human ability to model causality. This makes the novelty of the proposed approach. To do so one follows the minds ability to produce the multiple representations of time flow. So, we went beyond the traditional assumption about singularity of mental time flow and introduced the notion of the multiple time representations (Polunin, 2011, 2015, 2016, 2021). As each single time-representation is described by distinct functional features, it specifically impacts the mental representations of an event happening in its time, and consequently, the representation of causal relata. Therefore, we argue for essential variability of mental representation of causality in the space of the multiple cognitive representations of time flow. This variability can be demonstrated without any real change in the world events involved in the causal relationship, thus describing the mind's contribution to causality. The proposed approach allows for its empirical examination. It makes possible to manipulate individually the representations of cause and that of effect, examining more deeply the contribution of the human mind to their relationship. This stresses the mental nature of causality, its subjective judgment and it points to the possible deviations in judgment outcomes regarding availability vs absence of causal relationship.

Keywords: *causality, time, manipulability theories of causality, representation of time, multiple representations of time flow.*

Introduction

How do we explain our personal and social experience? What are the essential components of all arguments in science and everyday life? Are we not appealing in such cases to causality? But what do we rely on when judging a causal relationship? What makes an event perceived as having cause and effect? When answering these questions, the notion of time plays a crucial role. Mental representation of temporal connectedness is key factor for recognizing two events as causally related. Usually temporal connectedness is built upon conventional representation of singular time flow. And often we ignore that our mind is able to develop more than one concept of time (Gell, 1992; Widlok, 2014). Such time concepts are developed by the human mind in a reflective goal-directed mood. But in a prompt, daily judging of the events one relies on the cognitive representations of time flow. The mind develops also more than one cognitive representation of time flow (Polunin, 2015, 2016, 2021). In discrepancy to the findings by Boroditsky (2011), Boroditsky and Gaby (2010) who shown that people from the different cultures differ in their representation of time flow, we have shown that the subjects from one and the same culture, speaking the same language are able to develop the different mental representations of time flow. This finding rests upon the set of experimental studies on the role of time-representation in decision making (Polunin, 2009, 2011, 2013, 2014, 2015, 2016). Each of the cognitive representations of time has its distinguished features and accordingly impacts

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temporal representation of an event over time. Thus, alternation of the mental representations of time flow is the ground for the subsequent variations in cognitive representation of causal relata and then in representation of the whole causal relationship.

At the general level we are answering the *question* about the impact of time representation on establishing a *cause-effect relationship* within *the manipulability approach*. Our key move is to go beyond the traditional assumption of the singularity of mental time flow and elaborate the role of the different time-representations for mental modelling of causation. The general logic of the article is as follows: we start from the notion of the manipulability approach to causality modelling. We stress the role of the mind in representing causal relata and in judgment about presence or absence of a causal relationship. In the next step we point to the role of time in establishing a causal relationship. Thereafter we show that the human mind develops several different representations of time flow. Further, the idea of the multiple representations of time flow is interconnected with the mental modelling of causality. We analyze the key aspects of manipulativistic causality in the space of the multiple time representations. The causal relata are mapped on the known mental representations of time flow which results in a corresponding variation of relata-representation. As a result, one is confronted with variability of causal relationship, namely with instability of its mental representation. Thus, through manipulation of mental representation of time flow we specify the role of time as foundation to the causality modelling within the manipulability approach. Doing so we are also examining the limits of the manipulationist theories of causality.

Causality modelled within the manipulability approach

In metaphysics one finds a number of theories of causation – regularity theories, probabilistic theories, process theories, counterfactual theories, and manipulationist theories. The standard view of the causal relata is that they are of the category of *event*, and that their number is *two* (A and B), in the roles of *cause* and *effect*, such that A is the cause and B effect. While the standard view numbers the causal relata at two (Davidson 1980, Mackie 1965, Lewis 1986), one finds some support for the views featuring three and even four relata (Hitchcock 1996, Woodward 2003). Here we take three components of causal relata: event A, event B and a time distance between the events A and B. Since the human mind provides representations of all three components, we assume that variations in representation of the relata should result in variation of causality-representation. In our view the job of the relata is to provide a sufficient amount of information for a cognitive system for arriving at conclusions about the causal relationship. This amount can be varied in a way similar to our previous studies (Polunin, 2009, 2015, 2016). One manipulates temporal representation of each of the relata. Our thesis stresses the variability of the causality judgment for a formally similar case.

The manipulability theories of causation assume that causes are to be regarded as devices for manipulating effects. There are several prominent versions of such theories advocated by Gasking (1955), von Wright (1971), Menzies and Price (1993), and Woodward (2003). It is essential that the manipulationist approach assign a central role for understanding of causation to human *action*. We interpret human action as internalized information processing which results in the mental representations of the causal relata, namely the representations of event A, event B and that of time distance. For our case the action consists in activating different mental representation of time flow and mapping the causal relata on them. By manipulating each of these representations, one induces a discrepancy in the relata representation and puts a strain on the manipulability framework, examining its limits and reliability.

Anscombe (1975) claims that causation is an intentional relation, and takes causation to be relative to descriptions of the primary relata. On this view, causal relations have the form: A causes B relative to *D*, where *D* is an ordered pair of descriptions (for A and for B). The other thought arises from Pearl's (2000) work on causal modelling, where he treats causation as relative to a certain kind of mathematical representation. On this view, causal relations have the form: A causes B relative to *M*, where *M* is an apt causal model of the situation. So, we face a

kind of dependence of causality depending on the way the relata are represented. For our analysis we take not every kind of relata representation, but just the representation in time. One induces the variability of causal relata through impact on their properties by different representations of time. The specified variability in representing the cause-effect relationship highlights the contribution of the cognitive system to development of a causal picture of the world. Here we follow Buzzoni (2014, 377) who states that "human beings … *are the indispensable factor in establishing causal chains*."

Cook and Campbell (1979) write: "The paradigmatic assertion in causal relationships is that manipulation of a cause will result in the manipulation of an effect." In our view, manipulation of cause representation results in variation of causality representation. The same is true for effect: a variation in effect representation impacts the causality representation. Put simply: an absent or a minimal representation of cause or that of effect means no causality representation. So, we argue for an essential contribution of the mind in establishing causality. We assume that the mind relies on one's own ability to represent the A and B events before drawing a conclusion about availability/absence of a causal relationship. Thus, we distinguish *manipulation of cause* and *manipulation of cause representation*, and the same for *effect* and *representation of effect*. With this in mind, one also assumes, for instance in a priming effect, that a mental representation of cause implies that its variation varies the representation of effect. The way the mind processes a potential cause impacts the information processing relevant for mental effect processing. But how do we induce such manipulation of the A and B representations? By alternating time representation for one and the same worldly happening, one impacts the judgment outcome about availability/absence of the causal relationship.

Menzies and Price (1993) defend the claim that an association between A and B persists when A is "manipulated" in the right way and then A causes B. We need to be much more precise by what we mean by A and B. Somehow within such approach one ignores the role of the judging person; one ignores a contribution of the mind establishing the causal relationship between A and B. What is essential is whether A and B are taken as the worldly events or as their representations by cognitive system. The mind judges availability of causal relationship between A and B based on the mental representations of A, B and that of the time distance between them. Thus, one has to consider a possible variability of the corresponding mental representations. At least two sources of such variability should be considered: the real events in the outside world, and the mental information processing, for instance impact of framing. The examples of such impact were shown in the experiments on intertemporal decision making (Polunin, 2009, 2015, 2016), when one and the same monetary proposition (a worldly happening) essentially changed its value at the level of representation, and impacted behavior differently.

The notion of an intervention is rightly seen by many authors as central to the development of a plausible version of a manipulability theory. The basic idea is that of an exact change in A which is of such a character that if any change occurs in B, it occurs only as a result of its causal connection, if any, to A and not otherwise. In other words, the change in B, if any, produced by the manipulation of A should be attributed only to a causal route that goes from A. The described changes in the value of a variable that have the right sort of surgical features have come to be called *interventions* (Spirtes, Glymour, and Scheines 2000; Meek and Glymour 1994; Hausman 1998; Pearl 2009; Woodward 1997, 2003; Woodward and Hitchcock 2003; Cartwright 2003). Our *question* is about the nature of intervention. One can intervene on a worldly event. But one can also intervene in the representation of an event. We argue that there are interventions that change *representation* of A, and then change judgment of causal relationship between A and B, but do not impact the real-world causal A-B relationship. It is possible to have change in representation of A that forges a real-world change of A. Such intervention questions the reliability of the whole interventionists approach requiring its further development and specification of the possible interventions. If one can intervene in causality representation without any manipulation of the worldly events, one can produce a world picture based on a set of illusory causal relationships.

Here we are speaking only about direct causes. A is a *direct cause* of B if and only if under some intervention that changes the value of A, the value of B changes when all other variables are held fixed at some value. A direct causation presupposes an immediate connectedness between A and B. For the indirect cause it would be even easier to show some framing-effects that break a stable representation of the A-B causal relationship.

Manipulability models of causation and the multiple representations of time flow

Nature itself does not establish and does not judge the availability of causality. The human mind judges the absence or availability of a causal relation between A and B. It does so based on the mental representations of A, B and the time distance between them. Events A and B may be placed in a different time mode – past, present, future, which makes their mental representations sensitive to time flow. But the notion of time and time-representation are also developed by the mind. Moreover, the mind develops different representations of time flow (Boroditsky and Gaby, 2010; Polunin, 2015, 2016, 2021). This is why we are paying attention to the temporal dimension of all basic elements that later could be interpreted as causal relata. In addition to the intervention, the performer – actor – must be analyzed regarding temporal features. Each element, A, B, distance between A and B, and actor can be projected on the different representations of time flow. As a result, each of them can specifically vary within the time dimension.

Recognizing the critique by Hausman (1986, 1998) of the manipulability theories, namely that they lead to a conception of causation that is anthropocentric, we examine how far the human cognitive system contributes to manipulability on of the mental representations of cause, effect and their temporal relation. Taking the concept of causality as outcome of the human mind we are digging deeper in the anthropocentric domain of causation. Manipulating actual representation of time flow one produces different representations of causal relations that appear for the subject as being equally trustworthy. Up to the certain level, our approach goes along with the position by Menzies and Price (1993). They assign a central role to the notion of agency in a manipulability theory. We just fill this agency with different content. Here we distinguish a real-world intervention from an intervention applied to mental representation of causal relata. We also introduce a new kind of intervention, which uncovers dependence of all causal claims on the mental representations of time flow. So, establishing a causal relation becomes dependent on an actually activated representation of time flow. Thus, the notion of intervention must be reconsidered in the space of the multiple mental representations of time flow. It is similar to transition from modelling along a singular line to modelling in a multidimensional space. Such a step increases the scope of possible interventions, and so variability of the perceived causal relation. Even if this variation is given only in the mind of the actor or observer, a person establishing the presence or absence of a causal relation, it necessarily impacts the judgment outcome of presence/absence of a causal relation. Thus, a given event in the world, after being projected on the different mental representations of time flow, may show different power in serving as cause maker. Potentially, a projection of the A and B events on some representations of time flow may even break a representation of causal connectedness between A and B, initially established along the conventional singular time flow. So, it is necessary to specify the conditions under which variation of A, B and of time distance between A and B impact the mental establishing of an A-B causal relation.

It was experimentally shown (Polunin, 2009, 2014, 2015, 2016) that different mental representations of time differently impact the representations of an event in human mind. The value of A is a function of an actually activated representation of time flow: $A(t_j)=f(t_j)$, since $t_i \neq t_j$, one gets $A(t_i)\neq A(t_j)$, where t_i and t_j are the i-th and the j-th representations of time flow; and $A(t_j)$ is value of A within the t_j time flow. The same applies to the i-th representation of time. Holding constant all other variables, we can separately vary the values of A and/or B just by projecting them on the different representations of time flow. The "and/or" is used here in the sense that A and B are two different events. Each of them can be projected on a separate time

flow, t_i and t_j, inducing different variations in event-representation, e.g., $\Delta_{i\text{-}j}(A)$, and/or $\Delta_{i\text{-}j}(B)$. The variability in representing A and B describes a possible discrepancy in establishing a causal relation between A and B.

An inequality of A projections on the i-th and j-th time flows is: $A(t_i) \neq A(t_j)$. Similarly, if B is a projection in two time flows, one gets $B(t_i) \neq B(t_j)$. Since a causal relationship is based on the mental representations of the events (A and B), one expects variability in establishing of causality. Namely the causal relationship for $A(t_i) \rightarrow B(t_i)$ does not equal $A(t_j) \rightarrow B(t_j)$. Since each of the time representations differently impact the proximity of the events, one expects also the variation in stability of a causal relationship $A(t_i) \rightarrow B(t_i)$ vs. $A(t_j) \rightarrow B(t_i)$ as a function of a time distance. In such cases the initially established causal relation can even be eliminated or perceived as weak. This points to the manipulability of subjectively perceived strength of causal relation.

What causes an event to be perceived as a cause? What forces the human mind to perceive an event as a cause? It is the observation of a phenomenon that could be interpreted as effect. Such observation is possible on condition the phenomenon *attracts* a subject's attention and is *valued* by the subject. After having such effect, one begins to look for a forerunning event, which can be recognized as a cause. Doing so, one relies on the notion of time and on an assumption about the availability of a causal relationship. Conversely, if there is no noticeable change of B or significant change of B's mental representation, there is no ground to look for any A, no ground to imagine an A-event as a cause. One will never look for a cause of nothing, unless one was expecting a kind of nothingness. A subjective value of B predefines its potentiality for serving as effect. Because a search for a cause (A) begins only after an observable subjectively important event (B), a manipulation of a cognitive representation of B makes sense.

In our approach, A will qualify as a cause of B as long as value of A produced by a time representation j, $A(t_j)$, is perceived as sufficient for producing a change in perceived value of B. Similarly, for B projected on one of the time representations, e.g., on t_j, and having value of $B(t_j)$, it is true that $B(t_j)$ has to be perceived as sufficient to be a consequence of a changed value of A. The variations of A and B through their projection on the different representations of time flow must refer to the right sort of causal characteristics, otherwise a causal relation may be not established. Let us stress that it does not manipulations of real A and B, but of cognitive representations of A and B in the space of the multiple mental representations of time flow.

A great deal of work on manipulativistic causation has been accomplished by Pearl (2009), who provided an efficient illustration of the usefulness of a manipulationist framework. He (2009: 70) characterizes the notion of an intervention by reference to a notion of a causal mechanism. A functional causal model is a system of equations $Xi=F(Pai,Ui)$ where *Pai* represents direct causes of *Xi* that are explicitly included in the model and *Ui* represents an error variable that summarizes the impact of all excluded variables. A distinct causal mechanism is understood to be "autonomous" in the sense that it is possible to interfere with or disrupt each mechanism (and the corresponding equation) without disrupting any of the others. We argue that temporal representation of the components belonging to one causal mechanism, in first line a temporal representation of Pai, and that of impact on Xi, may vary. So, a description of the functional properties of a causal mechanism should be taken as a function of time representation, within which one describes such mechanism, namely $Pai=f(t_i)$ and $Ui=f(t_i)$.

Moreover, there are certain representations of time flow, e.g., situational time flow, which, if applied to one causal mechanism, most probably will also impact the other causal mechanisms. This may break the requirement of distinctiveness. So, a temporal outline of one mechanism may be relevant for temporal representation of the other mechanism, initially thought to be autonomous. Thus, a variation of time representation cannot always guarantee an independent impact on one mechanism alone, that is, without impacting the other one. The undoubtedly great contribution by Pearl (2009) misses at least some of the possible impacts of the human mind on establishing the causal relation.

In general, an intervention itself and relationship between Xi and its cause (Pai) can be determined by a time-representation they are placed in. Formally, one replaces initially singular Pai with an array of its projections on the different representations of time flow, getting $Pai(A,t_i) \neq Pai(A,t_j)$, and $X(t_i) \neq X(t_j)$. Furthermore, the different time representations can be activated in the mind of both actor and observer, so that one gets two arrays. An array for the actor: $Pai(Ac,t_1)$, $Pai(Ac,t_2)$, $Pai(Ac,t_3)$, $Pai(Ac,t_j)$; and the other for observer $Pai(Ob,t_1)$, $Pai(Ob,t_2)$, $Pai(Ob,t_3)$, $Pai(Ob,t_j)$, where Ac means actor, Ob – observer, and t_j means the j-th time mind representation of the actor and observer. Because of the discrepancy in the properties between $Pai(Ac,t_i)$ and $Pai(Ac,t_j)$; and also because of the discrepancy between the $Pai(Ob,t_i)$ and $Pai(Ob,t_j)$, one gets two arrays for Xi. One array corresponds to the mind of an actor and the other one to the mind of an observer: $Xi(Ac,t_1)$, $Xi(Ac,t_2)$, $Xi(Ac,t_3)$, $Xi(Ac,t_j)$; and $Xi(Ob,t_1)$, $Xi(Ob,t_2)$; $Xi(Ob,t_3)$, $Xi(Ob,t_j)$, where Ac means actor, Ob – observer, and t_j means j-th time representation in the mind of the actor or observer. Therefore, one expects certain discrepancies in descriptions of the causal mechanism. This points to a necessity of a further development of the manipulability theory of causation regarding the space of the multiple mental representations of time flow.

Based on what has been presented, we argue that there are special interventions that essentially impact our mental representations of causal relationship but without changing the causal relation itself. One can manipulate an outcome of causality judgment without any manipulation of the worldly events relevant for the causal relation. In other words, a subject can make a mistake producing an illusory causal relation. Or conversely a causal relation available in the world can be improperly represented in the mind and so denied.

The multiple representations of time flow

The singularity of time flow seems to be a very strong and centuries-long convention across different concepts of time. So, it would not be easy to overcome this singularity. But let us ask a question, is not our mind able to develop several different representations of time flow, so that it has several temporal perspectives on past events and future perspectives? Here we are not getting in the discussion whether time is real or not, we are just stressing the contribution of the mind to the development of time-representation. Our argumentation proceeds from the thesis that representation of time flow is a product of information processing by the human mind.

Some of the earlier philosophical studies can be seen as argument for time as outcome of mind activity. In various forms, one finds doubts as to the reality of time in the works by B. Spinoza, I. Kant, G.W.F. Hegel, A.Schopenhauer, and J. McTaggart. The modern philosopher Bas van Fraassen (1985) connects time to the mind's ability of reasoning. Other studies underline the role of perceiving subject (van De Grind, 2002). Since there is no specialized receptor for the transduction of time one can assume that time is constructed by cognitive system itself (Gibson, 1975). Gruber and Block (2013) are inclined to present time flow as a kind of perceptual illusion, product of information processing. The numerous distortions in time processing point to the fact that the mind is heavily involved in the development of time-flow-experience (Eagleman 2005; Terao, Watanabe, Yagi, Nishida, 2008). One finds additional arguments in the studies on time linguistics, e.g., Vater (2007), Jaszczolt (2009, 2012, 2013, 2017) and in the studies on time representation within different cultures (Boroditsky, Gaby, 2010; Gell, 1992; Widlok, 2014).

Our own experimental results (Polunin, 2009, 2015, 2016) point to the existence of quite independent representations of time flow: situational and propositional time flow, time flow modeled from the first- and the third-person perspective, and a number of other representations of time flow (figure 1). Each of the cognitive representations of time flow has its characteristic properties that specifically modulate subjective value of an object/event over time. For example, an amount of money placed in different representations of time flow shows the differing rates of value of an object. Consequently, each representation of time flow differently influences cognitive modelling of cause, effect, and subjective distance between them. The known time-representations are given in the figure 1, but they do not describe all representations of time flow

human mind may develop. (For a more complete list of the known mental representations of time flow, see Polunin, 2021).

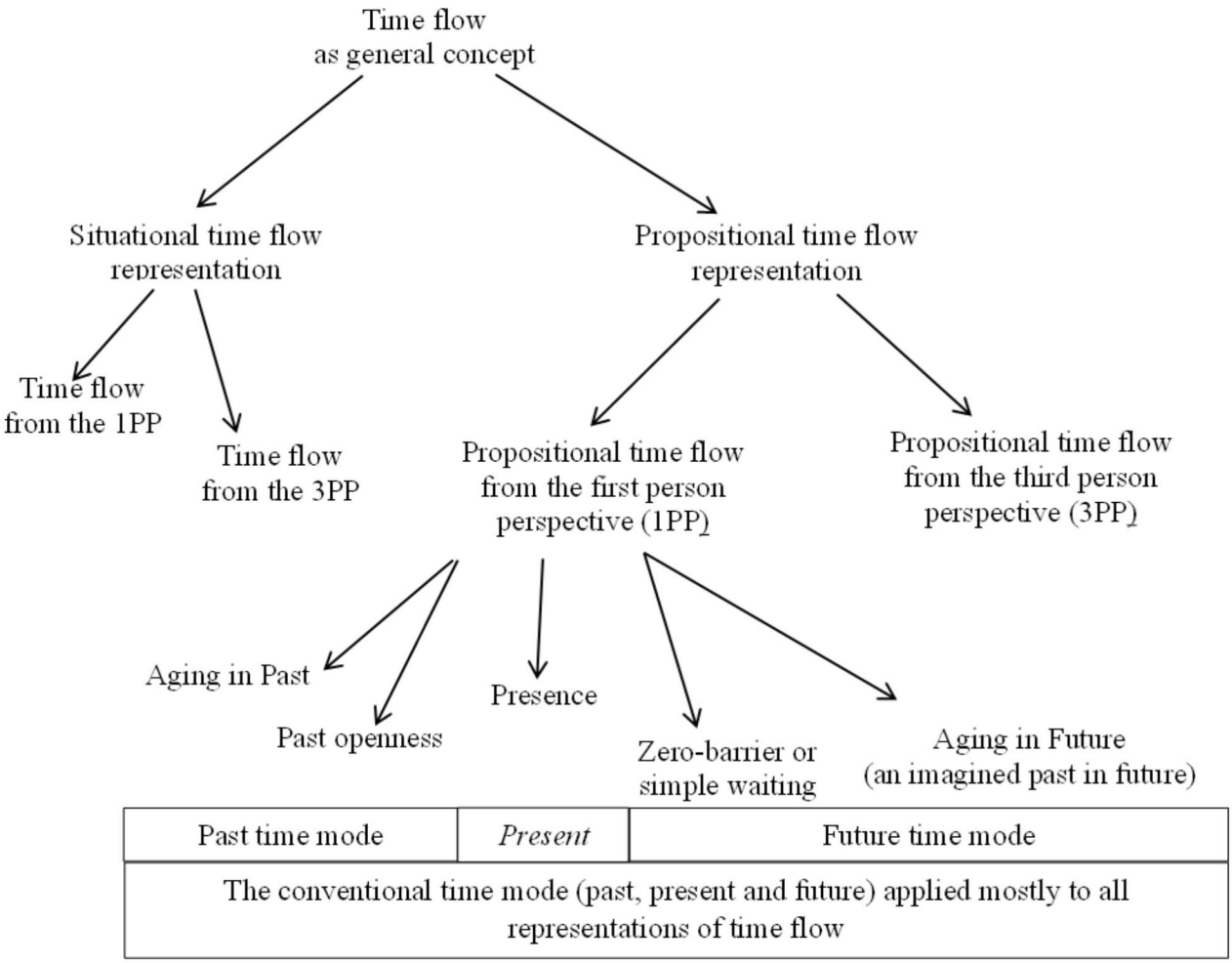
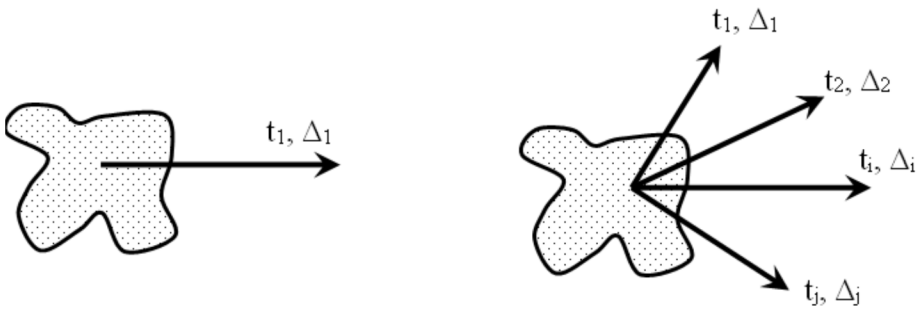


Figure 1. Mental representations of time flow. 1PP means a time representation modelled from a first-person perspective, 3PP means a time representation modelled from a third-person perspective. Zero barrier means simple waiting when probability to realize a proposition equals zero during the whole interval of waiting.

The multiplicity of time representations means a multitude of intertemporal changes (Δ_i) for one and the same object (event) over one and the same physical time distance. Figure 2a shows the conventional time flow when one object underlies one representation of time flow (t_1) and Δ_1 shows the object's change over time. Figure 2b shows a representation of an object within the multiple cognitive representations of time flow. The vectors show the possible time flows (t_1, t_2, … t_i, t_j) to be actualized. The variation Δ_i marks a corresponding change of object-(or event-) representation within time flow t_i. It is presupposed that $t_i \neq t_j$ and therefore $\Delta_i \neq \Delta_j$. In the same way as each time representation specifically impacts the evaluation of an object it should also impact the evaluation of causal relata. Such an impact can influence a final representation of an event and thus the final establishing of causality.



(a) (b)

Figure 2. The representations of an object changing over time. Each time arrow corresponds to a representation of a single time flow.

Following J.J. Freyd (1987; 1992) who argues that every cognitive representation has a temporal dimension, we must also accept that every event (cause or effect), which relies on cognitive representation, must include a time factor in an explicit or implicit way. Since both cause and effect, underlie a time-flow representation, both can show variability in their cognitive representation, meaning that Δ_i of cause and Δ_i of effect. This variability implies the dependence of cognitive representations of cause and effect from an actually activated representation of time flow, t_i. Since $t_i \neq t_j$, one gets inequality for the representations: 'cause in t_i ≠ cause in t_j'. The same argument is true for subjective representation of effect: 'effect in t_i ≠ effect in t_j'. This provides the multiple ways for evaluating an object (an event) over the same time. Thus, depending on actually activated time flow representation, instead of a conventional singular correspondence between an event representation and a physical time moment, one expects a multiple correspondence between an event representation and the physical time moment (figure 2b). So, one widens the subjective temporal component of the spatial-temporal region where causal relationship is established. This increases its correspondence to real human behavior.

An example could be a demonstration of how one can project a cause on the different representations of time flow. Let us take the following case. Imagine a monetary proposition of X Euro, which may serve as cause inducing certain action – a wish to go to the other shop for saving the proposed amount of money. So, we have a cause, the monetary saving proposition of X Euro, and a possible effect it induces – an acceptance of the proposition. To show how the same cause may change its power to induce an effect let us project it on two different representations of time flow – on a *situational time flow* and a *propositional time flow* (Polunin, 2015).

The situational time flow describes as a mental jump from one situation to the other one, so that all elements of the situation – a subject, a monetary proposition, and whole environment are momentarily transferred over time. After activating the situational time flow, a subject transfers themselves in a moment into the new situation. Propositional time, on the other hand, is tied to the proposition itself, which "flows" in time, in our case to the possibility to save money. The propositional time flow is partly similar to conventional time flow, but the difference is that it applies only to the object, e.g., to a proposition or a commodity. After activating this kind of time representation, the subject's mind follows the proposition over time. The proposition "flows" in time, but the person "remains" at the current time moment. A discrepancy arises between one and the same proposition (a potential cause) when one activates the situational and propositional time flow. As our study (Polunin, 2015) shows, the same proposition after being projected on the situational time flow causes a majority of people to accept it; while after being projected on the propositional time flow only a minority of the people were ready to accept it. So, despite the mathematical equality the same proposition, being projected in the different time flows, may or may not serve as a cause for inducing a certain action. The detailed description of this kind of temporal framing effect is given in our article

(Polunin, 2015).[1] Beside this example, one may project a cause on the time flows models from the first- and the third-person perspective (Polunin, 2016), which, despite the formal mathematical equivalence, may essentially modulate the power of cause to the point of elimination.

The temporal factors essential for representation of causality.

There are the other factors one should take into account. At the subjective level a cause is interpreted as something bringing about an effect, something what makes an effect more likely, or having the capability to produce an effect. This 'something' may be mapped (a) on the different representations of time flow and (b) it may be described through the different markers of time. One of the examples is an anomaly in intertemporal choice: the "date/delay effect" described by Read et al. (2005) when a discrepancy in the representation of time distance impacts perception of a proposition value. The same is true for an effect. The cause-effect relata can be modeled also within the representations of (a) direct and (b) inverse time flow, which modulates the cognitive costs of their processing. Facing the discrepancy in cognitive costs following the line of events along or against time flow, the mind should show a discrepancy in readiness to recognize causality. Moreover, a time distance between cause and effect can be mapped on the different representations of time flow or it can even include a switching from one mental representation of time flow to another. A composition of two different time representations within one task was used already as method in the study by Polunin (2015).

An additional variable is a 'placement' of a person judging a cause-effect relationship within the different representations of time flow. One distinguishes actor and observer regarding an event. An observer as judge of a causal relation, can be 'placed' within different representations of time flow. The discrepancy between an observer and an actor serves as an additional factor extended over time. The above listed factors make an array of the time variables that impact the subjective judgment regarding availability/absence of causal relations.

One has to consider that according to its nature each potential cause and effect (the A and B events) can be constant or variable. For instance, weight of a piece of metal taken as cause does not change under the constant external conditions. But value of the same amount of money changes over time. Furthermore, the potential cause and effect can be constant or variable at the level of mental representation. For instance, as long as I am alive I am represented in my mind as alive. But representation of me as thirsty man can vary in my cognitive system. Few hours ago I was thirsty, but now I am not. So, one distinguishes the causes and effects constant and variable in their nature, and the causes and effects constant and variable at the level of cognitive representation. This makes a limitation for the proposed approach. An event that remains constant at the level of representation most probably will not be impacted by its projection at the different mental representations of time flow.

A specification of impact of the temporal factors.

According to previous results (Polunin, 2009, 2014, 2015, 2016), a time representation impacts the proximity of an object given as proposition in a decision-making task. Some of the time representations make an object appear close and some as distant. This impacts the perceived value of the object/event. Proximity predefines also the subject's involvement in information

[1] The example of how one activates in mind the representation of situational time flow and propositional time flow. In the study we have used a monetary saving proposition in the Ukrainian currency (UAH). In both cases the proposed amount of money to save is the same – 99 UAH, time distance is also the same – 4 days.

Situational time flow. Please imagine that in 4 days you will go to the supermarket of electronics to purchase a notebook computer for 3199 UAH. When you choose a notebook computer and will be going to the cash desk a shop assistant informs you, that the notebook you wish to buy is on sale for 3100 UAH at the other branch of the store. Would you make the trip to the other store?

Propositional time flow. Please imagine that you went to the supermarket of electronics and are about to purchase a notebook computer for 3199 UAH. When you choose a notebook computer and are going to the cash desk a shop assistant informs you, that the notebook you wish to buy will in 4 days be on sale for 3100 UAH at the other branch of the store. Would you make the trip to the other store?

processing regarding this object/event. For instance, despite the same physical time distance to an event, an activated representation of situational time induces a stronger proximity effect than propositional time flow. Time flow modeled from the first-person perspective results in a stronger involvement than time representation from the third person perspective. In this case, we must also consider the variables like absolute and relative attractiveness of proposition. A time representation reflecting an aging of event in past time mode induces higher decrease of proximity than representation of past openness; but for these two kinds of time representation, we have to consider the relative attractiveness of the object/event and time distance. A representation of aging in future time mode induces stronger decrease of proximity than simple waiting which is also called a zero-probability barrier (figure 1). With some generalization and simplification one can present it as it is given in Table 1. Here we see the term of high proximity means experiencing an event (object) mentally closer to subject, and as being more valuable and important. A high mental proximity corresponds to low ignorance towards such object/event. A condition of low proximity corresponds to a high ignorance towards an object/event. Table 1 describes the impact of each individual representation of time relative to the other time representation, given in pairs.

	Level of subjective proximity	
	Proximity LOW	Proximity HIGH
The representations of time flow given as opposing pairs	propositional	situational
	3PP	1PP
	past openness	aging in past
	simple waiting in future	aging in future

Table 1. The impact of time representation on proximity of an object/event. The change of proximity is considered regarding growing physical time distance.

Table 1 describes the possible outcomes in event evaluation if it were projected on one of two paired representations of time flow. It goes about projection of A and/or B events (potential causal relata) on different representations of time flow. The proposed projection of causal relata on different representations of time flow goes up to a certain level according to the Pearl's (2009) understanding of an intervention. Formally, we are following a procedure: if A were to be changed by an intervention to such and such a value, the value of B would change. If representation of A were to be changed by an intervention consequently changing its value level, the representation of A-B relationship would also change. And here we are getting an additional possibility to vary a representation of B without changing A. If representation of B were to be changed by an intervention changing its value level, the representation of the A-B relationship would also change. Furthermore, we can simultaneously change the representations of A and B, and so impact the representation of the causal relation. Thus, one manipulates the A- and B-representations in the subject's mind and impacts the conclusion about causal connectedness between A and B. The other manipulation would be projecting of time distance between A and B on the different representations of time flow. Applying different representations of time distance, one can also vary the value of each component (A and B) of the causal relation. The actor and observer could also be placed within different time flows.

In general, applying the different representations of time flow, one induces change in representations of A, B and in that of A-B-distance, and so one impacts their subjective value. The last one may vary from a strong overestimation and down to an underestimation. Consequently, it impacts the subjective "weight" of each single event and the conclusion regarding the causal relation between A and B. Due to these manipulations, a previously established representation of a causal relation between A and B may be disrupted, or conversely, we might find one where it was earlier taken as absent.

Discussion.

The manipulability theories of causation were developed for cases when all elements of the causal chain are given within conventional linear time flow. As soon as the elements of a potential causal chain are given within a different representations of time flow, a representation of a causal relation has to be essentially deformed. Thus, not all causal relations established within conventional time flow will be confirmed when the corresponding causal relata are projected on a different representations of time flow. On the other hand, the human mind naturally relies on varied representations of time, therefore the described instability of a causal relation is rather a natural outcome of the human cognitive system. In some cases, it manifests through doubts regarding causality.

Cartwright (2002) contends that the interventionist account is "monolithic:" it takes just one of the criteria commonly thought to be relevant to whether a relationship is causal. When introducing multiple mental representations of time flow we are following the "pluralistic" account. We are showing that the diverse representations of time flow are relevant for establishing whether a relation is causal or not. We are pointing to the factors described as subject's mental constructions, and not as the variables from the outside world. The introduction of the multiple time representations leads also to a deeper reductionism. It highlights the more elementary contributors to establishing of cause-effect relationship in our thinking.

The next question is how many causal relations one can develop for the same A and B events but projected on the different mental representations of time flow? And what allows for the discrepancy among them? To give an exact number, one would have to know all possible representations of time flow the human mind can generate, which is not possible (at this point anyway). A projection of all elements of a potential causal chain on all possible representations of time flow and on their different combinations, also with consideration to the possible locations of the subjects (actor and/or observer) in all time modes, should give the total number of theoretically possible causal relationships for a pair of the A and B events. Formally one can describe it as a function: CR=*f* (events, time representations, actor/observer, location of actor/observer on timeline), where CR stands for a conclusion about the availability of a causal relation. The proposed approach is valuable in the sense that it allows for empirical examination. It makes possible to manipulate individually the representations of cause and that of effect, examining more deeply the contribution of the human mind to their relationship. Such experimental examination of causality representation serves as a research program. It shapes the theoretical background for a number of new empirical studies on time and causality in cognitive sciences and psychology.

Thanks to the specification of the mentioned variables, we are able to emulate an intervention that impacts the judgment outcome about a presence/absence of a causal relationship. This is a manipulation in the person's internal world without touching the worldly causal relation itself. Thus, the described variability of cause-effect relationship highlights the contribution of the cognitive system to development of the world picture. This contribution is analogous to the role of a functional features of a microscope for creating an object's picture. The functional features of every registration device predefine the outcome of its work, which is also true for the cognitive system.

Introduction of the multiple time representations induces an uncertainty in causality modelling. But it is just an initial uncertainty. One faces the multitude of representations of events serving as potential cause and effect. But since the properties of each single representation of time flow enjoy a more precise specification, the inferences should also be more precise. The mentioned variations in causality judgment are closer to real human thinking. From a computational perspective the introduction of multiple time representations in causality modelling contributes to its high precision and high correspondence to reality. Such modelling of causal relations preserves a perfect match of the facts and descriptions over the largest possible spatial-temporal region. This gives value to an extended modelling of causality within a complex

temporal dimension. One widens the temporal component of the spatial-temporal dimension of causality.

Causality does not only have explanatory power, but it is an essential part of action preparation (Brown, Pluck, 2000; Jeannerod, 2003). Thus, the modelling of causality in the space of multiple mental representations of time flow should contribute to the further and more precise modelling of individual and social behavior. In a permanently changing world, we create the number of world pictures reflecting different dynamical aspects and so different predefined reactions for each of these world pictures. In this sense, the described variability of causality representation widens the spectrum of behavioral responses to the world and reflects one of the adaptive mechanisms onto the cognitive level.

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(НЕ)СТАБІЛЬНІСТЬ РЕПРЕЗЕНТАЦІЇ ПРИЧИННОСТІ У ПРОСТОРІ МНОЖИННИХ МЕНТАЛЬНИХ РЕПРЕЗЕНТАЦІЙ ПЛИНУ ЧАСУ

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АНОТАЦІЯ

У статті досліджується взаємозв'язок між часом і причинністю. Описується нестабільність репрезентації причинності, що виникає тоді, коли відносини причинності проєктуються у простір множинних когнітивних репрезентацій плину часу. Традиційно маніпулятивні теорії причинності розглядають випадки, коли всі елементи причинного ланцюга задані в межах звичного лінійного плину часу. У межах маніпулятивного підходу до причинності стаття досліджує, якою мірою когнітивна система людини спричиняє варіативність ментальних репрезентацій причини, наслідку й їхньої часової пов'язаності. У роботі дається відповідь на питання, чи й яким чином різні репрезентації часу впливають на здатність людини моделювати причинно-наслідкові зв'язки. Саме в цьому полягає новизна запропонованого підходу. Для цього аналізується здатність людського розуму породжувати множинні репрезентації плину часу. Отже, ми виходимо за межі традиційного припущення про єдину ментальну репрезентацію часу й запроваджуємо поняття множинних

репрезентацій плину часу (Polunin, 2011, 2015, 2016, 2021). Оскільки кожна окрема репрезентація часу характеризується специфічними функціональними властивостями, вона по-своєму впливає на ментальну репрезентацію події, що відбувається в її часовому вимірі, а відтак – і на репрезентацію причинних відносин. Тому ми обґрунтовуємо тезу про істотну варіативність ментальної репрезентації причинності в просторі множинних когнітивних репрезентацій плину часу. Цю варіативність можна продемонструвати без будь-яких реальних змін у подіях, пов'язаних причинним відношенням, що дає змогу описати внесок людського розуму у формування причинності. Запропонований підхід відкриває можливість його емпіричної перевірки. Він дає змогу окремо маніпулювати репрезентаціями причини й наслідку, забезпечуючи глибше дослідження внеску людського мислення у формування причинно-наслідкового зв'язку. Це підкреслює ментальну природу причинності, її залежність від суб'єктивного судження й вказує на можливі відхилення в оцінці наявності або відсутності причинного зв'язку.

Ключові слова: *причинність, час, маніпулятивні теорії причинності, репрезентація часу, множинні репрезентації плину часу.*

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