# Time and Consciousness

Markus A. Maier[1*], Vanessa L. Buechner[1]

[1]Department of Psychology, Ludwig-Maximilians-University, Munich, Germany.

***Correspondence:**

Prof. Dr. Markus Maier
University of Munich
Department of Psychology
Leopoldstr. 13
80802 Munich, Germany
markus.maier@psy.lmu.de
phone: +49-89-2180-5215

**Abstract**

Some theories in physics and beyond argue that the emergence of an arrow of time is strongly related to conscious experience. Few approaches -known under the term quantum models of the mind- even claim that *consciousness creates time*. In the following we will provide theoretical arguments and empirical evidence showing that the arrow of time disappears when an individual's information processing mode changes from conscious to unconscious states of mind. This implies that unconscious processing allow for a better than chance anticipation of random future events. The theoretical and practical implications of these models are discussed.

Keywords: time, consciousness, retro-causation, precognition, quantum mind

## 1. Introduction

The central idea we would like to put forward here is based on a millennia old argument made by philosophers, theologians, physicists, and psychologists stating that the concepts of time and consciousness are strongly interwoven and cannot be understood without mutually referring to each other (for an overview see, [1]). Some authors in philosophy, physics, or psychology even propose a causal relationship between them and suggest that *consciousness establishes an arrow of time* or in other words that *consciousness creates time* (see for example, [2]). Advances in theoretical physics and especially in quantum mechanics provide solid grounds for this hypothesis and we will outline these theories in more detail in the first part of this paper. In the second part, we will review empirical evidence showing that conscious states of mind have an arrow of time that uniformly points from the past to the future whereas unconscious states of mind seem to act time undirected and thus unconscious processing is able to anticipate classically unpredictable future events.

The terms "consciousness" and "time" need to be defined as we will use those in the following theoretical considerations. According to Searle [3], consciousness consists of subjectively experienced qualitative states and processes of awareness. The qualitative aspect is the core feature of conscious experience making it distinct from other mental activities. Chalmers [4,5] calls this subjective knowledge of how it feels to be in that state "Qualia". Consciousness evolves through discrete events occurring one after the other being separated in time [6]. Conscious information processing is characterized by categorical thinking, that is based on binary classifications that decide whether something belongs to that category or not (Boolean logic; [7]). Unconscious states on the other hand occur without awareness and phenomenal experience and process information in an acategorical manner with overlapping and imprecise categorical borders.

With regard to time, Römer [2] referring to McTaggart [8] distinguishes between an A-time and a B-time. A-time is an internal time carrying the quality of "nowness" that experientially moves into the future turning the nows into the past. B-time, in turn, is the objective time of physics characterized by the ordering of two physical events into before and after, although the directedness of this strict order can be absent if time-symmetric laws are involved. A-time could be described as psychological time based on subjective experience and B-time as an objective time measured by clocks or similar cyclic repeating devices. In our paper here we refer to B-time when using the term "time".

## 2. Consciousness Creates Time: Theoretical Considerations

Most theories in physics treat the passage of time as pure illusion and natural laws are formulated without any reference to and independently of time. This is documented by the fact that many physical laws are time-symmetric and equally work for forward and backward time propagation (see [9]). However, there are a few exceptions which naturally introduce time-asymmetry into the description of our world. Interestingly these special cases within the family of physical laws are somehow related to conscious experience.

One example is the second law of thermodynamics introduced by Boltzmann (see [10]). It states that entropy steadily increases from the past to the future and in this way is related to the arrow of time. Penrose [11] argues that entropy is the most basic principle from which time evolves. According to him "*…our experience of the passage of time is dependent upon an increasing entropy….so whatever time-direction we believe to be the 'future' must be that in which entropy increases… had the entropy been decreasing … then our conscious feelings of temporal flow would project in the reverse direction…. Thus, so the argument goes, our psychological experiences of the passage of time would always be such that the Second Law holds true, irrespective of the physical direction of the progression of entropy* (p. 52)". It is not the flow of time that forces entropy to increase, rather an increase of entropy is consciously perceived as passage of time. Time in this framework is nothing else than a

consciously perceived order of events that follows the road of increasing entropy. The arrow of time in this framework is thus a consequence of conscious perceptions of changes in entropy.

Recently, Smolin [12,13] went even further and argued that the passage of time is based on objective grounds and constitutes an innate principle of the universe from which all physical laws evolve. This approach is now known as *temporal naturalism* [13]. According to his view, time is understood as a succession of moments that defines the future as elements that presently are not real and there are no facts of the matter about it, whereas the past is characterized by events that have been real and could in principle be described by facts. In other words the past is consciously knowable and the future is not (yet) consciously accessible. The author also emphasizes a strong relationship between the passage of time and the emergence of conscious experiences about the world. "Qualia", that is conscious moments of experience, can only be incorporated in theories that are grounded on the passage of time whereas conscious moments cannot exist in a timeless description of the world. As Smolin [13] says "*qualia can only be real properties of a world where "now" has an intrinsic meaning so that statements about now are true non-relationally and without contingency. These are the case only in a temporal natural world* (p. 32)." According to this approach, the undeniable existence of consciousness in the universe forces time and an arrow of time to exist as well (see also [14]).

Another group of theories relating the passage of time to conscious experiences is based on quantum mechanics [2], [15,16,17,18,19,20,21,22,23,24]. In these theories the transition from the quantum to the classical state is usually caused by a collapse of the wave function. This transition marks the origin of a conscious moment and a series of collapse-dependent conscious moments introduces the passage of time. These theories relate quantum states to unconscious processing and the sudden reduction of the state vector to a conscious 'now'. Although there is some disagreement amongst these models with regard to the proposed physical reality underlying the wave-function [25] and with regard to the exact nature of the collapse postulate, they all agree in quantum-based timeless existence during unconscious states of mind and that the flow of time evolves in strong relation to conscious processing states that are based on classical physics.

We try to explain the relation between quantum physics and consciousness in more detail by referring to the Orch OR model as one prototypical theory of quantum mind processing ([18] for a recent description see [24]). Although applicable to any physical system the authors focus on quantum mechanical descriptions of basic brain processes located in the micro-tubulins of nerve-cells and how 'qualia' can evolve from those structures. According to this theory, before a conscious experience is made, unconscious processes exist in a state of superposition. Superposition involves the simultaneous and timeless existence of qualitatively different pre-conscious thoughts. They are captured within a quantum framework as slightly differing space-time geometries [22]. Each space-time relates to one unconscious thought that has a specific potential of becoming conscious according to a probability function assigned to the superposed states. Before the collapse, they exist in a space of potentialities [26] and are pre-real in the sense that they can be experienced only on a vague, unconscious, non-verbal level. These processes provide pre-factual knowledge represented in an implicit style most likely experienced as weak affective impressions. They are timeless, that is past, present, and future are undistinguishable and future impressions can causally influence past ones. The collapse that marks a conscious moment of 'now' is caused by quantum gravitation based on spacetime-separations. These separations resemble a curvature being located between superposed states. The frequency rate of the collapse can vary from a few milliseconds but might normally occur at much slower pace "*..., say, one half a second or so, i.e. ~500msec,...*" ([24], page 16). Thus, within a time window of a few hundred milliseconds timeless states of

minds co-exist, which implies that within this time period past, present, and future are interchangeable. After the collapse the ordinary classical flow of time is observed.

A similar quantum mechanical approach of consciousness that however abandons the collapse process is the Extended Everett Concept (EEC; [19,20]). It is based on Many-Worlds interpretation of the evolution of the Schrödinger Equation (see [27]; see also [19], [28]) which assumes that during the state of superposition all quantum states involved in a system branch up into separate worlds each of them representing one potential quantum state. The collapse postulate is replaced by a change in perspective during the measurement process. During superposition all quantum states are treated as a whole leading to wave-like outcome of the quantum system. This is metaphorically described by Tegmark [29] as the bird perspective. After the measurement the observer takes on a frog perspective [29], that is, one single branch of the superposition is randomly selected (particle-like outcome). Importantly, the other braches still exist but are during that perspective temporarily inaccessible and separated from each other. In EEC, Mensky [19,20] identifies this separation of alternatives with consciousness. Limited consciousness provides access to all experiences made in the alternative worlds simultaneously. Since these alternatives co-exist timelessly such a state of mind also provides access to future experiences. Future events can thus be experienced in a pre-conscious state of mind and influence behavioral choices accordingly. Individuals who rely on unconscious impulses during decision making could have a richer amount of information than those who just base their decisions on conscious thinking. Mensky [20] calls this phenomenon "super-intuition". The innovative idea in EEC is that changes within mental states are able to explain transitions from timeless quantum alternatives to time-dependent experiences of the classical world. Similar as in the theories described above, the existence of consciousness is strongly related to the emergence of an arrow of time (see also [2]).

## 3. Consciousness Creates Time: Empirical Evidence

According to the quantum models of the mind mentioned above, conscious states of mind are strongly related to the arrow of time and unconscious states are operating timeless. On the one hand, this implies that conscious processing can only be affected by past experiences including anticipations of future events that are based on past experiences and thus are nothing else than extrapolations of memories (see other authors in this volume). Causal effects in this processing mode therefore always emerge from the past. On the other hand, unconscious information processing should exist in a state of timelessness and therefore the usual direction of causality could be reversed in some occasions. In other words unconscious processing could also be affected by and benefit from unpredictable future events. Such phenomena are known as *retro-causal* effects.

In the following paragraphs we will describe a number of psychological experiments and meta-analyses that report retro-causal effects of future events on human reactions in the past. Also a number of replication failures will be reported. We briefly describe those studies in the following section and we will show that –taken the whole picture including successful und unsuccessful replication attempts- retro-causality is restricted to unconscious processing modes. Next we present studies from our own research group [30] that directly tested the effect of unconscious processing during the avoidance of random negative future events.

In a recently published series of nine experiments using five different paradigms, [31] demonstrated that classically unpredictable future stimulus presentations had an effect on participants' responses preceding these presentations. For example in Experiment 2 participants had to indicate their preference for one of two neutral pictures (an original and its mirror image) by pressing a key on the keyboard. After the key-press a randomly chosen negative or a positive masked picture was presented subliminally three times. The hypothesis was that if the individual unconsciously 'knows' or feels the future consequence of his or her preference judgment, he or she should be more likely to choose that neutral picture from the

pair that leads to the presentation of a masked positive picture. This should lead to a better than chance (50%) avoidance of a subsequent negative masked picture presentation. The results were in line with the predicted avoidance of negativity effect: On average, less negative subliminal pictures were presented than expected by chance. Similar retroactive influences of future events were found for precognitive selection (forced choice) of erotic stimuli (Exp. 1), time-reversed evaluative priming (Exp. 3 and 4), retroactive habituation (Exp. 5 and 6), retroactive induction of boredom (only marginally significant, Exp. 7), and retroactive facilitation of recall (Exp. 8 and 9). In the latter two experiments, future practice of some items had a positive effect on recall performance for these items in a preceding memory task. One of the memory studies yielded the highest effect size ($d$ = .42, Exp. 9) and was considered to be the easiest of the nine experiments to be replicated.

As explicitly suggested by [31] several independent research teams tried to replicate the retroactive memory practice effects [32,33,34]. These replication attempts took into account most of the critical arguments raised in response to Bem's work focusing on various statistical issues [35,36]: They predetermined sample sizes and avoided optional stopping and multiple analyses. In addition, they used the same data analytical strategies, usually simple t-tests, and the same procedure and methods as in Bem's original publication. With few exceptions, almost all of the early replication attempts failed. Galak et al. [33] did a meta-analysis including also unpublished replication attempts (Milyavsky unpublished data; Snodgrass unpublished data; Subbotsky unpublished data; Tressoldi et al. unpublished data) that revealed no evidence for retroactive influences in the facilitation of recall paradigm. Thus, it seemed that the effects reported by Bem were not robust and the existence of precognition effects was called into question. At this point, serious doubts arose whether similar replication failures can be expected for the other studies reported by Bem [31].

However, a meta-analysis of all forced choice precognition experiments by Honorton and Ferrari [37], that included 309 experiments which were quite similar to the design of Bem's Experiment 1, reported a small but significant precognition effect (but see [38]). Furthermore, Mossbridge et al. [39] did a meta-analysis that included 26 studies on the effect of predictive physiological anticipation of unpredictable stimuli. They found an overall significant retroactive influence of emotionally arousing stimuli on various kinds of physiological reactions. This might be considered as a conceptual replication of Experiment 2 in Bem's article in which a similar anticipatory emotional preparedness effect, i.e. avoidance, was found. Rouder and Morey ([40]; see also, Tressoldi et al. submitted) did a meta-analytic Baysian analysis on several types of Bem's experiment. They found some evidence that individuals can avoid negatively valenced pictures, but no supportive evidence for the other paradigms used by Bem.

Given the actual empirical data, it seems that retroactive facilitation of recall might not be a robust effect, whereas the empirical validity of retroactively influenced forced choices and emotional stimulations remained still open at this time. The latter effect was obtained with subliminal presentation modes and was based on affective reactions aroused by the pictures. This indicates that unconscious processing might primarily be driving these effects. Someone might speculate that differences in effect size found between those paradigms might also reflect differences in the degree of how much unconscious processing is involved during response acquisition and stimulus presentation. Also, Bem [31] noted in the discussion section of his manuscript that an unconscious processing mode might increase the reliability of retro-causal effects in the lab. This is in line with the theoretical models described above which restrict retro-causal influences to unconscious states of mind.

As a consequence, Maier et al. [30] took the propositions made by quantum models of the human mind seriously. They developed a research design that ensured an unconscious processing mode throughout each stage of the participants' actions. They applied the unconscious avoidance task, similarly to that originally used by Bem ([31], Exp. 2) with a few

minor but important modifications. First, they ensured that the participants' anticipatory responses were made without the involvement of a conscious selection processes. That is, they solved the contradiction of forcing an individual to decide about alternatives without knowing about the decision. Secondly, the future outcome, that was supposed to retro-actively bias these unconscious decisions, was introduced outside awareness by using a subliminal presentation technique. In all studies, participants had to press two keys on a keyboard as simultaneously as possible before the subliminal (i.e., below threshold) picture presentation appeared. Each key was randomly associated to a positive (neutral) or negative future outcome. As one of two keys was always triggered first, either a left or a right key-press was registered and thus resulted in a positive (neutral) or negative masked picture presentation. The participants were not aware of this relationship and did not realize that pressing those keys basically constitutes a decision for one of the two future alternative states. The main idea was that the unconscious mind subtly influences the finger movements in a way that the key-press result was biased in favor of the participant's biological motives (avoidance of future harm). This procedure allows two minimize the likelihood that awareness was involved during perception and decision. In Study 1, each key-press was randomly assigned to either a positive or negative masked picture presentation in the future. Results revealed that participants unconsciously avoided negative pictures and selected more often the positive ones. This study did not allow an interpretation of whether this effect was due to an avoidance of negative future states or an approach of positive alternatives. As research on the impact of approach versus avoidance on behaviors indicates, bad events seem to have more impact than good ones [41]. It seems therefore to be likely that the effect of Study 1 was primarily driven by avoidance. To test this retro-active avoidance effect in isolation, in Study 2 negative and neutral (instead of positive) pictures were used. Again, participants were able to better than chance unconsciously avoid negative future outcomes. In Study 3, a much bigger sample was targeted by doing the same study online. The analysis revealed a significant deviation from 50%, showing that participants unconsciously avoid negative future outcomes. In another web-based study, a replacement instead of a non-replacement procedure (as in the previous studies) was used for the trial randomization. The results only revealed a statistical trend for an avoidance effect. In another study, that was done after Study 1, the unawareness of the masked pictures was probably jeopardized by mentioning that this study is about positive, negative, or neutral pictures in the instruction (instead of mentioning the term "colored stimuli"). As a consequence, no significant effect was obtained within this study. A further study that explored the effects of individual differences in cortisol level on the avoidance effect failed to reveal a significant avoidance main effect, too. However, in Study 4, Maier et al. [30] run a high powerful study with a more sophisticated randomization, that is a combined use of a predefined randomized list of trials (PRNG) and a hardware based true random generator (RNG, i.e., a quantum based number generator) that passed both DIEHARD and NIST tests of randomness. Participants therefore could not "algorithmically know" the consequence of their response before or during the key-press and thus, any avoidance effects could only be explained by retro-causal effects from the future (see [31]). Results revealed a significant deviation from 50%, showing that participants were able to unconsciously avoid a negative future outcome.

Taken together, retro-causal effects defined as backward-time causation can be predicted from theories that unify the emergence of consciousness with the arrow of time. Specifically quantum approaches such as the Orch OR model (e.g., [24]), the EEC theory (e.g., [19,20]), and the weak quantum model (e.g., [2], [15,16,17]) predict such time anomalies when unconscious processing dominates behavioral responses in the anticipation of future events. Although the empirical evidence for retro-causal effects is mixed and skeptical critics dominate the field and question the results, one stable pattern can be identified: Affective responses based on unconscious behavioral choices that are triggered by

subliminally presented stimuli in the future seem to be sensitive for retro-causal effects. This is true for Bem's [31] Study 2 with supporting Bayesian statistical evidence provided by Rouder and Morey [40] as well as Maier et al.'s [30] Study 1 to 4, who also provide meta-analytical evidence when null findings are included. Similarly, anticipatory effects of physiological parameters are meta-analytically reported by Mossbridge et al. [39]. Hence, it seems that preliminary empirical evidence exists for retro-causality during unconscious processing states.

At this point, we need to take one step back. Even if someone takes the quantum model of the human mind serious and even if someone is convinced by the admittedly weak empirical evidence for retro-causality during unconscious processing, still there are some quite good theoretical arguments that speak against the existence of retro-causal effects. One is related to the time travel paradox that is involved in retro-causal information transmission and another one is related to the impossibility of supra-luminal signal transfer postulated by special relativity. In the following sections we will describe the problems raised by these issues with regard to retro-causality and try to provide approaches that might offer at least preliminary solutions for them.

## 4. Retro-Causality, Time Travel, and the Grandfather Paradox

Retro-causal effects found during unconscious processing states imply that –at least on the level of information- time travel is possible. This raises the question: what about the paradoxes involved in time travel? Shouldn't time travel be forbidden as Hawking [42] argues through a chronology protection agency since we would otherwise run into unsolvable contradictions? This dilemma is nicely described by the well-known grand-father paradox. Transferring the grand-father paradox to the retro-causal effects described in the psychological studies above would imply that sending information back in time could affect the birth of one of the sender's ancestors. For instance, if the signal chances her grand-father's dating behavior, the sender's mother and the sender herself will not be born and therefore could not send back the signal in time. So, isn't this a strong argument against the possibility of sending information back in time since it would change a known and probably objectively recorded history? The answer is, "No", for one reason: The effect of a future event on the past operates on unconscious grounds. Thus, any effects obtained remain outside a conscious registration and therefore do not alter a consciously accessible recorded history. Thus, the evidence for time travel is only indirect and remains below the horizon of conscious facts and therefore prevents the emergence of a paradox. Changing the grandfather's knowledge about his dating behavior either by the individual himself or an outstanding historian will never occur since only unknown facts might be altered. So the argument goes: Time-travelers might exist but neither they themselves nor any past agent will ever consciously register their presence.

## 5. Retro-Causality and Supra-Luminal Signal Transfer

At first sight, the notion of information moving also backward in time (which implies that a signal travels faster than the velocity of light) stands in sharp contrast to Einstein's [43] special relativity theory according to which nothing can move quicker than the speed of light. However, this statement needs to be clarified a bit: No *classical* information - defined as a bit of 0 or 1 - can move faster than light, but as Gauthier and his colleagues [44] (see [45]) could demonstrate, distorted information, which was made unreadable to some extent, moved faster than the speed of light and thus arrived at a detector before it was sent. The detector needed additional time to decode the bit leading to the results that the classical bit could not be consciously detected quicker than the speed of light. So, for classical information, special relativity holds but for degraded information the classical concept of causality can be violated. If a classical bit is equal to a conscious moment of knowing, any degraded information would

be processed unconsciously since it is not fully consciously accessible. This means that the more unconsciously – i.e. not classically – a signal is processed, the more likely it can exert the velocity of light and therefore can travel backward in time.

## 6. Retro-Causality and its Implications for the Physical Reality We are Living in

At the end, we would like to speculate about the features of the physical reality we are living in given that retro-causality is a true phenomenon. In our view at least two possible consequences for the physical reality surrounding us can be identified:

1. *The existence potential realities or parallel worlds*

As mentioned above, according to the quantum models of the mind (e.g., [2], [19,20], [24]) future alternative experiences simultaneously exist side by side and are able to influence the past even if only one of the alternatives classically arises in the future. The future before it becomes classically real can be considered to be a space of potentialities and each potential future event is able to affect the actor's behavior in the present. With regard to the experiments exploring precognitive avoidance ([31], Exp. 2; [30], Exp. 2 to 4), one could assume that during each trial two potential realities evolved: One containing a negative and the other a neutral (or positive) future outcome. The unconscious mind seemed to timelessly experience both alternatives simultaneously in a state of superposition [20,21,22]. For example, in a given trial, the unconscious mind simultaneously 'knew' that a left key-press resulted in a negative masked picture presentation and the right key-press in a neutral one. The experiences made in both alternatives states of mind took place in potential realities which are different from classical, but nevertheless can have an effect on an individual's behavioral choice. The causal effectiveness of such a potential reality is demonstrated by the fact that negative masked pictures were unconsciously avoided and therefore, from a classical perspective, not presented, but nevertheless caused an avoidance reaction. In other words, something that is from a classical perspective non-existent had an effect on a previous response and thus must have existed in some non-classical, i.e. potential, form. In sum, potential states can have effects that can indirectly be measured and must therefore exist in a form that is only compatible with the idea of parallel worlds or parallel realities [26]. It seems that our consciously perceived world is swimming on an ocean of potential realities affecting us during any time of our existence.

2. *The randomness postulate in quantum mechanics*

Another important feature of the Orch OR model is that state vector reductions can occur non-randomly [21,22]. Information embedded in fundamental space-time geometry is able to bias the probability that one of the superimposed states becomes classically real (see also [26]). Penrose identifies this information as Platonic values such as mathematical truth, ethical and aesthetic values along with precursors of physical laws, constants, forces, and intentions [46]. The non-randomness postulate not only provides the basis of free will ([47]; see also [26], [48,49]), but also allows biological motives, such as harm avoidance, to unconsciously influence the outcome of the collapse [26]. In Bem's ([31], Exp. 2) and Maier et al.'s ([30], Exp 2 to 4) studies, the authors found that a biological motive, harm-avoidance, biased the occurrence of purely randomly chosen alternatives (especially in Bem's Study 2 and Maier et al's Study 4 as true random generators were used). Such a finding is therefore in line with Penrose's idea of non-random objective reductions that is influenced by information embedded in fundamental space-time geometry (see also [26], [47,48,49]). Similar effects of mental influences on superposition states in a double slit experimental design are reported by Radin et al. [50]. The randomness postulate that plays a central role in leading theories about quantum mechanics seems thus to be violated under such specific experimental conditions. This offers the possibility for Free Will to be introduced into our world (see also [47]).

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