

Further Steps in the Science of Temporal Consciousness?

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Abstract. Temporal consciousness, the field that focuses on how time figures in our conscious states, is essentially interdisciplinary and has received attention from philosophers and psychologists alike. Nevertheless, there has been little cross-talk between these two disciplines. In this paper, I argue that the reason for this resides in crucially different interests: whereas philosophers have been preoccupied by phenomenology, psychologists have approached the field by downplaying the phenomenology and emphasizing their subjects' performance in various experiments. Despite this difference, existing research already suggests that there are fruitful grounds for interdisciplinary collaboration, should philosophers and psychologists aspire for it.

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1 Introduction

Our conscious states, in so far as they are brought about by neural processes, do not occur instantly. Furthermore, our experiences and perceptions themselves are not always only of instant events in the world. Quite contrary, sometimes the crucial features of stimuli that we perceive are temporal in nature. Examples of these include perceived temporal order, pace, and duration.

Investigation of our awareness of the previous temporal phenomena belongs to the field of temporal consciousness (I am following Barry Dainton's [1] terminology here), which is sometimes also called time consciousness. It can be defined as a field that focuses on how time and temporal properties figure both in consciousness and as contents of conscious states. This is a rather broad characterization, yet such is needed to address the multifaceted and interrelated issues in temporal consciousness.¹

Although the topic is interdisciplinary in nature, interaction between philosophers and psychologists of temporal consciousness has remained scarce. This is somewhat surprising, given the state of affairs in similar issues. In consciousness studies, for example, philosophers make explicit use of many empirical research results and theories, and scientists have begun addressing the questions philosophers have posed

¹ Indeed, researchers from many different disciplines have tackled the topic and the field appears to be at the center of the interdisciplinary TD0904 (TIMELY) COST Action (www.timely-cost.eu).

to them. In the topics of self, agency, and ownership, such interdisciplinary discussion is even more prominent, and this applies also to discussions related to social cognition. Regardless of these encouraging examples of cross-disciplinary influence, it is yet to occur in the topic of temporal consciousness (with late Francisco Varela's research [2,3] being a notable exception).

The overarching objective of this paper is to take steps toward bridging the gap between philosophers and psychologists of temporal consciousness. I will begin by explicating what I take to be the central reason why philosophers have not paid much attention to empirical research on temporal consciousness. Given that my background is in philosophy, I will not speculate on the reasons why scientists have not found the philosophy of temporal consciousness significant for their studies. It is nevertheless worth reminding oneself that one obvious reason for the lack of cross-talk between philosophy and psychology is that the research questions in one of the disciplines are not often relevant in the other. Instead of elaborating on the issue of crucially different research questions in the two disciplines, I will end this article by providing a brief discussion on the detailed topics where a common theme already exists. I hope that these few examples will illustrate why engaging in interdisciplinary discussion would in some cases be useful.

2 Two Approaches to Temporal Consciousness

Prima facie it appears that the issues in temporal consciousness can be approached in two different ways. On the one hand, one can ask what the relationship is between the temporal properties of a stimulus and our experiences and judgments about it. For example, how asynchronous do two stimuli need to be for us to perceive them as asynchronous? How do we estimate that certain duration time has passed? Given that these questions need to be approached through subjects' performance in various experiments, I call this a *performance-based approach*.

On the other hand, the issue of temporal properties as experienced can also be raised without any reference to the external world and the properties of stimuli. In this case the questions that one aims to address are whether we really experience phenomena with temporal properties and, if we do, then what is the nature of consciousness and conscious states that makes it possible? This approach can be called a *phenomenology-based approach*, as here the emphasis is on the question of whether temporal properties figure in contents of experiences in the same way as colors, tastes, and sounds do. That is, can we really experience temporal properties such as simultaneity, temporal order, and duration?

Although nothing prevents one from investigating the issues in temporal consciousness by combining both approaches (and in fact Paul Fraisse [4] and William James [5] did so), they can also be investigated independently. More importantly, as will be discussed below, it appears that this has happened and in accordance with the distinction between the disciplines: psychologists have focused on the performance-based approach and philosophers have adopted the phenomenology-based approach (with very little regard to the psychological mechanisms underlying the

phenomenology).² As each line of research can be conducted without the other, cross-talk between these disciplines has been lacking.

Philosophers' preference for the phenomenology-based approach is understandable—after all, the other approach would require experimentation, which is not their forte! As a result, in their own research on the field of time consciousness, philosophers have instead focused on two interrelated questions concerning phenomenology.³ The *first one* is whether we really experience temporal properties such as simultaneity, temporal order, and duration. Thomas Reid famously argued that this does not happen. He writes:

It may be here observed, that, if we speak strictly and philosophically, no kind of succession can be an object either of the senses, or of consciousness; because the operations of both are confined to the present point of time, and there can be no succession in a point of time; and on that account the motion of a body, which is a successive change of place, could not be observed by the senses alone without the aid of memory. [6, p.235]

Reid argues thus that our consciousness, and the things we can be conscious of, are confined to momentary points in time—neither of them have any temporal width. Our experiences are static, motion-free snapshots that do not have any duration. Accordingly, Reid claims that we do not really experience succession, change, persistence, melody, or any other temporally extended phenomena. This also includes motion, which for Reid is merely a matter of succeeding snapshots. In fact, for Reid the stream of consciousness is mere continuous stream of momentary states of consciousness.

Although Reid's view of consciousness provides us with *the succession of experiences*, whether they are related to, say, visual stimuli or tones, it does not provide us with *experiences of succession* or melody. Our phenomenology suggests however that we can experience also succession and melodies.⁴ Hence, those philosophers who draw their intuitions from such phenomenology (which includes

² It should be noted that the claim how philosophers prefer the phenomenology-based approach over the performance-based approach concerns only on how philosophers approach the topic of temporal consciousness. Accordingly, it makes no claims as regards to how philosophers approach the study of time. Indeed, on this latter topic conceptually-oriented and even logic-oriented approaches are commonly used, while there is little use for the phenomenology-based approach.

³ Although it is safe to say that the topics philosophers have engaged with belong to this approach, no philosopher has been as explicit about the importance of temporal consciousness as Edmund Husserl, who is one of the most influential philosophers on temporal consciousness. He writes that "[the key themes in the phenomenology of time consciousness are] extremely important matters, perhaps the most important in the whole of phenomenology" [7, p.346]. That is, those philosophers who aim to understand our experiences better should give proper attention to issues such as how temporal phenomena can be experienced in the first place when considered from the point of view of a subject.

⁴ Here we are reminded by Husserl's remark that the "duration of sensation and the sensation of duration are two very different things. And this equally true of succession. The succession of sensations and the sensation of succession are not the same." [7, p.12].

almost everyone) have disagreed with Reid's view. Thus, they maintain that our awareness and/or its contents are not confined to durationless moments. For example, William James writes in his much cited passage that

the practically cognized present is no knife-edge, but a saddle-back, with a certain breadth of its own on which we sit perched, and from which we look in two directions into time. ... we seem to feel the interval of time as a whole, with its two ends embedded in it. [5, p.609-610]

In the light of our phenomenology, James suggests that we need to distinguish two notions of 'present'. On the one hand, there is the strict mathematical notion that is durationless, and on the other hand, there is the "cognized present" that possesses a brief duration. Since this latter notion refers to the phenomenon that is not really present in the mathematical sense but comprises a short temporal width, James calls it "specious present" (others have sometimes called it "subjective now"). Because our subjectively experienced present has a short temporal width, we can *experience* change, persistence, and other temporal phenomena.

It is important to note that accepting the idea that subjectively experienced *now* is not a durationless moment does not yet provide a proper explanation for the specious present nor for the experiences that this notion is supposed to help us explain. Consider the experience of succession for instance: those who disagree with Reid and endorse some notion of specious present maintain that our experiences can really have succession as their content. Accordingly, they argue that in one episode of experiencing or awareness, we can experience one stimulus succeeding the other because in such episodes both stimuli are somehow present (and thus their temporal relation itself can be experienced). But this sounds paradoxical: if we have one episode of an experience, and this is what we experience as *now*, then how can our experiences related to two stimuli not be experienced as simultaneous (and yet they cannot be, because otherwise we could not experience one succeeding the other)?

We are therefore led to *the second question* that the philosophers of temporal consciousness focus on: assuming that we do have temporally extended experiences (such as experiences of succession, melody, and persistence), then what must consciousness be like to provide us with them? Given that most philosophers do disagree with Reid, the debate over the philosophical issues in temporal consciousness has mainly centered on the best way to resolve the paradox resulting from specious present.⁵

It should be noted that one aspect of this debate is the apparently seamless flow of our consciousness, which James called the stream of consciousness. This is, of course, apparent in the sense that this is how the stream appears to us; the phenomenology of how one conscious state transforms to another. Its neural or metaphysical background

⁵ Essentially, two different views have been proposed to resolve this paradox. The first one is the Extensionalist view that is often related to James's theory. According to this alternative, it is the episodes of experiencing that are temporally extended. The alternative is Husserl's Retentionalist view, where the episodes of experiencing are momentary but their contents are temporally spread.

does not need to be seamless. The stream of consciousness implies the passage of time because specious present describes what is experienced as now, whereas the stream of consciousness describes how these states, specious presents, follow each other. One specious present concerns the contents of our consciousness in one subjective now, whereas the stream of consciousness concerns the phenomenology of how one specious present changes to another. Philosophers, especially those in the Husserlian tradition, refer to this by the term 'temporality'—the continual background awareness of passing time.⁶

Despite the fact that the performance-based approach requires experimentation, and is thus not something that philosophers do themselves, one might think that results achieved through it would be useful in philosophers' endeavors. Yet, a brief look at the philosophical papers shows that empirical results are rarely (if ever) cited in them. In fact, it appears as if they silently agree with Husserl, who wrote:

It might also make an interesting investigation to ascertain how the time that is posited as objective in an episode of time-consciousness is related to actual objective time, whether the estimations of temporal intervals correspond to the objectively real temporal intervals or how they deviate from them. But these are not tasks for phenomenology. [7, p.4]

The above may at first appear surprising but on closer inspection Husserl's indifference to the performance-based approach is actually quite understandable. As discussed above, the disagreement with Reid's view, and the resulting paradox, are at the crux of philosophical debates. This is significant for the topic at hand because most of the research done by psychologists is compatible both with Reid's and with his opponents' view. Accordingly, this research does not touch on the issues in which philosophers are interested in and, hence, the lack of philosophers' interest in the performance-based approach to temporal consciousness.

To see this more clearly, consider the temporal order tasks (where one of the two stimuli appears first). Arguably, to account for our performance in them does not require us to address the issue of whether we really experience succession or not. For example, what happens in the cases of succession could be explained with the help of memory: when the second stimulus is perceived, we still have a lingering memory of the stimulus that preceded it. Another possible way to account for the performance in temporal order tasks is simply by reference to some automatic, unconscious mechanisms.⁷ Yet another possibility is that the performance mirrors our experiences of succession. In the first two cases, we would have succeeding experiences, whereas

⁶ Two key issues concerning temporality can be used to separate the philosophical theories of time consciousness. The first one asks how much continuity there really is between two episodes of experiencing. The second one is: what establishes the continuity? Is it memory, contents of experience, self? What this means in practice is that philosophers tend to combine the issues at hand with the broader context of consciousness (and in many cases self-awareness too). Accordingly, the question they want to address is the general question of what the conditions for conscious experiences are.

⁷ Much like the visual guidance of our actions is done by unconscious, dorsal processing and not by the conscious experiences that we base our reports on.

only in the latter case would we have an experience of succession.⁸ The first two are thus compatible with Reid's view whereas the latter is compatible with his opponent's views. In so far as we only know the performance in these tasks, little is revealed about the possible mechanisms underlying them and nothing is revealed about the nature of conscious states.

This conclusion is supported also by the fact that psychologists themselves write about temporal order *judgments* instead of *experiences*, despite early remarks by Fraisse, who emphasized the phenomenology related to them.⁹ Obviously this does not mean that psychologists deny the possibility that these judgments are accompanied or even based on related phenomenology. Instead, it only suggests that psychologist consider phenomenology unhelpful in their pursuit of understanding the mechanisms underlying the role of timing in human behavior. Nonetheless, it is exactly because of such a noncommittal approach to the phenomenology that psychological results have only a little direct bearing on the matters that philosophers are interested in.

A similar consideration holds for duration perception. Fittingly, psychologists emphasize that we do not experience durations. (It has been argued, for example, that there is no sense organ for time perception in a sense there are sensory organs, say, for vision and hearing.) The fact that we do not experience durations *per se* does not however mean that we could not have some accompanied phenomenology. Correspondingly, although philosophers agree with psychologists on the experiences of durations themselves, many of them argue that we can experience something related: persistence—that something has lasted, been present, for some time. In fact, the phenomenology of persistence is one of the reasons to postulate the notion of specious present (see for example [1,9]).

Here again appears the gap between performance-based and phenomenology-based approaches to temporal consciousness: Given that psychologists explicitly deny the existence of the experienced durations, they pay no attention to the possibility of related phenomenology and write about duration estimation (rather than duration perception), thus emphasizing the cognitive side contra phenomenology. Hence, their research is largely restricted to the performance-based approach. From the philosophers' side, on the other hand, it is not obvious how the experience of persistence relates to the duration of stimuli—even though it appears likely that one cannot have a feeling of persistence without some way of tracking the passage of time. Thus, for philosophers, it appears likely that merely focusing on performance for example in duration estimation, duration generalization, and temporal bisection tasks does not provide new insights into this phenomenology because it does not address the issue of what causes the feeling of persistence.

In short, I have been arguing the following. Philosophical investigations are by their nature mostly limited to the phenomenology-based approach to temporal

⁸ Here is a useful analogy to think about: Based on the footprints on the beach one can infer that someone has walked there, but one only sees the footprints not the person who made them. Likewise here, maybe we can infer that two stimuli were presented in succession based on two separate experiences and with the help of some unconscious processes (or memory), or maybe we can indeed experience the succession itself and our performance is based on them. It could be either case, but if we look only the results in the task and never ask the questions concerning the phenomenology, we do not know which case it is.

⁹ Needless to say, there are also exceptions [e.g., 8].

consciousness. More importantly, however, the research done on the performance-based approach is such that it largely has no (direct) relevance to the issues philosophers are interested in. For example, the mechanisms for something can be researched without taking a stand whether the research results indicate that the temporal properties are experienced or that they are simply judgments that the subjects make. Thus, there is little need or interest from philosophers' side regarding the performance-based approach.

Both performance-based and phenomenology-based approaches are viable options for psychologists, unlike for philosophers. Yet they tend to emphasize the performance at the expense of phenomenology. From psychologists' point of view, it does not appear to matter much whether the results mirror the experienced phenomenon or mere judgments.¹⁰ Of course the latter are based on experiences too (except possibly in the forced choice tasks—think of blindsight) but not on the way that something is really a content of an experience instead of being merely inferred from the contents of experiences. The above does not mean, obviously, that psychologists could not also incorporate the phenomenology-based approach in their research.

3 Bridging the Disciplines

Although philosophers and psychologists have kept the performance-based and phenomenology-based approaches to temporal consciousness largely separate, there are issues where these two disciplines have much to offer to each other. For instance, there is no reason why properly planned experiments that put emphasis on phenomenology in addition to performance should not benefit both philosophers' and psychologists' endeavors. One could, for example, incorporate subjective confidence ratings in experiments and their analysis—as is done nowadays in some experiments concerning consciousness (see for example [10,11]). Instead of elaborating on this option, in this section I want briefly to mention more specific topics that have a bearing on philosophers' interests and in which some empirical research has been done. These serve as examples where collaboration between the disciplines is most likely to bring about advancements in both.

To begin with, philosophers' discussion on specious present means in practice that they are interested in issues that could shed light on the nature of specious present. For example, empirical issues that philosophers find interesting in relation to the notion of *specious present* are those that either motivate the endorsement of the specious present itself (perception of succession, change, etc.) or particular features of it (such as the notions of persistence for retended content and temporal orienting for protention in Husserlian tradition).

Another take on this matter concerns the minimal duration of experiences; if some notion of specious present is empirically sound, then each episode of sensing has some (kind of) temporal extension. Accordingly, it is reasonable to ask how long this temporal extension is (what the duration of one episode of experiencing is) and

¹⁰ This should not be taken as a criticism against the way research is done (and in fact, the author himself has been involved in few studies of this kind), but merely as an indication that psychologists' interest in the issues of temporal consciousness does not reside on the related phenomenology.

whether its duration is fixed. James, for example, thought that specious present could last up to twelve seconds, whereas more recently Dainton has argued that it lasts around half a second. Both of these questions, at least *prima facie*, are close to, although not identical, with Robert Efron's [12,13] research on the minimal duration of perception, whereby he explicitly separated the duration of stimulus, processing epoch, and conscious perception. Furthermore, he argued that the minimal duration of experience differs for visual and auditory sensory systems, which in turn suggests that the duration of specious present is not fixed. This, in turn, fits nicely with some philosophical theories of time consciousness but not necessarily with others.

Empirical investigations have a bearing on the issues concerning *temporality* too. One obvious example of this is the quantification of experiences and mental processes. Is our conscious perception discrete as is sometimes argued or is it continuous [14]? Or maybe merely some mechanisms leading to perceptions function in a discrete manner [15]? That is, some discontinuity in our stream of consciousness could happen either in the level of how one specious present follows the other or in the contents of succeeding specious presents. Whether there is some discontinuity or not, it is obvious that the experiments that psychologists have conducted and the theories they have subsequently put forward (especially concerning the notion of psychological moment [16]) appear to have a close connection with the philosophers' debate on how much continuity there is in the stream of consciousness.

Imagine, for example, that we find that our conscious episodes are in fact discrete. Although philosophers can still maintain that this is not how it appears to us—our phenomenology is a continuous stream—this would mean that philosophers only need to explain the appearance of continuity. On the other hand, if there are no grounds to argue for discontinuity, then philosophers need not only to explain the appearance of continuity but also to do it in such a way that the underlying process itself could be continuous. Currently, very few philosophical theories incorporate such continuity.

Another, previously mentioned, issue concerning temporality where empirical research could have a direct impact is the question concerning the interrelation between the experienced passage of time and performance in the duration tasks. Can they vary independently of each other or is one's judgment on the passed duration dependent on the experience of the passage of time?

One can also begin bridging the gap between philosophy and the psychology of temporal consciousness by pondering what philosophers can offer psychologists. Despite my modest knowledge of psychology, I think that here too are grounds for possible cross-talk. The most obvious contribution that philosophers can make to psychological undertakings derives from their interest in the phenomenology of temporal consciousness.

For instance, phenomenologically-oriented philosophers have put forward some notions that psychologists have later (often independently of philosophers) begun researching themselves. One example of this that relates to specious present comes from Husserl, who appeared to regard retention as separate from mere (visual) persistence. Here, Max Coltheart's [17] notion of informal persistence, formulated 70 years after Husserl, is rather similar.

Another example of the inspiration that phenomenology of temporal consciousness can bring about concerns the Husserlian notion of temporality: the idea of a continuous stream of consciousness and the general emphasis on the temporal

structure of consciousness have been successfully used in developing new methods of fMRI analysis, which in turn has resulted in new perspectives on schizophrenia [18].

It may be worth adding that most philosophers focusing on temporal consciousness link their discussion to the broader context. Thus, Husserl (and other phenomenologists) as well as Dainton [19], for example, link the discussion on temporality to the discussion on the notion of (pre-reflective) self-consciousness. Julian Kiverstein [20], in turn, approaches these issues from the perspective of embodiment. As regards specious present, Rick Grush's [21] trajectory estimation model puts emphasis on spatiotemporal illusions such as flash-lag effect and representational momentum. This opens up new frameworks on how to approach temporal consciousness in general and hence philosophers working with abstract theories can also suggest frameworks that might be useful to explain certain empirical results within more psychologically-oriented theories. Philosophers have used, for instance, results in the timing of experiences in short timescales to propose a view where the experienced time can differ from the time of representing and then contextualized this research in temporal illusions on a broader framework of consciousness studies [22,23]. More recently, Shin'ya Nishida and Alan Johnston [24] postulated a time-marker view that makes explicit use of this framework that was first put forward merely as a theoretical possibility.

4 Summary

Temporal consciousness, the field that focuses on how time figures in our conscious states, has been a keen interest of both philosophers and psychologists. Although one could assume that these two disciplines have had some influence on each other while tackling related issues, such cross-talk has yet to occur. The objective of this paper was to begin amending this situation.

One possible reason why philosophers and psychologist have had so little interaction on these matters is that their approaches are so far apart that they have little relevance to each other. It was argued that this is indeed how things currently stand, as philosophers focus on phenomenology and psychologists on subjects' performance in various experiments.

Another, equally valid, reason is that cross-talk between disciplines is difficult, if not even impossible, when researchers in one discipline do not know what researchers in the other disciplines work with. Hopefully, this latter reason has lost some of its force with the explication above on where philosophers' interests lie in the topic of temporal consciousness, because some of the research that has been done suggests that there are fruitful grounds for interdisciplinary collaboration for those philosophers and psychologists who wish for it.

References

- [1] Dainton, B.: Temporal Consciousness. The Stanford Encyclopedia of Philosophy (2010), <http://plato.stanford.edu/archives/fall2010/entries/consciousness-temporal/>

- [2] Varela, F.J.L.: The specious present: A neurophenomenology of time consciousness. In: Petitot, J., Varela, F.J., Pachoud, B., Roy, J.-M. (eds.) *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science*, pp. 266–329. Stanford University Press, Stanford (1999)
- [3] Varela, F.J.: Present-time consciousness. *Journal of Consciousness Studies* 6, 111–140 (1999)
- [4] Fraisse, P.: *The psychology of time*. Harper & Row, New York (1963)
- [5] James, W.: *The principles of psychology*. Dover, New York (1890)
- [6] Reid, T.: *Essays on the intellectual powers of man*. In: Walker, J. (ed.). Derby, Boston (1855)
- [7] Husserl, E.: *On the phenomenology of the consciousness of internal time (1893-1917)*. In: Brough, J.B. (ed.). Kluwer Academic, Dordrecht (1991)
- [8] Bschor, T., Ising, M., Bauer, M., Lewitzka, U., Skerstuweit, M., Müller-Oerlinghausen, B., et al.: Time experience and time judgment in major depression, mania and healthy subjects. A Controlled Study of 93 Subjects. *Acta Psychiatrica Scandinavica* 109, 222–229 (2004)
- [9] Kelly, S.D.: The puzzle of temporal experience. In: Brook, A., Akins, K. (eds.) *Cognition and the Brain: The Philosophy and Neuroscience Movement*, pp. 1–26. Cambridge University Press, Cambridge (2005)
- [10] Overgaard, M., Overgaard, R.: Neural Correlates of Contents and Levels of Consciousness. *Frontiers in Psychology* 1, 2008–2010 (2010)
- [11] Overgaard, M., Rote, J., Mouridsen, K., Ramsøy, T.Z.: Is conscious perception gradual or dichotomous? A comparison of report methodologies during a visual task. *Consciousness and Cognition* 15, 700–708 (2006)
- [12] Efron, R.: The relationship between the duration of a stimulus and the duration of a perception. *Neuropsychologia* 8, 37–55 (1970)
- [13] Efron, R.: The minimum duration of a perception. *Neuropsychologia* 8, 57–63 (1970)
- [14] VanRullen, R., Koch, C.: Is perception discrete or continuous? *Trends in Cognitive Sciences* 7, 207–213 (2003)
- [15] Stroud, J.: *The fine structure of psychological time*. In: Quastler, H. (ed.) *Information Theory in Psychology*. Free Press, Glencoe (1955)
- [16] Allport, D.A.: Phenomenal simultaneity and the perceptual moment hypothesis. *British Journal of Psychology* 59, 395–406 (1968)
- [17] Coltheart, M.: Iconic memory and visible persistence. *Perception & Psychophysics* 27, 183–228 (1980)
- [18] Lloyd, D.: Functional MRI and the study of human consciousness. *Journal of Cognitive Neuroscience* 14, 818–831 (2002)
- [19] Dainton, B.: *Stream of consciousness*. Routledge, London (2000)
- [20] Kiverstein, J.: The minimal sense of self, temporality and the brain. *Psyche: An Interdisciplinary Journal of Research on Consciousness* 15 (2009)
- [21] Grush, R.: Brain time and phenomenological time. In: Brook, A., Akins, K. (eds.) *Cognition and the Brain: The Philosophy and Neuroscience Movement*, pp. 160–207. Cambridge University Press, Cambridge (2005)
- [22] Dennett, D.: *Consciousness Explained*. Little, Brown, Boston (1991)
- [23] Dennett, D., Kinsbourne, M.: Time and the observer. *Behavioral and Brain Sciences* 15, 183–247 (1992)
- [24] Nishida, S., Johnston, A.: Marker correspondence, not processing latency, determines temporal binding of visual attributes. *Current Biology* 12, 359–368 (2002)