Building perception block by block: a response to Fekete et al.

Adrien Doerig1,*, Frank Scharnowski2,3,4,5 and Michael H. Herzog1

1Laboratory of Psychophysics, Brain Mind Institute, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland; 2Department of Psychiatry, Psychotherapy and Psychosomatics, Psychiatric Hospital, University of Zürich, Lenggstrasse 31, Zürich 8032, Switzerland; 3Neuroscience Center Zürich, University of Zürich and Swiss Federal Institute of Technology, Winterthurerstr. 190, Zürich 8057, Switzerland; 4Zürich Center for Integrative Human Physiology (ZIHP), University of Zürich, Winterthurerstr. 190, Zürich 8057, Switzerland; 5Department of Basic Psychological Research and Research Methods, Faculty of Psychology, University of Vienna, Liebiggasse 5, Vienna 1010, Austria

*Correspondence address. Laboratory of Psychophysics, Brain Mind Institute, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland. Tel: +41 21 693 72 29; E-mail: adrien.doerig@epfl.ch

Abstract

Is consciousness a continuous stream, or do percepts occur only at certain moments of time? This age-old question is still under debate. Both positions face difficult problems, which we proposed to overcome with a 2-stage model, where unconscious processing continuously integrates information before a discrete, conscious percept occurs. Recently, Fekete et al. criticized our model. Here, we show that, contrary to their proposal, simple sliding windows cannot explain apparent motion and related phenomena within a continuous framework, and that their supervenience argument only holds true for qualia realists, a philosophical position we do not adopt.

Key words: consciousness; discrete perception

Intuitively, consciousness is a continuous stream of percepts. We see a diver jumping from a cliff into the ocean and have the feeling we perceive their motion trajectory at each single moment of time. However, continuous perception theories face serious problems known since ancient times. For example, a disk is presented at two locations separated by a blank period (Fig. 1). We do not perceive two small disks presented at two locations, but a single disk moving between the locations even though there is no motion at all in the stimulus (apparent motion; Fig. 1). Obviously, we can only perceive the motion after the second disk is presented and, hence, perception cannot be immediate. Other examples demonstrating that the percept cannot occur immediately include feature fusion, the flash-lag illusion, the continuous wagon-wheel illusion, etc.

To accommodate these findings, discrete theories propose that percepts occur only at certain moments of time. For example, snapshot theories propose that we sample information from the environment like a surveillance camera, taking pictures periodically. However, these positions also face severe problems (see Herzog et al. 2016). In particular, no experiment has ever shown evidence for a unique and paradigm-independent sampling rate. In addition, any information between snapshots would be lost.

To overcome these problems, we proposed a 2-stage theory (Herzog et al. 2016) where continuous, unconscious processing with high temporal resolution integrates information for several hundred milliseconds (Stage 1), which is then rendered conscious as a coherent percept at a discrete moment in time.
Importantly, temporal features, such as motion, are not consciously perceived while they occur. They are not even perceived over an extended period of time, but are encoded as any other feature, such as colour or shape, by a static label. For example, motion is not represented by a signal that moves in time but by the output of a motion detector.

Fekete et al. (2018) criticized our model based on two main arguments.

1. Sliding windows: They argue that phenomena such as apparent motion can be explained within a continuous framework by sliding windows. We will explain why this argument fails.

2. Perceptual change and neural change: They claim that perceptual change must be mirrored by neural change: ‘admitting that there is perceptual change (e.g. in the location of the object) not mirrored in neuronal change [...] would
amount to violation of supervenience—the notion that consciousness is determined by physical processes [ ]’. We will show that either there is a misunderstanding about supervenience in their argument or they subscribe to a realist position about qualia.

Sliding windows

There is agreement that ‘instantaneous’ continuous theories, in which sensory evidence is immediately translated into a conscious percept cannot be true because phenomena such as apparent motion require integration over extended periods of time. Fekete et al. proposed that continuous theories can explain such phenomena by sliding windows (Fig. 1). For example, a window, starting integration with the presentation of the first disk and terminating with the second one, might explain apparent motion. Conscious perception just occurs after the presentation of the second disk—it is delayed but continuous (Fig. 1a). However, the example fails for a very simple reason. Integration does not start with the presentation of the first disk and terminates with the second one. It is continuous! Let us consider—step by step—what would happen in the sliding window account (Fig. 1). First, the window comprises only an empty screen and, hence, only an empty screen would be perceived. When we move the window further, it comprises empty screen moments and the first disk. At this stage, we would perceive the first disk—and only it. When we move the window further, both disks are now present, and we would perceive motion. Finally, we would perceive only the second disk when the first disk is outside the sliding window. However, this is not what we actually perceive. We see only one moving disk and never single static disks. Hence, the idea of a rigid sliding window is not tenable.

As mentioned, a sliding window can explain why we perceive motion when the window contains both disks. For example, a classical motion detector fires only when it is stimulated by two distinct consecutive events (for certain spatial positions and delays, thus, creating a direction and speed sensitive neuron; Adelson and Bergen 1991; Jancke et al. 2004; Lu and Sperling 1995; Watson and Ahumada 1985). Such a motion detector is equivalent to an integration model and explains why we perceive two discrete events as continuous, as is the case in apparent motion. Hence, it explains why we perceive continuity instead of discrete events. However, it does not explain the discreteness of perception. Namely, it cannot explain why we only perceive a single moving disk and not two additional static disks in windows preceding and following the window containing both disks—even though the visual system clearly can detect both the first and second disk when they are presented alone (e.g. using a ‘static disk’ detector). The very same argument applies to feature fusion and other phenomena where two discrete events are perceived as a single continuous event.

Perceptual change and neural change

We completely agree with Fekete et al. that different percepts must come with different brain states. It cannot be that the very same brain state gives rise to different percepts. This is a prerequisite for studying consciousness neuroscientifically. However, this does not imply that temporal changes in perception, such as motion, are mirrored by temporal changes in the brain. Motion in the external world does not need to be represented by brain dynamics—it can simply be coded statically by the output of a motion detector. Different kinds of motion (speed, direction, etc.) are encoded by different motion detectors. Likewise, a 40 ms stimulus may not be perceived over a duration of 40 ms but instead might be encoded by the output of a duration detector, i.e. a ‘static’ number indicating a 40 ms duration. And a duration of 50 ms might be encoded by another detector. According to our theory, different percepts correspond to different brain states. Thus, there is no supervenience problem. It seems that Fekete et al. postulate that each physical moment of motion needs to be represented by a different brain state, potentially because they subscribe to a realist position about qualia (see Qualia and philosophical assumptions section of this contribution). Accordingly, when we perceive a ball moving continuously from A to B, there must be a different brain state for each intermediate position of the ball. In our approach, this is not the case—a single brain state encodes the entire motion percept.

Related arguments

Subsequent arguments against our model rest on this misunderstanding of the supervenience argument, or on strong qualia realism. For example, Fekete et al. argue that, if perception were discrete, updates would need to occur roughly every 33 ms (i.e. at 30 Hz, but the precise value is not crucial) because neural change needs to match perceptual change. They further argue that this is impossible because of the slow neural dynamics of the primary visual cortex. However, this argument does not apply to our theory for the reasons described above.

Qualia and philosophical assumptions

The question about the time course of perception directly relates to the question of qualia. As mentioned, motion detection does not need to be coded by a dynamically changing representation. What about motion experiences? In our model, the experience of motion does not extend in time, it only seems to. In this respect, we are close to the illusionist position (Dennett 2016; Frankish 2016), which proposes that qualia do not exist as real distinct entities—they only seem to. Similarly, the meta-problem research program (Chalmers 2018) aims to explain why we think there is a hard problem of consciousness, i.e. why it seems that qualia exist as real distinct entities.

Our approach is at odds with a realist interpretation of qualia, which Fekete et al. seem to adopt. Given such incompatible philosophical underpinnings, our proposals are naturally very different. Thus, our dispute gets to the heart of the heated debate on how to link neural processes to conscious percepts. Because the sliding window argument fails to account for phenomena in which two discrete events are perceived as a single continuous event (and for other independent reasons, e.g. Sergent 2018), we suggest that discrete models should be favoured. Whatever the final answer is, we believe that questions about the time course of conscious perception, a highly under-investigated research area, are a fundamental stepping-stone to understand perception and consciousness, and we thank Fekete et al. for their stimulating contribution to this crucial debate.

Funding

This work was supported by the SNF grant ‘Basics of visual processing: from elements to figures’ (176153).

Conflict of interest statement. None declared.
References

Adelson EH, Bergen JR. The plenoptic function and the elements of early vision. In: Landy MS, Movshon JA (eds), Computational models of visual processing. Cambridge, MA: The MIT Press, 1991, 3–20.

Chalmers D. The meta-problem of consciousness. J of Conscious Stud 2018;25:1–41.

Dennett DC. Illusionism as the obvious default theory of consciousness. J Conscious Stud 2016;23:65–72.

Fekete T, Van de Cruys S, Ekroll V et al. In the interest of saving time: a critique of discrete perception. Neurosci Conscious 2018;2018: doi: 10.1093/nc/niy003.

Frankish K. Illusionism as a theory of consciousness. J Conscious Stud 2016;23:11–39.

Herzog MH, Kammer T, Scharnowski F. Time slices: what is the duration of a percept? PLoS Biol 2016;14:e1002433.

Jancke D, Chavane F, Naaman S et al. Imaging cortical correlates of illusion in early visual cortex. Nature 2004;428:423.

Lu Z-L, Sperling G. The functional architecture of human visual motion perception. Vis Res 1995;35:2697–722.

Sergent C. The offline stream of conscious representations. Philos Trans R Soc B 2018;373:20170349.

Watson AB, Ahumada AJ. Model of human visual-motion sensing. J Opt Soc Am A 1985;2:322–42.