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Box 1. Perceptual Competition in BR and Transition Signals in the PFC

One of Block's major arguments against a PFC involvement in conscious perception derives from the premise that 'explanation of binocular rivalry is that pools of neurons that represent each of the stimuli are mutually inhibitory' [2]. Therefore, these interactions should be detectable and not finding them in PFC spiking activity between rivalry and nonrivalry conditions [9,10] is evidence against its involvement. Firstly, this is a theoretical assumption originally proposed as part of a mechanism, that BR results from competition between eyes and therefore depends on monocular neurons in early visual areas. However, only a minority of them were found to be perceptually modulated [6]. Therefore, Block's argument should take these findings into account. Secondly, such inhibitory interactions could still occur in earlier sensory regions (nonconsciously), with PFC, among other associational cortical areas, reflecting the resolution of competition, signaling ongoing perceptual content. Thirdly, such competition among stimulus representations does not necessarily imply interaction between neuronal ensembles mediating them, since the two processes could exist mutually exclusively. Indeed, neural activity preceding changes in conscious perception during rivalry but not during nonrivalrous conditions [11] suggests differential PFC modulation. Taken together, the (non)existence of differential activation requires careful scrutiny before considering it as evidence against the role of PFC in conscious perception.

We believe that current empirical findings from fMRI and electrophysiological BR studies may have a different interpretation and suggest that two mechanisms of intrinsically generated transitions might exist in the cortex. One mediating unconscious switches in sensory cortical areas, and another in association cortical areas that gates conscious access and therefore transitions between consciously perceived contents.

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Spotlight

Advances in Emotion-Regulation Choice from Experience Sampling

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Gregory R. Samanez-Larkin [1]

Recent experience-sampling studies by Blanke *et al.* and Grommisch *et al.* provide insights into how individuals regulate their emotions in daily life. The rich datasets accessible from experience sampling allow researchers to detect nuances in the relationship between emotion-regulation choice and psychological health that may not be observed in traditional laboratory studies.

Stressors are common in life, from traffic jams on the way to work to chronic illnesses. How individuals respond to stressors is an important indicator of psychological health and well-being [1]. Research conducted in the laboratory has led to foundational discoveries of how individuals regulate their emotions in response to stressors and how their regulation choices are associated with different health outcomes [1–6]. However, how individuals regulate in the laboratory may not reflect how they regulate in their daily lives. To study how emotion regulation is associated with psychological health and well-being, it is important to study how individuals choose to regulate outside the laboratory.

New research by Blanke and colleagues [7] and Grommisch and colleagues [8] has ventured into the wild using experience sampling to investigate how individuals choose to regulate in varying contexts – outside the confines of the laboratory. They gathered data about how individuals were feeling and choosing to regulate by sending brief surveys to their phones. These studies helped to identify new patterns of how individuals choose to regulate in complex, evolving environments. By collecting rich and versatile datasets, they detected valuable information about the consequences and dynamics of how individuals regulate outside the laboratory. These methodological and analytical advances have brought us closer to a more comprehensive understanding of how individuals choose to regulate based on their personal goals and the larger context.

Blanke and colleagues [7] investigated how variable individuals were in their regulation choices by analyzing data from four experience-sampling studies. They investigated whether individuals who were more variable in their use of regulation strategies experienced less negative affect than individuals who were more rigid (less variable) in their regulation choices. To do this, they analyzed how variable individuals were in their use of a specific regulation strategy over time (within-strategy variability) and in how they regulated at specific sampling occasions (between-strategy variability). Within- and between-strategy variability capture distinct constructs. An individual with low within-strategy variability may always, for example, strongly suppress negative emotion, regardless of the circumstances. Separately, an individual with high between-strategy variability may use a range of strategies but prioritize, for example, cognitively reframing, at a given moment. However, an individual with low between-strategy variability may be more lackadaisical in how they chose to regulate and endorse numerous regulation strategies to the same extent without prioritizing one. For the first time, Blanke *et al.* show that individuals who prioritized certain regulation strategies (i.e., high between-strategy) over others experienced less negativity. However, the relationship between within-strategy variability and negativity varied based on how depressed individuals were (i.e., level of depressive symptoms). Specifically, individuals who did not rigidly regulate in the same way across varying contexts (i.e., had high within-strategy variability) experienced less negativity, but only when controlling for depressive symptoms. Furthermore, individuals with higher levels of depressive symptoms were more likely to have higher within-strategy variability, indicating that within-strategy variability may be maladaptive [7].

Grommisch and colleagues [8] similarly investigated how individuals' regulation choices influenced their well-being. They analyzed how individuals' repertoire of strategies – the range of strategies they used across situations – influenced how happy and satisfied they were with their lives. They computed profiles of regulation for each occasion and classes of individuals to understand differences in regulation choices over time. They identified five classes of individuals: those who used a diversity of strategies but tended to actively regulate, such as by removing themselves from or accepting the situation; those who used a diversity of strategies but tended to suppress negative emotion; those who moderately used most strategies; those who did not regulate; and those who intensely used all strategies. Based on these phenotypes capturing how individuals tended to regulate across varying situations, Grommisch and colleagues determined that those who used a diversity of profiles but tended toward active regulation strategies experienced lower anxiety and higher positivity than those who tended to suppress. These results illustrate that using more strategies is not necessarily adaptive. Rather, the type of strategies individuals employ is important. Individuals who use a range of strategies may be healthier, but that varies based on which strategies they employ [8].

These findings are important because how individuals regulate in the laboratory may not be an accurate indicator of how they regulate in everyday life. Experience sampling allows researchers to study how individuals choose to regulate in a variety of ways and synchronize their regulation choices to the environment outside the laboratory. Healthy regulation emerges from a complex interaction between the individual, the situation, and the technique [9]. Taken together, these findings help to bring the field closer to a personalized account of emotion regulation.

Experience sampling offers a tool for gathering data in everyday life, so researchers do not have to limit or dictate how individuals regulate across a range of contexts. Researchers in the laboratory typically instruct individuals to use specific strategies or allow them to choose between a limited range of strategies. In addition, researchers in the laboratory may expose individuals to a select range of stimuli and not adequately vary the situational demands and context [1–6]. In addition, by collecting data at numerous momentary occasions, individuals do not have to bear the difficult tasks of recalling responses from past events or summarizing how they tend to regulate.

Future research may benefit from further investigating how individuals regulate in various ways. For example, it is important to characterize the relationship between regulation choices and well-being in various contexts. What are the occasions that are best suited for a certain regulatory profile? In addition, future research should aim to disentangle the temporal dynamics of concurrently using various regulation strategies. Is there a specific order of implementing those strategies that is most effective for certain individuals, regulatory goals, and contexts?

Insights from recent experience sampling should not simply motivate additional experience-sampling studies but should inform laboratory studies. Laboratory studies of emotion regulation are crucial cornerstones of research that continuously move the field forward. Researchers conducting studies in the laboratory could aim to collect temporally-rich data to better understand the dynamics of regulation. Similarly, researchers could expand how many choices individuals can make about how to regulate. By combining versatile laboratory studies and experience-sampling studies that allow individuals to freely engage in daily life, we can move closer to a personalized account of emotion regulation.

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Forum

The Dark Room Problem

Zekun Sun[1] and Chaz Firestone[1,*]

Predictive Processing theories hold that the mind's core aim is to minimize prediction-error about its experiences. But prediction-error minimization can be 'hacked', by placing oneself in highly predictable environments where nothing happens. Recent philosophical work suggests that this is a surprisingly serious challenge, highlighting the obstacles facing 'theories-of-everything' in psychology.

A dark, empty room presents few surprises. The information reaching the eyes is constant, uniform, and unremarkable; effective soundproofing could do the same for the ears. Add some creative seating, and the whole experience will be as dull and predictable as any experience could be.

Humans and other animals tend not to seek such experiences, and even find them aversive when endured for long enough: if several hours in such a room would be dreadfully boring, days or weeks would be unbearable. But according to a sweeping account of cognitive and neural functioning, this seemingly should not be the case. Predictive Processing theories (PP) hold that the mind's core aim is to 'minimize prediction-error' about its experiences – to be as least wrong as possible about what is happening [1–3]. This single principle is invoked to explain a vast array of behaviors and capacities, including attention, learning, memory, action, emotion, motivation, and more – a psychological theory-of-everything to 'unify these very diverse aspects of our mental lives under one principle' [1]. Yet, at first glance, PP seems committed to a bizarre hypothesis: that prediction-error minimizers – us, allegedly – should find their deepest motivations fulfilled by the most utterly boring experiences, since a sure way to minimize prediction-error is just to place oneself in a highly predictable environment (such as a dark, empty room where nothing much happens).

That prediction-error minimization might be short-circuited in this way is now known as the 'Dark Room Problem' [4]. Though it may sound fantastical, recent work in philosophy of cognitive science has amplified this challenge and highlighted its seriousness [5–7]. Why, according to PP, should anyone do anything other than idle in a predictable room? Here, we briefly review some answers to this question. We give special attention to one solution that recalls our field's oldest and most foundational disputes over all-encompassing theories of the mind and brain.

Some Intuitive Replies

Is the Dark Room Problem really a problem? You might think not. For example, enough time in the room would surely make you hungry or thirsty; wouldn't you leave to satisfy such needs?

Indeed, you would; but this observation only refocuses the original problem. If agents aim only to minimize prediction-error, then states should be avoided only insofar as they increase prediction-error. However, for someone idling in a dark room, hunger is highly predictable. As Klein notes [5], 'predicting hunger is not the same as being motivated by it. As I lay with my eyes shut, my cognitive system could predict perfectly well the progression of hunger signals. (It is not that complicated: I will get more and more hungry, and then die)'. The challenge posed by the Dark Room Problem is not to say why someone would leave; it is to say why prediction-error minimization should make someone leave – and it is not clear that it does, even to eat.

A less dismissible reply might invoke curiosity and exploration. Even if leaving a dark room increases short-term prediction error, perhaps doing so could reduce long-term prediction-error (e.g., if exploring the outside world can further hone your prediction skills). However, even this intuition underestimates the Dark Room Problem's insight. As Clark acknowledges [7], not all motivations that drive us from dark rooms reduce to instrumentally valuable exploration, even over the long-term. Humans are endlessly creative: we dance, ride rollercoasters, donate to charity, and read poetry; we even seek surprise itself in certain aesthetic pursuits, purposefully entering unpredictable states just for the thrill of it. In its most ambitious flavors, PP aims to explain every psychological state we have: 'perception and action and everything mental in between' [1]. However, even if some behaviors reduce long-term prediction-error, it is not clear