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Mentalising Allostasis: The Sense that I Should Eat: Comment on: "The sense of should: A biologically-based framework for modeling social pressure" by Jordan E. Theriault, Liane Young, and Lisa Feldman Barrett

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One cannot but be impressed with this fascinating article (Theriault et al., 2020) on the internalisation of social pressure, written in a thoroughly multidisciplinary way: spanning from evolutional theories to maths, psychology and social sciences. The articleproposes a novel basis for understanding the experience of social pressure, the Sense of Should (SoS) not as inflicted by external punishment, but rather as the internalised need to align oneself to others' expectations in order to promote stability in one's social environment and thus ultimately optimise the expenditure of one's metabolic resources. There is no doubt that this article stands to act as an innovative 'disruptor' in the field, changing long explicit and implicit behaviourist assumptions about human social motivations of compliance and conformity. As the authors themselves brilliantly outline, the implications of their position are nothing less than a much-needed shock in the system for current psychological and sociological understanding of certain human social motivations. Of particular importance is their author's ability to trace highly complex and interactive social phenomena down to the evolutionary and biological imperatives of embodiment. The last time somebody dared to link fundamental human motivations of sociality withbiological imperatives of self-preservation was Freudian metapsychology. Freud believed that the human mind is hierarchically structured by how humans are socialised, from the cradle to the grave, to respond to their inherited and ever pressing bodily needs. To account for how socialisation progressively inhibits, mentalises and symbolises bodily imperatives, Freud introduced concepts such as such as projection, identification and superego (all of relevance to the currently proposed SoS concept) that took the 20th century by storm. By the 21st century however, scientific psychology has largely moved away from some of the subsequent, unfortunate developments of psychoanalysis and espoused more cognitive, modular models of the mind. Nevertheless, the recent mathematical innovations (the Free Energy Principle, Friston, 2010) that are used so innovatively by Theriault et al.,are actually based on ideas first developed at theend of the 19th century, when von Helmholtz, and then under his inspiration, Freudtried to account for the human mind on the basis of the fundamental physical principles of human embodiment, such as for example his idea that thinking is as a kind of experimental, delayed action that relied on binding 'free energy'(Freud, 1911, p. 221; for more recent psychodynamic neuroscience proposals, see Fotopoulou et al., 2012; 2013; Cathart-Harris & Friston, 2010; Fotopoulou & Tsakiris, 2017). In that sense, the current article holds a place among such 'disruptive', interdisciplinary theoretical giants.

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Nevertheless, despite the radical proposal of the SoS, there is a theoretical aspect in their model that could be further extended in order to place the origins of the social phenomena under consideration on fundamental imperatives of embodiment. Specifically, while the authors seem to emphasise that the SoS arises as a solution to the need for minimising metabolic costs, thecosts they discuss throughout the paper are mainly the costs of neural signalling and of information. Indeed, the Bayesian Brain Hypothesis, on which this article is based, entails that the brain acts as a regulator of the organism and facilitates survival by modelling its interactions with the environment. However, thecosts of the modelling itself are only part of the overall energy budgetof the organism which depends on the brain, as much as it depends on dynamic interactions with the environment(Gallagher & Allen, 2018). The authors start on this premise, but seem to focus mainly on social, epistemic costs. Their account can be enhanced by a deeper consideration of the metabolic costs of the whole organism, which entails the optimised modelling of conflicts between different bodily imperatives, as potentially formed in development in interaction with different social agents. In other terms, it is not only the accuracy of modelling (the reduction of prediction error in any given interaction) that needs to be taken into account but also its complexity. Indeed, once the whole organism, its socially-depended nature and its conflicting needs are taken into account the addition of concepts like ‘precision’ become imperative in understanding the SoS.

Thus, a compatible but more radically embodied view of how the SoS arises would focus on the costs of bodily rather than just brain metabolism and consider how an organism solves the conflict entailed in regulating metabolic energy among many, and at times competing physiological and social needs. Briefly, the SoS is a resource optimisation solution due to inevitable biological competition. To use the example of Amelia that the authors introduce, before understanding why Amelia paints her nails or tells a dirty joke, one needs toask how a SoS motivates her eating with Bob against another activity such as painting her nails for Bob. To give a simple but critical example, the sense that Amelia should want to eat breakfast when Bob expects her to want to eat breakfast, has its origins in the fact that Amelia’s energy metabolism throughout her infancy was totally depended on her parents feeding practices, which themselves were deeply embedded in their culture. Theriault et al. come very close to been able to integrate scientific models of energy metabolism with the neurobiology of social affiliation and cognition, but their approach can be extended beyond the metabolic costs of the individual, isolated brain, as in some other previous internalist models of human emotion (e.g. Craig, 2009, Seth, 2013). These theories describe humans as having exclusive, private access to their physiological states (interoception) and hence are in need to infer each other’s expectations on the basis of exteroceptive signals alone, as it were ‘from a distance’. These models fail to apprehend that the inferential mind is born out of a full integration between embodiment and socialisation(see Ciaunica & Fotopoulou, 2017; Fotopoulou & Tsakiris, 2017 for discussions). However, the SoS does not need to apply to *a priori* ‘separated’ organisms. After all, humans begin life inside the womb and then in a prolonged social dependency. Below I offer an example of such an extension in relation to the social aspects of the fundamental motivation to eat.

The regulation of energy metabolism in general, is the backbone of individual, human survival. In humans however, feeding and survival more generally is not a job only for the

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individual against his physical environment. Aswe stressed in previous work (Fotopoulou & Tsakiris, 2017), human infants are unique among primates in having an especially extended period of motor immaturity and hence dependency on their caregivers for feeding (even after weaning) and for survival and learning, more generally. Thus, infants come to build expectations of their own bodily states (a process we have termed embodied mentalisation) and particularly interoceptive expectations such as feelings of hunger, stomach fullness and satiation on the basis of a kind of calibration process between their physiological needs and social caregiving.Put simply, babies cannot eat by themselves. Thus, without caregiving, there is no possibility of active inference, that is no possibility of resampling the world to fulfill one's interoceptive predictions, and hence refine or update them. Therefore, caregiving does not only ensure infants survive, it also allows them to gradually develop generative models of their own physiology and its regulation (Fotopoulou & Tsakiris, 2017). Although the authors have kindly commented on this perspective in the past (Atzil & Barret, 2017) and then published similar perspectives themselves (Atzil & Barret, 2018), they somewhat surprisingly do not describe SoS as developing out of such embodied, interactive processes of metabolic regulation, but instead focus on the brain's modelling needs and emphasise the additional mentalistic and exteroceptive skills that the infant should acquire, namely the abilities to predict the behaviour of others and to make precise inferences about their expectations of her.

An alternative developmental origin for the SoS would conceptualise the anticipatory anxiety occurring when violating learned social expectations, not as the result of a generic increase in epistemic prediction error, but rather as *the consequence of failing to optimise precision across different homeostatic and social imperatives* (Fotopoulou, 2013; Crucianelli et al., 2019). For instance, caregivers have to ensure children engage in the safe 'exploitation' of the variety of different food resources humans have explored (Ungar and Teaford 2002), while at the same time continue to cognitively develop by engaging in maximal exploratory, 'trial-and-error' behaviours in other aspects of life, such as rough-and-tumble play. As Gopnic and colleagues have suggested (2017), low executive control and high brain plasticity, coupled with social caregiving early in life are evolution's solutions to the need to maximize exploration and flexible learning while infants and children are kept nourished and protected by social structures. The neurobiology of feeding holds certain clues to this social solution to the need to balance exploration and exploitation, and the origins of the SoS.

For example, from the point of view of an infant's homeostatic regulation, a decrease of blood glucose levels can be viewed as a deviation in a homeostatic variable that elicits infant crying as a signal to the caregiver to initiate a corrective feeding response, which will eventually restore blood glucose levels. However, as progressively the mother will establish a feeding schedule, in response toboth the infants signals and her own needs and life schedule, the baby will learn to anticipate these 'social' meals times. Hence, the same premeal drop in blood glucose will progressively become an anticipatory regulatory response,elicited by the infant when she knows a meal is imminent; premeal secretion of insulin lessens glucose to prevent the risk of the anticipated dangerous rise in glucose that follows a meal. In that sense, social caregiving has transformed an initial arousal-based, homeostatic mechanism into an allostatic model capable of making numerous anticipatory

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responses to cope efficiently with the homeostatic imbalance created when the food is absorbed. While people have come to think of the interoceptive feeling that accompanies lower glucose asa hunger signal in the brain that needs to be ‘corrected’ by proportional eating, neurobiological studies have shown that eating is an effector motivated by the need to be robust against many other physiological considerations about metabolic energy, achieved by managing adiposity on larger timescales (Ramsay & Woods, 2014). On a daily basis, and since infancy, eating times are dictated by social culture, habit and convenience, as opposed to being reactions to deficits of available energy (Strubbe & Woods, 2004). Therefore, children are eating when their parents are expecting them to eat, not because in each meal prediction errors are reduced to save the brain metabolic resources but because eating according to social convention facilitates the brain to optimise its allostatic robustness (minimisation of prediction errors across several physiological systems and varied timescales).

Indeed, in addition to genetic differences, parental and more broadly cultural behaviours influence eating appetitive motivation, taste preferences and feeding behaviours in human children (Birch 1999; Rozin 1996), as well as in other primates such as chimpanzees and monkeys. For example, chimpanzee infants respond to novel foods in an interested but hesitant manner and refer to their mother for some kind of cue before attempting to ingest them (Ueno & Matsuzawa, 2005). Perhaps it is no accident that humans seem to like to eat with company across the life span. Social eating, whether in feasts or everyday meals with family and friends, is a human universal (Dunbar, 2017), studied by archaeologists and anthropologists across many cultures and periods. This socialisation of eating may among other things, serve to create the stable and predictable social conditions needed for individuals to learn to make premeal responses that allows sufficient energy intake while allostatically minimizing pertubations to other parameters. This anticipatory active, regulation of multiple, and at times conflicting homeostatic imperatives is what characterises allostatic regulation and in active inference, allostatic regulation relies on being able to optimise the precision of prediction errors between these conflicting systems (Stephen et al., 2016).

Accordingly, I propose that the SoS, such as Amelia’s sense that she needs to eat breakfast in the morning, does not derive from the need to reduce epistemic prediction error about Bob’s common breakfast expectations, but rather its derives from interactive, social learning, particularly during socially stable periods, such as childhood. These established patterns of identification with the social practices and habits of certain individuals (frequently the parents and later mentors, or culture leaders) optimise the allostatic regulation of metabolic energyso that there is some robustness against internal and external perturbations, such as for example periods where there is social competition. It also follows that environments characterised by severe unpredictability, conflict or lack of reciprocity during sensitive periods (e.g. childhood, adolescence, pregnancy) will affect how individuals optimise the precision of their different metabolic and social needs. In such environments, people may face life-long struggles with knowing and regulating their bodily states and a highly prescriptive, persecutory SoS that they can never satisfy and that stifles their ability for exploration and creativity. In forthcoming work, we apply such considerations to the understanding of eating and somatisation disorders. More broadly, it should be evident by the above that the novel concepts the authors of SoS have introduced have wide-ranging implications for all the aforementioned fields but also for psychiatry and mental health research.

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