



Effort, Uncertainty, and the Sense of Agency

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Abstract

Orthodox neurocognitive accounts of the bodily sense of agency suggest that the experience of agency arises when action-effects are anticipated accurately. In this paper, I argue that while successful anticipation is crucial for the sense of agency, the role of unsuccessful prediction has been neglected, and that inefficacy and uncertainty are no less central to the sense of agency. I will argue that this is reflected in the phenomenology of agency, which can be characterized both as the experience of (1) efficacy and (2) effort. Specifically, the “sense of efficacy” refers to the perceptual experience of an action unfolding as anticipated. The “sense of effort”, in contrast, arises when an action has an uncertain trajectory, feels difficult, and demands the exertion of control. In this case, actions do not unfold as anticipated and require continuing adaptation if they are to be efficacious. I propose that, taken individually, the experience of efficacy and effort are insufficient for the sense of agency and that these experiences can even disrupt the sense of agency when they occur in isolation from each other. I further argue that a fully-fledged sense of agency depends on the temporally extensive process of prediction error-cancelation. This way, a comparator account can accommodate both the role of accurate prediction and prediction error and thus efficacy and effort.

1 Introduction

The prediction of the sensory consequences of bodily action is widely considered a necessary condition for the sense of agency. To experience oneself as the author of one’s physical actions depends on predicting what will happen next. If such predictions are not available, no sense of agency will ensue. This assumption is largely taken for granted by orthodox psychology, neuroscience, and psychopathology. And even though there is no consensus on how to construe the phenomenology of agency in detail (Gallagher 2012), there is substantial agreement concerning the role of successful

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prediction (Blakemore et al. 2002, 2000a, b, 1999, 1998; de Vignemont and Fourneret 2004; Fletcher and Frith 2009; Frith 2012, 2005; Haggard and Clark 2003; Synofzik et al. 2008, 2009; Tsakiris and Haggard 2005, 2003). For the purpose of illustration, consider the following case of bodily action: I reach out for a glass of water on my desk. Thereby, the experience of agency depends on my “awareness of the predicted limb position” (Frith et al. 2000, p. 1784). Moreover, the sense of agency will only arise if the sensory consequences of one’s action are predicted *successfully*. That is, the sense of agency only arises if there is a match between predicted and actual sensory consequences of action (Synofzik et al. 2009). One might take this to imply that *only* successful prediction is necessary, while unsuccessful prediction undermines the sense of agency. However, even though successful prediction of action-effects is crucial for the sense of agency, we should not conclude that, conversely, unsuccessful prediction merely undermines the experience of agency.

The goal of this article is to show that unsuccessful prediction plays a more complicated and even positive role for the sense of agency, or so I shall argue. Unsuccessful prediction might undermine the sense of agency under certain conditions, but in general, it might still be a necessary condition for the experience of agency to arise.

This idea is not a novel one and has more recently been presented in the “predictive processing” accounts of Gerrans (2014) and Clark (2016). Gerrans’ and Clark’s consideration is that the sense of agency is not simply an experience of efficacious prediction, but that it also involves precariousness or uncertainty:

Slightly paradoxically, it seems that the sense of agency is more likely to arise in situations where the control of action is precarious—actually or potentially unsuccessful. This is not a paradox, however; we *are* more aware of our agency when learning a musical instrument, walking through a minefield, or threading a needle, than when performing a task automatically and successfully. (Gerrans 2014, p. 169)

Considering this, “precarious” action is understood as *potentially* unsuccessful action or action that is likely to proceed in unexpected ways. That is not to say that an action *must* be unsuccessful for there to be a sense of agency. It is to say that the sense of agency only arises when an action unfolds under precarious or “difficult” circumstances, that is, when perturbing factors are present and when action is thus prone to err. The sense of agency might, therefore, depend on the unpredictability of an action’s sensorimotor, or perceptuo-motor trajectory. By way of example, we should not take the almost automatic gait of an adult as the *only* paradigm for movement facilitating agency experiences, but the unsteady, insecure gait of an infant, for whom walking is not yet a matter of course. Gerrans’ idea, then, is that the unpredictable and clumsy gait of the infant will not undermine her sense of agency. Rather, it ought to be understood as a condition for its emergence. An account of the sense of agency should cover both of the cases just described.

On the one hand, the goal of this article is to refine this idea and its rationale remains closely aligned to Gerrans’ (and Clark’s) theory of the sense of agency. On the other hand, it raises an important worry that such an account must answer to: how could both, successful and unsuccessful prediction of reafferent feedback contribute to the sense of

agency, considering they seem to be mutually exclusive? Neurocognitive models of agency experience suggest that a mismatch between predicted reafferent feedback and actual feedback will undermine the sense of agency. So how could unsuccessful prediction play a positive role?

1.1 Temporal Dynamics of Agency

There is an elegant and simple solution to this problem: I will explore (and argue for) the idea that the realizer of agency experiences can be conceptualized as the *temporally extended process* of decreasing prediction error. We might call such an account “dynamic” as opposed to “static”: traditionally, the comparator model is set up as a static account, suggesting agency experiences are based on the state the comparator is in at a certain point in time—specifically when it detects a match between predicted and actual feedback. A dynamic account, however, holds that the state of the comparator will not tell us whether an agent experiences a sense of agency. The account I propose contends that we need to pay attention to how prediction error *changes over time*.

To construe the sense of agency in terms of temporally extensive dynamics has the advantage that we can accommodate both, the role of successful and unsuccessful prediction. That is, unsuccessful prediction might not undermine the sense of agency, for the process of reducing prediction error simply requires prediction error.

In other words, if a feeling of agency is to emerge, it is necessary for an action to unfold adaptively and for the prediction of its sensory effects to change over time in such a way that the prediction error continuously decreases. We could therefore describe the temporal profile of agency experience as “proportionate waxing and waning” (Gerrans 2014, p. 182), which allows for the continuous presence and reduction of prediction error.

1.2 Experiences of Efficacy and Effort

My account also has another major advantage over the orthodox comparator model. It can explain why we often talk about the sense of agency in an equivocal way: sometimes we talk about it as if it were an awareness of (successful) predictions, but sometimes we talk about it as if it were (or at least involves) a sense of effort or difficulty. Along these lines, I shall call these different ways of characterizing the experience of agency (1) the sense of efficacy and (2) the sense of effort.

The sense of efficacy can be described as the *perceptual awareness* of one’s action unfolding as predicted. Usually, proponents of the comparator model define the sense of agency this way (e.g. Synofzik et al. 2009; Bayne 2011; Frith et al. 2000). They hold that the sense of agency is an awareness of successful, effective prediction—they consider it an experience of efficacy.

In contrast, some proponents of the comparator model opt for a different approach, identifying the sense of agency with the experience of *effort* (e.g. Gerrans 2014; Clark 2016). The experience of effort roughly refers to the sense of difficulty of a bodily action, and as Preston and Wegner (2009) point out, it must not be confused with the bodily feeling of muscular force or the experience of heaviness. Rather, it refers to the feeling one has when attempting, for example, to play a difficult tune on the guitar: it is the feeling that one’s fingers do not obey perfectly and fail to hit the strings at the exact

place intended or in the right timing. As opposed to the sense of efficacy, the sense of effort is not a perceptual awareness but often defined as a bodily feeling or the immediate phenomenal character of an action's difficulty. For the current discussion, it is most important that those proponents of the comparator model who identify agency with effort, explain the sense of effort in terms of *prediction error*. In other words, the sense of effort is strong when an action is precarious, difficult or relatively unpredictable, requiring a constant management of prediction error—and this is exactly when the sense of agency is strong.

1.3 Are Efficacy and Effort Compatible?

The problem I will discuss looks like this: None of the theories just presented can explain why one could have a feeling of agency over highly predictable actions but also over precarious and uncertain actions: it can only be strong in one of the two cases. In that sense, they force us to choose between identifying the sense of agency with either effort or efficacy, but not both.

What I propose instead is a comparator account that can explain why the sense of agency can be strong in both cases. To explain the sense of agency as a temporally extended process has the advantage that we can accommodate both, the role of successful and unsuccessful prediction. On such an account, the sense of agency is not determined by either accurate predictions or prediction error, but by how effectively prediction error can be reduced *over time*. It would allow the sense of agency to depend neither on the strength of effort nor the strength of efficacy.

In what follows, I shall make a case for the thesis just presented. But before doing so, let me outline the structure of this article. I will begin with a section on the sense of effort as the concept has many connotations I want to avoid—and so as to further clarify the phenomenology of effort.

In the second section, I will discuss the possibility that there are distinct, mutually exclusive experiences of agency, where one involves effort and the other effortlessness (Pacherie 2007). For that purpose, I will focus on the “sense of control” as a (necessary but insufficient) key component of the sense of agency. The reason for my focusing on the sense of control is that it is the source of the putative paradox that the sense of agency involves both successful and unsuccessful prediction, or effort and efficacy. In other words, there are two ways in which we can feel in control of a bodily action. One can feel that one *is* in control, or that one has to *exert* control (ibid.). Control can thus involve effort under precarious circumstances, but one can also feel in control over one's action if it proceeds as anticipated. Even though one can distinguish between experiences of effortful control and effortless control, I will suggest that both are necessary for a fully-fledged sense of control (and agency).

I will then turn to a discussion of some empirical findings that support my thesis. In particular, I am going to discuss cases of paralysis and deafferentation (Jeannerod 2006), suggesting that one can experience a sense of effort without a sense of efficacy. Experiences of effortless flow (Nahmias 2005), on the other hand, suggest that one can have a sense of efficacy without a sense of effort.

Finally, I will turn to some phenomenological studies of schizophrenia, which might be considered as possible cases of a dissociation of the sense of effort and efficacy.

Moreover, passivity experiences in schizophrenia might be explainable in terms of a disrupted temporal dynamics (rather than a patent lack) of the sense of control.

2 Sense of Effort: The Experience of Difficulty

I defined the sense of effort as the *phenomenal character* of difficulty. It must not be confused with the bodily feeling of muscular force or the experience of heaviness (Preston and Wegner 2009) and therefore is most conspicuous when one performs a movement that requires a minimum of muscular force, but that is nonetheless difficult to steer. A simple example would be the attempt to play an instrument, which, in some cases, does not require a lot of force, but can still be experienced as effortful and difficult.

As the terminology suggests, an action's difficulty challenges its success and one might experience a sense of difficulty over unsuccessful actions too. One may have a sense of effort or difficulty even if one fails to carry out an action or is simply not aware of one's success. And indeed, the experience of effort is thus most conspicuous when we fail to act or when re-afferent feedback is unavailable. This is illustrated by cases of paralysis and deafferentation (Jeannerod 2006, p. 55–58). Both, paralyzed and deafferented subjects reported that they are aware of a “sense of effort” regarding an attempted movement, while the actual movement did not occur or was not experienced due to deafferentation. Once again, this shows that the feeling of effort does not correspond to purely physical effort, as subjects with paralyzed limbs report them in the absence of physical movement.

2.1 Different Notions of Effort

There are several other notions of effort that are superficially similar to the one I use here. It is especially important to distinguish the experience of effort as the bodily feeling of difficulty from what Shepherd (2016, 2017) calls the “feeling of trying”. He defines it as the “effort towards the satisfaction of an intention” or the “phenomenal character as of directing effort” (2016, p. 419–420) towards a movement. The important difference between the sense of trying and what I call the sense of effort is that the experience of trying simply refers to the phenomenology of *directing* effort. Shepherd argues that such a sense of directing effort toward a movement of a limb can be experienced even when the limb itself cannot be felt. The feeling of trying is simply the phenomenology of directing effort towards the satisfaction of a goal regardless of sensory feedback. Some studies in exercise physiology arrive at a similar idea, claiming that the experience of effort can be understood as the correlate of the efferent, central motor command initiating a movement (de Morree et al. 2012; Marcora 2009).

However, the sense of effort I have in mind is something different. It is not an experience of trying or *directing* effort. That is not to deny that there are experiences of trying. But if they exist, they are not what I mean by “sense of effort”. I understand the sense of effort as an experience of resistance and difficulty that increases the more an action deviates from its goal. It is the bodily feeling that ensues when one's action faces internal or external perturbations.

2.2 Effort in Bodily and Mental Action

As I defined the sense of effort as the experience of difficulty, the question arises as to whether it is somehow related to experiences of mental effort. Most interestingly, some accounts of mental action conclude that the phenomenology of mental effort is representative of a task's difficulty (Kurzban et al. 2013; Bijleveld 2018). Do I have something similar in mind when I discuss the sense of effort over bodily action? Indeed, Preston and Wegner (2009) make no distinction between the sense of effort over bodily and mental action. For them, the feeling of effort is an experience of "cognitive difficulty" in both physical and mental action. I am inclined to endorse such a view. Yet, there are two major objections against considering the bodily sense of effort and mental effort as synonymous. First, any account of the phenomenology of bodily action that claims to extend its reach to mental action will bear the burden of proof that this can be done in the first place. The constraints of bodily and mental action are vastly different and cannot be put aside without further ado. This is also why the comparator model of agency is usually only applied to bodily movement and not to mental action (Frith 2012; Frith et al. 2000; Gallagher 2004, 2000). Hence, as I intend to examine the possibility that the experience of effort can be explained by a comparator model, it seems to be a necessary matter of caution not to extend such an account to mental action without further explanation.

Preston and Wegner provide a very useful *phenomenological* characterization of effort, which I subscribe to. However, to explain effort by the comparator model will limit the scope of such an explanation to bodily movement. My focus will therefore exclude the discussion of mental effort, even though its phenomenology might cut across the boundaries of physical and mental action.

3 The Sense of Agency: the Experience Effort and Effortlessness

For the most part, proponents of the comparator model characterize agency experiences in terms of the awareness of accurate prediction. It is less common to define the sense of agency as a feeling of effort. Yet, there are also accounts on offer that try to integrate these two ways of conceptualizing agency.

Such accounts usually emphasize that the sense of agency is multifaceted and that it features distinguishable aspects (e.g. Gallagher 2012). A particularly nuanced conceptual analysis of the phenomenological components of agency (the most careful I know of) can be found in Pacherie's framework of the "phenomenology of action" (Pacherie 2008, 2007). It deserves our attention for the current discussion as it can be seen as an attempt to integrate both experiences of effort and efficacy into a unified account of agency. However, as we will see, Pacherie's ultimate conclusion is that there are *distinct* experiences of agency, which are mutually exclusive.

To begin with, Pacherie claims the sense of agency is composed of the sense of initiation, the sense of intentional causation, intentional binding, and the sense of control. For our current purpose, it is worthwhile to look at the experience of control in more detail. For the way we talk about feeling in control of a movement reveals an ambiguity between the feeling of *exerting* control, as opposed to the feeling of *being* in control, or so Pacherie (2007) argued.

3.1 Ambiguity in the Sense of Control

Let me first defuse a worry. Given that we are trying to understand the sense of agency, why does the experience of control deserve our attention? Pacherie argued that we simply lack a sense of agency if we also lack the experience that we *control* our bodily movements and thus feel like our movements happen “by themselves” or are controlled by an external force. As stated in the previous section, Pacherie does not suggest that the sense of control is all there is to the sense of agency, yet that it is an important, necessary component. For what follows, I merely assume that the sense of control is a crucial phenomenological aspect of agency experiences.

Pacherie’s discussion of control is helpful as it shows that the way we talk about control and agency involves an ambiguity; specifically, the ambiguity that the sense of agency implies both, predictive certainty and uncertainty: The sense of control (and thus the sense of agency it contributes to) can involve experiences of smooth effortless control (under conditions of high predictability), but it can also involve experiences of effortful, attentionally focused control (under conditions of low predictability). Moreover, one can have the former without the latter, and vice versa:

[The] sense of control for an action can refer to two rather different kinds of experience. On the one hand, it may refer to the extent to which *one feels in control* of an action, where at one extreme everything happens exactly as expected and the agent feels in full control of his action and at the other everything goes astray and the agent feels completely powerless. On the other hand, by sense of control we may refer to the sense that *one has to exert control* to generate and maintain an appropriate action program despite perturbing factors. Normally control in this latter sense is felt as effortful: the more one has to exert control to attain one’s goal, the more effortful the action feels. (ibid., p. 18)

Again, Pacherie notes that we should not reject one of these notions in favor of the other and that they make different contributions to the sense of agency. Nonetheless, Pacherie takes the experience of *being in control* as opposed to *exerting control* as two distinct experiences. They are distinct because there is no need to exert control when one is already in control and vice versa. The difference is one of *having* to attain control versus *not* having to do it, as one is already in control. Moreover, if the sense of control is part of the sense of agency, then this distinction carries over to how we understand the sense of agency too. That is, one might feel that one is the author of one’s action by *exerting* control and one might feel as the author of one’s action while one is already in control. Most importantly, one cannot have both experiences at the same time.

I think that a lengthy discussion of Pacherie’s account is not in order here, even if her account might seem controversial to the reader. It suffices that it raises an important issue: it is one thing to say that the sense of agency consists of different components that *synchronously contribute* to the experience of agency. But it is another thing to suggest that there are different maybe mutually exclusive experiences of agency. That is, one could have an experience of agency of type A or an experience of agency of type B, where A and B are mutually exclusive: One might (A) have a sense of agency because perturbing factors require the effort to keep one’s movement on the right track,

but one might (B) also have a sense of agency because one's movement proceeds effortlessly, that is, exactly as anticipated and *because* there are *no* perturbing factors.

The distinction between the experience of effortless and effortful control predates my distinction between effort and efficacy. The similarity between these distinctions is obvious: I too define effort as the feeling of having to overcome unpredictable perturbations and efficacy as the feeling that movements unfold as anticipated. However, in the following sections, I will contend that the sense of agency requires *both*, effort and efficacy. This partly explains my terminological decision to not use the term *effortlessness* and *effort*, as this suggests mutual exclusivity. Yet, mutual exclusivity still seems to be implied by the very definition of effort and efficacy. In the subsequent sections, I will show that rather than being mutually exclusive, they are antagonistic and that their antagonistic interplay is exactly what is required for a full-blown sense of agency. In the following section, I present an alternative account, suggesting that effort and efficacy are attuned to a temporal profile that serves as a basis for the sense of control and agency.

4 Effort and Efficacy in Cognitive Science

The starting point of my discussion is Gerrans' account of delusions of control (2014). Unlike Pacherie, Gerrans argues that the sense of agency *necessarily* involves an experience of effort. However, he suggests that the sense of effort might even be tantamount to the sense of agency—a take that I will reject in favor of the weaker notion that effort is a necessary but insufficient aspect of the sense of agency.

To begin with, Gerrans (2014) argues that neuropsychological findings concerning the sense of agency are seemingly inconsistent. In particular, it is not clear why heightened activity in the right inferior parietal cortex is associated with a *lacking* sense of agency in delusions of control, while it is associated with a sense of agency in cases of paralysis, deafferentation, and imagined bodily action. Gerrans' attempt to dissolve this *prima facie*-inconsistency arrives at the conclusion that the sense of agency involves both successful and unsuccessful anticipation. I shall spell out the details in what follows.

Delusions of control in schizophrenia are associated with high levels of activation in the right inferior parietal cortex (Blakemore et al. 2000a; Frith et al. 2000; Spence et al. 1997). Frith et al. suggested that the parietal cortex underpins the “awareness of the current and future states of the motor system” (2000, p. 1785). More specifically, right IPL activity is usually attenuated when predicted sensory feedback matches actual sensory feedback. Subjects with delusions of control, however, lack the awareness of the predicted limb position due to a disruption of “forward modeling”; i.e. the prediction of self-produced sensory feedback based on the efference copy of motor commands. If there is no match between prediction and reafferent sensory feedback then, activity in the right IPL is not attenuated. As a consequence, the experience of agency is disrupted.

However, one can also be aware of one's action as self-produced in the absence of sensory feedback, as can be demonstrated by cases of paralysis, deafferentation, and imagined action, all three being instances of what Jeannerod calls extended *covert action* (2006). For instance, Jeannerod describes paralyzed

and deafferented patients who experience a sense of *effort* for actions or attempted actions, respectively. They are aware of the effort even though these actions do not produce any reafferent feedback, either because no afferent information is available or because no action is executed. Gerrans takes this as evidence that these subjects can experience a sense of agency in the absence of reafferent feedback. He further substantiates this claim, noting that subjects report a sense of agency for imagined action (Decety and Lindgren 1991; Jeannerod and Frak 1999).

It might come as a surprise then, that “[i]maging studies show that this awareness of covert processes is associated with activation in the right inferior parietal cortex” (Gerrans 2014, p. 177). It is specifically surprising because delusions of control (and hence the lacking sense of agency) are also associated with higher levels of right IPL activity, which—in non-pathological cases—would be attenuated by successfully predicted sensory feedback. Due to a disruption of such predictions, IPL activity will stay high. While this might be surprising at first, there is also a plausible explanation for IPL activation in the case of paralysis and imagined action: action-effects are *not* successfully predicted too. They are simply not available since no action will be *executed* in the first place, leading to increased activity in the right IPL. Hence, in both cases, in delusions of control, on the one hand, and paralysis and deafferentation, on the other hand, no reafferent feedback is available to attenuate IPL activity. Right IPL activation can thus be explained in the following way:

In these cases [i.e. paralysis and imagined action], motor output is suppressed and there is no sensory reafference. As Jeannerod would put it, the action is entirely covert. Yet there is a sense of agency. Jeannerod describes awareness of agency in cases such as this as becoming conscious of covert actions, which are normally inaccessible to consciousness, as a result of sustaining activation in circuitry that normally decays almost instantaneously. The important point is that these cases dramatize the fact that covert activation decays when transformed into overt because overt action produces reafferent sensory feedback that cancels covert activity. (Gerrans 2014, p. 177-178)

In short, Gerrans treats the cases of paralysis and imagined action as overextended covert action (caused by the absence of reafferent feedback). It is a prolongation of covert action that yields an “awareness of agency” *in the absence* of sensory feedback. But disregarding this speculation, do these cases really involve a full-fledged sense of agency?

To describe the awareness of action in deafferentation and paralysis, Jeannerod does not use the term agency, but “effort”, leading Gerrans to use these terms synonymously—but how can we be using them synonymously? Or how can we be treating them synonymously if heightened right IPL activity is a marker for a lack of a sense of agency in delusions of control, but a marker of its presence in the “Jeannerod cases”? Gerrans recognizes this conundrum:

How can high levels of IPL activity be associated with a sense of agency in the Jeannerod cases (as I shall call them) and with loss of the sense of agency in schizophrenia? I think that the reason is the context in which that activity arises. The sense of agency is produced by the attempt to control movement, which, in effect, is the attempt to reduce the prediction error signaled by activity in the IPL. Thus, when a movement is initiated, activity in the IPL is initially attenuated (the “prediction”). If the movement is unsuccessful, preattenuated activity rises driving further attempts to reduce it by adjusting the movement. It is this *process of reduction of prediction error* that produces the sense of agency. (ibid., p. 181, emphasis mine)

The main claim of the current article is exactly this; the sense of agency is contingent on the *process of reducing prediction error*.

But again, Gerrans still insists on his claim that the sense of agency also arises in the “Jeannerod-cases” (i.e. covert action). However, this is exactly where the distinction between the sense of effort and the sense of efficacy would come in handy. The Jeannerod-cases are best described as cases of an *isolated sense of effort, and a lacking sense of efficacy*. There is no reason to suppose that “covert actions are [...] accompanied by a *sense of effort or agency*” (ibid., p. 182, emphasis mine). They are accompanied by a sense of effort, but not a sense of agency. A simple argument can be made in favor of this distinction: In the case of covert action (i.e. paralysis and deafferentation), reafferent feedback cannot be used for the reduction of prediction error. The sense of agency, however, involves the process of reducing prediction error via reafferent feedback. Thus, covert action cannot involve a sense of agency. Yet, deafferented and paralyzed subjects report a sense of effort when they move or attempt to move. Following this, the sense of effort does not seem to be sufficient for the sense of agency.

However, considering this, a second question remains to be answered. Should we also reject the idea that a sense of effort is necessary for a sense of agency (and therefore for the sense of control)? *Can we experience a sense of agency without the sense of effort?*

If the answer is yes, then the sense of efficacy will collapse into the sense of agency. However, there is evidence that suggests that the answer is negative. Studies on “flow-experiences” or the experience of effortless control can be considered as indirect evidence that the sense of efficacy is not sufficient for the sense of agency.

4.1 The Sense of Agency and Effortless Flow

Our intuitive assumption might be that effortless action yields a strong sense of agency. However, in contrast, Nahmias suggests that “actions that require an exercise of ‘willpower’ or concentration may be accompanied by a greater sense of personal agency than skilled actions performed more effortlessly” (2005, p. 774). If we take this to be true, we might wonder whether flow-experiences can weaken the sense of agency, rather than strengthening it. In what follows, however, I will show that there are two different kinds of flow experience: (1) the experience of flow and (2) the experience of *effortless* flow. While the former is accompanied by the feeling of effort or difficulty, the latter

is characterized by a lack of difficulty. Experiences of effortless flow, I will argue, do not elicit a sense of agency.

As of today, there is at least some empirical evidence that supports Nahmias' prediction that the sense of agency can be dissociated from effortless flow-experiences. Vuorre and Metcalfe (2016) have tested subjects in a computer game setting introduced by Kennedy et al. (2014) to induce experiences of flow in various strengths. Specifically, subjects had to play a game in which a cursor was supposed to touch, and thereby cancel out randomly distributed Xs and Os that were scrolled down the screen. Experiences of effortless flow can thus be manipulated by the movement speed of Xs and Os. Thereby, judgments (of the strength) of flow increased as a function of speed.

Vuorre and Metcalfe used the same paradigm to inquire whether subjects experience a stronger sense of agency during flow-experiences, initially expecting that they will be positively correlated. They suggest that the "smoothness that sometimes accompanies and is a cue for the positive sense of agency—where the person's intentions play out without apparent opposition from the outside—is highly reminiscent of the reports that people give when they are experiencing a state of effortless flow" (Vuorre and Metcalfe 2016, p. 134). However, the initial idea proves false. As opposed to judgments of flow, the subjects report that the sense of agency was *decreasing* as a function of movement speed. Thus, the authors conclude that they have found a "robust dissociation" (p. 140) between the sense of agency and the experience of flow.

It is certainly too early to tell whether experiences of flow decrease the sense of agency since the study in question runs the risk of misrepresenting the phenomenon of "flow". To explain: experiences of flow are associated with highly skilled action, but the feeling of flow does not only involve skillful mastery but also a high level of task difficulty that necessitates a certain level of attentional control. Experiences of flow occur, one might say, when a specific balance between attentional control and skillful habit is maintained (Nakamura and Csikszentmihalyi 2002). A task that is too easy or too difficult to carry out will not elicit experiences of flow. Vuorre's and Metcalfe's experiment does not yield any clear results as to whether such a balance could be elicited in the subjects. Moreover, Nahmias' speculation does not concern flow experiences in this specifically "balanced" sense, but experiences of *effortless* flow, which are associated with action that requires a low level of attentional control and allows for a high degree of automaticity. Yet, this would also explain why Vuorre's and Metcalfe's experiment arrives at the counterintuitive conclusion that experiences of flow disrupt the sense of agency. Their experiment misrepresents experiences of *effortless flow* (i.e. a *sense of efficacy*) as proper flow-experiences, which usually come with a sense of agency.

4.2 Unconscious and Conscious Motor Control

What conclusion can we draw from this? The experiment above might not be taken to show that the sense of agency is *lacking* in experiences of effortless flow. At the same time, the experience of effortless flow should also not be understood as an instance of an isolated experience of efficacy. It suffices to say that (1) experiences of flow can be accompanied by a strong sense of agency, while (2) experiences of *effortless* flow might be accompanied by a diminished sense of agency. That is, the experiment might only suggest that high degrees of efficacy can *diminish* the sense of agency. Such a

finding would be enough to confirm Nahmias' speculation that effortless control weakens the sense of agency.

This should not come as a surprise since experiences of effortless flow involve a high degree of automatic control. We might feel detached from such actions for there is no need to consciously steer them, or only to a minimal degree. In other words, the sense of agency could be weakened if automatic control can take over. This is indeed what Gerrans claims:

The "sense of agency" for actions arises at the border between controlled and automatic processing. Automata do not have a sense of agency and, in so far as we are automata, neither do we. The sense of agency arises in the process of transferring control of action from automatic to controlled processing. Equally, when the control of action is successfully delegated to automatic systems, the sense of agency disappears. (Gerrans 2014, p. 168)

Following this, the experience of agency and control depends on the insufficiency of nonconscious automatic control, suggesting that the sense of agency only arises when subpersonal action monitoring cannot dissolve prediction error. Hence, if prediction error cannot be resolved on the subpersonal level of motor control, then we become aware of the unsuccessful prediction of sensory action-effects. This was tested in an influential experiment by Fourmeret and Jeannerod (1998), showing that sensorimotor control can proceed without conscious awareness: in said experiment, subjects had to manually trace a line on a tablet screen, while their hands were occluded by a mirror. The mirror was used to project the line via another screen placed above the mirror, thus representing the subject's movement. The experimenters then introduced biases, shifting the lines on the mirror in different angles. Small biases were corrected without subjects being aware of these corrections while biases that exceeded a mean angle of 14° led subjects to change their strategy and to consciously monitor their corrections. That is, if there is a discrepancy between predicted and actual sensory feedback during movement, then the degree of the discrepancy determines as to whether subjects become aware of it.

Moreover, according, to Gerrans (2014), the transition from non-conscious to conscious registration of discrepancies coincides with the emergence of the sense of agency (see also Pacherie 2008). Hence, if the sense of agency only arises when there is a discrepancy between predicted and actual reafferent feedback, then it necessarily involves an awareness of such discrepancies. Again, we come to the conclusion that the sense of agency involves both, an awareness of prediction error and an awareness of successful prediction. The crucial upshot of this section is that this can be explained in terms of the interplay of successful and unsuccessful prediction resulting from the *process of reducing* prediction error.

Furthermore, prediction error and successful prediction underpin the experience of effort and efficacy, respectively. The difference between effort and efficacy, however, only becomes apparent, if prediction error cannot be reduced, such as in cases of deafferentation (and possibly delusions of control) or when prediction error is sufficiently low to evade conscious awareness, such as in cases of effortless flow. This takes us to another important issue. How do efficacy and effort play together when I, say,

move my arm in order to grab my cup of tea? Do I experience them both at the same time or are there temporal differences in how these experiences unfold?

4.3 Temporal Dynamics of Agency

At the beginning of this paper, I emphasized the temporal dimension of agency, claiming that one can only have a sense of agency over a temporally extensive process. My point is simple: the temporally extensive process of error cancelation is necessary for a sense of agency. In contrast (and *ceteris paribus*) the comparator's state registering a match between predicted and actual feedback will not suffice.

While this might be a straight-forward proposal, one might wonder what this means for an action and its temporal dynamic.

To illustrate, imagine that someone will constantly perturb the predicted trajectory of my movement (for example, by poking my limb) thereby continually inducing (and thus increasing) prediction error. If I do not constantly compensate for this perturbation, my movement will feel as if it is not guided by myself, but by an external force (in that case, the perturbing force). However, if prediction error is continually compensated for, I will maintain a sense of agency over said movement. For the sake of illustration, one could discern different phases of perturbation, leading to discernable prediction errors: In phase 1, the first perturbation occurs, leading to prediction error 1. As a response, the movement trajectory will be adjusted leading to a decrease of prediction error, but in phase 2, my movement will be perturbed once again, leading to prediction error 2 and its subsequent cancelation. The process repeats until the action is concluded. My point is that the sense of agency is based on this *waxing and waning*. Of course, my example simplifies things too much. Unlike in my example, perturbations are often subtly distributed over a temporal continuum and cannot be separated into temporal slices as my example suggests. Hence, if perturbation and its compensation happen continuously, a simultaneous increase and decrease of prediction error will be possible.

One might contend that this is overly speculative. Yet, one can still appeal to the idea's conceptual plausibility. Again, consider an action, in which error-cancelation is achieved by the adaptation of movement; performing the task of drawing a straight line. One constantly sheers off a little and then corrects for the deviation. Every time one sheers off, the predicted course of action is not met, resulting in prediction error. The prediction error is eventually attenuated, specifically, by further adapting one's movement so as to stay on course. Once the action is concluded, we can consider the predictive success over time. It turns out that in sum, all discrepancies were well compensated for. The line will be a straight line, as intended, but not *perfectly* straight. More or less subtle, yet compensated deviations are evenly distributed all over the line.

Now, imagine drawing a straight line without being able to compensate for the error. If one fails to (sufficiently) compensate for prediction error, then the discrepancies between the predicted movement trajectory and the actual trajectory would become increasingly bigger, thwarting the action's overall success. If prediction error is not continuously decreased, then discrepancies between predicted and actual sensory effects of movement will increase, since the longer the movement proceeds on an unexpected path, the more likely will it deviate from its goal. It might be compatible with my proposal that *increasing* prediction error does *not disrupt* the sense of agency, but the example I just provided suggests that such an increase must be compensated for

sooner or later. Otherwise, I will be aware of a movement that does not correspond to what I intended—and it is hard to see how one could retain a sense of agency over such movements.

But does that mean that the experience of agency can be *homogenous* over time? If a movement is accompanied by a constant level of prediction error (e.g. due to constant perturbation), while the error is also continually compensated for, does that mean that efficacy and effort remain constant too?

My proposal is consistent with this possibility. However, we might have reason to believe that the sense of effort and efficacy are not evenly distributed over the course of an action. First, the Jeannerod-cases (2006) suggest that during attempted movement or covert action, right IPL activity might represent an initial discrepancy between the goal state and the current state of the motor system. IPL activity increases precisely as a result of a continued mismatch between predicted and actual feedback. Brown et al. (2013) follow a similar rationale, suggesting that the initiation of action will be accompanied by prediction error, as the desired goal and ensuing predictions do not yet correspond to the actual state. There are two options available for reducing the error signal in such cases: by aborting the desired action, or by acting. Hence, if a movement starts off, prediction error will decrease because the predicted state will be attained in the course of action. Considering this is true, the initiation of action might be accompanied by a sense of effort due to initial prediction error, which is then gradually overcome in the course of action.

Yet, first, it is one thing to say that no afferent signal is emitted from a limb and entirely another thing to say that this prevents the comparison of predicted and actual feedback. Secondly, there is an advantage of construing effort as being based on afferent feedback: the sense of effort might be correlated with the physiology of movement initiation and motor preparation *because of the initial discrepancy between predicted and yet-to-come actual feedback*.

What does all this mean for the sense of effort and efficacy? As the former is based on prediction error and the latter on successful prediction, they can be characterized as antagonistic. However, they can, and indeed, might have to occur simultaneously in order to give rise to a fully-fledged experience of agency. And even though the sense of effort might be more pronounced during the initiation of action (Jeannerod 2006), it can accompany prediction error throughout the course of movement.

4.4 Effort and Efficacy—Bodily Sensation or Perceptual Representation?

I argued that the sense of efficacy usually occurs in tandem with the sense of effort. Yet, while the sense of effort is defined as the *phenomenal character* of difficulty, it is important not to define the sense of efficacy in terms of a non-intentional phenomenal feeling or bodily sensation of efficacy.

We have seen that we are not aware of small discrepancies between the predicted and actual motor trajectory. This might raise a problem for my account. One might say that such discrepancies are what I mean by the sense of effort and that the sense of effort is thus the only *positive* aspect of agentive phenomenology. If an action proceeds as anticipated, one might only witness one's action *perceptually* and observe that it unfolds as predicted. Hence, while prediction error might contribute to the first-hand phenomenal character of effort, the experience of successfully predicted action is based on perceptual awareness.

Indeed, Grünbaum argues that one can have an account of agentic phenomenology without postulating a “feeling of agency” (2015) and that the evidence for the comparator model does not support the existence of an agency-qualia. He claims that agentic awareness involves “conscious intentions, conscious anticipations, awareness of what one is trying to do, and various bodily and perceptual experiences” (2015, p. 3334), but not the phenomenal feeling of agency.

My account at least partly overlaps with Grünbaum’s (2015) as it does not postulate the existence of an agency-qualia: Remember that what I call sense of efficacy is called sense of agency by the orthodox comparator model and while the latter sometimes conceptualizes efficacy as phenomenal feeling, I explicitly defined it as perceptual awareness. That is to say, both, Grünbaum’s and my account deny that there is a “phenomenal feeling” of efficacy.

However, I also hold that the sense of agency involves *some* phenomenal quality or non-intentional phenomenal character. I claim that there can only be a fully-fledged sense of agency if the phenomenal feeling of effort accompanies the awareness of efficacy.

Considering this, there remains a worry; one might contend that my account is not parsimonious. If we are indeed interested in the *phenomenal character or the phenomenal feeling* of agency as opposed to the perception of action, why not just focus on the sense of effort then? We might end up with a negative account, stating that only a diminishment of agency is accompanied by agentic bodily feelings: the more accurate an action, the more impoverished the non-intentional, phenomenal feeling of agency.

My answer to this is simple. On the one hand, this is exactly where my account ends up. Yet, on the other hand, I disagree with the framing and specifically the focus on effort. The perceptual awareness that my action unfolds as anticipated is as crucial to the experience of agency as the bodily feeling of effort. If the focus on either of them would do any good, cases of dissociation would help us identify the sense of agency with either effort or efficacy. In the following section, however, I will show that cases of isolated efficacy and effort are both cases of a lacking sense of agency. For that purpose, I will revisit my account from a phenomenological perspective, suggesting that schizophrenic passivity experience could be explained in terms of a dissociation of the sense of effort and efficacy.

5 Phenomenological Accounts of Schizophrenia

5.1 Disrupted Anticipation in Schizophrenic Self-Disorders

Delusions of control are often associated with schizophrenia. Therefore, cases of schizophrenia can serve as case studies to investigate the disruption of agency experience in delusions of control. The standard comparator model of delusions of control in schizophrenia holds that subjects are not aware of the predicted position of their limbs (Frith et al. 2000). This is explained in terms of lacking sensory attenuation (Blakemore et al. 2002, 1998). Normally, the sensory effects of self-produced actions are attenuated and “classified as self-produced” (Blakemore et al. 2002, p. 240). More recent approaches, falling under the label of “predictive processing” or “integral forward modeling” even increase their emphasis on prediction (Clark 2016; Fletcher and Frith 2009; Pickering and Clark 2014).

That being said, these accounts of schizophrenic delusions of control cohere well with how phenomenologically informed psychiatrists and psychologists have conceived the disorder (Sass and Byrom 2015).

A more recent phenomenological account suggests that the disruption of the sense of agency in schizophrenia occurs due to two complementary phenomena: (1) *reflective hyperreflexivity* and (2) *diminished self-affection* (Parnas and Sass 2011; Sass and Parnas 2003). Hyperreflexivity refers to a state of exaggerated attention that is directed to previously tacit domains of one's subjective life. For instance, having an awareness as of a tree entails the implicit self-presence of one's awareness. In contrast, one could also direct one's awareness toward itself, hence, making one's awareness an object of reflection (rather than the tree). While the tacit dimension of one's subjectivity coincides with the self-presence of conscious awareness, by becoming an object of awareness itself, these tacit features lose their pre-reflective character. The implicit self-presence of a subject's awareness involves what Sass and Parnas (Sass and Parnas 2003) call "self-affection"—where "affection" denotes the implicit, pre-reflective directedness of awareness toward itself, similar to a flame continuously illuminating itself. The diminishment of self-affection occurs complementarily to reflecting on the formerly tacit self-presence of conscious awareness.

This idea, again, coheres well with the neuropsychological account that the sensory effects of self-produced actions are attenuated and thereby experienced as self-produced (Blakemore et al. 2002, p. 240). The awareness of agency is normally a recessive experience and if one's self-produced movements become too salient in experience, they are felt as "external".

5.2 Disrupted Awareness of Action

Phenomenological studies further suggest that this leads to a disruption of action monitoring. For instance, Sass (2004) shows that patients' experiences of *usually predictable, non-surprising* events appear to them as highly unusual and alienating. For instance, an ashtray—usually a non-exciting, ordinary object to be confronted with—can be experienced as a highly unusual and overly salient thing. For the patient, it appears as being disposed to be explored *ad infinitum*, notably without gaining insight into the object's nature, but rather obscuring it. Crucially, the heightened salience of otherwise predictable circumstances is also expressed in the subjects' movements. Take for instance a case-study by Wolfgang Blankenburg (2012): patient A. describes the sheer difficulty of engaging in the most habitual of actions, like using a salt shaker. Objects and states of affairs that one otherwise encounters in reliable regularity become objects of disconcertment. Patient A. is only able to use a salt shaker in an overly time-consuming procedure, under utmost concentration, while having the feeling that she has lost the grip on the practical meaning of her action entirely.

Drawing on the discussion of the previous section, we might describe these experiences of hyperreflexive action in terms of an excessive sense of effort at the expense of a sense of efficacy. Note that this would be in line with findings that suggest that heightened right IPL activity in delusions of control is associated with an experience of effort. These findings suggest that the reafferent sensory feedback cannot be used for attenuating IPL activation leading to continued high levels of both IPL activity and experiences of effort. Further note that in my terminology, these cases can be explained

in terms of (1) a diminished sense of agency, (2) a diminished sense of efficacy, and (3) a strong sense of effort.

Yet, that is not to say that a diminishment of agency implies a disruption of the sense of efficacy in schizophrenia. This takes us to an oftentimes neglected phenomenological finding.

5.3 Hyperautomaticity

De Haan and Fuchs claim that schizophrenia does not only involve hyperreflexivity but also a phenomenon called *hyperautomaticity* (de Haan and Fuchs 2010). As opposed to the experience of hyperreflexivity, hyperautomaticity might not be accompanied by a lacking experience of efficacy. Still, subjects with schizophrenia suggest that experiences of hyperautomaticity are *not* accompanied by a sense of agency. Hence, the sense of efficacy might not be a self-standing experience of agency or control after all.

To explain: Hyperautomaticity is the precise opposite of hyperreflexivity. Being in a state of hyperautomaticity, the patient would go about his everyday-life habits without having to “consciously steer” them at all. Thereby, the patient feels withdrawn and detached from her body, seemingly witnessing it from the distance like a “ghost in the machine”. The mind does not seem to affect the body’s conduct, being reduced to the role of a passive observer. In the case of hyperautomaticity, we are facing an entirely different *explanandum* that does not involve disrupted anticipation but quite the opposite; the awareness of rigid and overly accurate prediction.

Again, my account suggests that in the first case (hyperautomaticity), the patient experiences a sense of efficacy for the successful instantiation of everyday-life conduct and habitual action. Even though the patient perceives her actions as perfectly predictable, she lacks a sense of agency for them. One might draw a parallel between hyperautomaticity and findings of studies on effortless flow-experiences since both suggest that highly predictable, close-to-automatic action diminishes the sense of agency. As noted in the previous sections, effortless control (such as in flow experiences) weakens the sense of agency rather than increasing it (Vuorre and Metcalfe 2016).

5.4 Are Hyperreflexivity, Hyperautomaticity, and “lack of modulation”

De Haan and Fuchs (2010) further suggest that hyperautomaticity and hyperreflexivity are not two isolable phenomena but that they are mutually dependent. They arise due to a dissociation of habitual, automatic conduct, on the one hand, and conscious steering, on the other, calling it a “lack of modulation”:

Normally, when we are immersed in some action or thought, we do not need to completely steer it, but neither are we like sleepwalkers who cannot consciously interfere at all. Even when immersed, we are still able to *adjust* to whatever slight changes present themselves. We naturally modulate our focus of attention. (de Haan and Fuchs 2010, p. 332)

This assessment reflects the one provided in this paper. Effortful, attentional steering never fully replaces the efficacy of automatic action and vice versa. They interact in

such a way as to create a seamless interplay between automatic and conscious control, which ultimately gives rise to the sense of agency. Again, the “sense of agency arises in the process of transferring control of action from automatic to controlled processing” (Gerrans 2014, p. 168) and this is what goes awry in schizophrenic delusions of control. Subjects with schizophrenia have no problems with the automatic control of action (Jeannerod et al. 2003; Danckert et al. 2004). Yet again, automatic, subpersonal control will not yield a sense of agency, but is, at best, accompanied by an experience of efficacy, which, in isolation, is nothing but an experience of the body’s automatic conduct.

We might be entitled to maintain the thesis that schizophrenia involves a lacking sense of agency, but we could be more specific about this claim. Just consider de Haan’s and Fuchs’ patient S.N.’s statement describing the experience of hyperautomaticity: “[w]hen I felt like shit after 4 hours of work, it was like runners with their ‘runners-high’: sometimes I really got into it, and I completely switched off, my mind was totally away from my body, and I just worked” (2010, p. 330). It will not do justice to such reports to merely consider them as a lack of agency. I suggest describing such cases of hyperautomaticity as exaggerated experiences of efficacy at the expense of experiences of effort. On the other hand, hyperreflexivity involves exaggerated experiences of effort at the expense of a sense of efficacy. Hyperreflexivity and hyperautomaticity thus seem to be mutually exclusive experiences. However, that is not to say that, normally, experiences of efficacy and effort are strictly mutually exclusive. Rather, they should be characterized in terms of their antagonistic, albeit seamless interplay. A strong sense of efficacy will be associated with a weak sense of effort and vice versa. Yet, neither efficacy nor effort must exhaustively prevail for the sense of agency to arise.

6 Concluding Remarks

I claimed that the sense of agency and (its constitutively necessary component) the sense of control are not only multifaceted experiences but should also be characterized in terms of their underlying, temporally extended process of prediction error-cancellation. This allows us to have a unified comparator model that can explain two antagonistic experiential components of the sense of agency: the sense of efficacy and the sense of effort.

What proponents of the comparator model usually refer to as “the sense of agency” is, on my account, called “the sense of efficacy”. The sense of efficacy, however, is not sufficient for a fully-fledged sense of agency. My attempt to put this to the proof was based on studies on effortless flow experiences and phenomenological accounts of schizophrenia. Experiences of effortless flow diminish the sense of agency; a finding that is also reflected in schizophrenic hyperautomaticity, which also exhibits the insufficiency of isolated experiences of highly predictable, automatic action.

The sense of effort is also not a novel term but, again, occasionally used as a synonym of “sense of agency” (Gerrans 2014; Clark 2016). However, cases of deafferentation and paralysis suggest that experiences of effort are not fully-fledged experiences of agency. This is consistent with the finding that both, (1) the disruption of agency-experiences in delusions of control and (2) experiences of effort in deafferented

subjects are associated with heightened right IPL activity; a marker for disrupted experiences of agency.

I shall conclude by addressing my account's scope and pending questions. First, the orthodox comparator model of agency claims to state necessary and sufficient conditions of agency experiences. Yet, as of today, empirical evidence indicates that the comparator model is insufficient to explain the experience of agency. Hence, if one were to model an artificial agent able of simulating a sense of agency, then further components must be involved over and above prediction and forward modeling (Zaadnoordijk et al. 2019). This line of criticism raises an important issue. Assuming my account has any credence, can it serve as a sufficient explanation of bodily agency experiences? In the present article, I made no such claims. I was concerned only with the necessary components of agency and how a comparator model can explain them in a unified way. That is not to say that such a model can explain all there is to the experience of agency.

Furthermore, while my account suggests a reconceptualization of already existing evidence, it raises new issues. For instance, it is unclear how the strength of the sense of agency is regulated according to my account. Candidates for an explanation might be the weight of prediction error (Clark 2016), but we might even speculate that the speed of error-cancellation plays a crucial role. The latter could explain the intuition that highly habitual action can be accompanied by a strong sense of agency since the awareness of error is less salient due to its rapid attenuation. How could we address these open questions empirically (and, of course, corroborate the answers I provide)? First, simulations of action such as in (Brown et al. 2013) are natural contenders to simulate the behavioral aspects of my proposal, while paradigms for manipulating refferent feedback (e.g. Fournieret and Jeannerod 1998) might provide a setup to empirically corroborate models from computational neuroscience.

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