What is (perception of) effort?

Objective and subjective effort during task performance

James Steele
Solent University

Abstract

Despite its apparent intuitiveness and widespread interest from across various fields, ‘effort’ is a variable that seems difficult to define. The purpose of this article is to consider and define ‘effort’ during task performance. In doing so I argue for a distinction between the actual effort (objective effort) required, and the perception of that effort (subjective effort), during intentional performance of tasks. I adopt a set theoretical approach to defining both actual effort and the perception of effort as both constructs and concepts. Further, I aim to present discussion and definitions that are agnostic of the specific task demands being performed (i.e. physical, cognitive, self-control, or a combination of task demands). Throughout, I attempt to draw upon and synthesise thoughts and ideas from across a multitude of disciplines (though note that this is not intended to be an exhaustive interdisciplinary review), engage in considerable armchair philosophising, and also offer what small insights I have from my own experience both as someone experiencing ‘effort’, and as a third-person observer investigating it. This work is intended to, at the very least, make my own current conceptualisation and understanding of ‘effort’ transparent to other researchers, and aid in the interpretation of any subsequent empirical work on the topic. Further, I hope that it might be of use to researchers from the various fields interested in this topic, and assist in fostering opportunities for integration of learnings across disciplines. It is my intention for this work to support further understanding of the role of ‘effort’ and its perception from a broad scientific perspective.

Introduction

“There is no greater impediment to the advancement of knowledge than the ambiguity of words”
(Thomas Reid, 1852. Essays on the Intellectual Powers of Man)

Effort, that eponymous term of task performance (physical, cognitive\(^1\), and self-control; Preston and Wegner, 2009; Massin, 2017), is a variable that seems difficult to define despite being seemingly intuitive to many. Its distinct phenomenology appears easily recognisable; the fact that we seem capable of perceiving when we ourselves are employing it, and identifying it when others do the same. Given everyone’s somewhat tacit understanding, in addition to its history (briefly reviewed below), you might be forgiven for thinking that there is consensus at least on the character of the variable (Richter and Wright, 2014; Massin, 2017). The origin of the term apparently comes from the old French portmanteau of the Latin ‘ex-’ meaning ‘out’, and ‘fortis’ meaning ‘strong’; esforcer (or esfor\(z\)). However, the Oxford\(^2\) (“A vigorous or determined attempt”) and Cambridge\(^3\) (“physical or mental activity needed to achieve something”) English dictionaries definitions of effort are somewhat vague, at least from a scientific perspective. Indeed, most scientific disciplines with interest in understanding it seem at a loss for an adequate definition.

Effort has been a source of interest to scientists and philosophers for some time. Indeed, wu wei (Chinese: 無為; pinyin: wú wéi), literally meaning “in the absence of/without doing exertion” or “effortless action”, was a concept that emerged from Confucianism and became an important aspect of Daoism (Slingerland, 2003): “Act without action; work without effort” (Laozi, Dao De Jing, Chapter 63, cited in Lee et al., 2009). In Ancient Greece the spirit Horme (Ancient Greek: Ὄρμη, pronounced Ormi) personified energetic activity, impulse or effort (to do a thing), and an altar was held to her in Athens (Pausanias, 1918). The concept of willed effort was central to much of the work of early French philosopher Maine de Biran (1805). An-

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\(^1\) Note, I use the term ‘cognitive’ in lieu of the term ‘mental’. As noted by Bruya & Tang (2018), most researchers agree upon the general reductionist desideratum that cognition has its origin in physiological processes in the nervous system and that the term ‘mental’ may be misconstrued as supporting a dualist conception of the body and mind.

\(^2\) https://www.lexico.com/definition/effort [accessed 2nd June 2020]

\(^3\) https://dictionary.cambridge.org/dictionary/english/effort [accessed 2nd June 2020]
other, Henri Bergson revived many concepts of Brāhmanian philosophy and psychology, in combination with aspects of Hellenistic thought; Hercules, the hero-god of the ancient Cynics and Stoics (Kotva, 2016). Indeed, there was a religiosity and mysticism in this such that Bergson thought “…effort is of God, if not God [H]imself” [my insertion] (Kotva, 2016). Around the end of the 19th century a considerable body of work was conducted regarding the notion of effort in both physical and cognitive tasks. Bastian (1887) coined the term ‘kinaesthesia’ which encompassed not only the sense of movement, position, and muscle force or tension, but also the ‘sense of effort’. Though, there was considerable debate (which continues to this day) regarding where the sensory signals came from for the feeling or perception of effort (i.e. it’s phenomenology); some argued for its central origin (e.g. Bain, 1855; Helmholtz, 1866; Müller, 1842, Wundt, 1902), while others supported a peripheral source (Bastian, 1896; James, 1880, 1890). Around a similar time, the French philosopher Guillaume Ferrero discussed the role of effort in regulating human behaviour (Ferrero, 1894) and John Dewey (1897) wrote on the psychology of effort. Both Ach (1910; 1935) and Hillgruber (1912) in the early 20th century considered the role of the ‘will’ to overcome performance barriers. Effort as a variable involved in work was discussed in the 1940s by Hull (1943) and reviewed two decades later by Lewis (1965). Further, in the 1950s, von Holst and Mittelstaedt (1950), and Sperry (1950), both independently proposed (in agreement with earlier thought), that signals relating to motor commands (efference copies) helped clarify whether sensory signals received from motor action where a result of volition or from external environmental forces (i.e. did I move my arm, or did someone else?). In 1973 Daniel Kahneman published his influential book Attention and Effort claiming that the two were in essence synonymous. Later, Brehm and Self (1989) formally described what is known as Motivational Intensity Theory; in brief, this suggested that how much effort someone is willing to put into achieving a given task is dependent upon what is termed their ‘potential motivation’. Regarding measurement, development of the first psychophysical scales for the perception of effort, relating to the perception of ‘heaviness’ of activity, occurred in the 1950s (Stevens, 1957). However, at least in relation to physical tasks, nowadays people are mostly familiar with the scales developed by Gunnar Borg from the 1960s onwards (Borg, 1998). It has been thought for some time that effort is inherently aversive; the “Principle of Least Effort” (Zipf, 1949). Yet others have discussed effort as being something of inherent value (Massin, 2017; Maharaj, 2017). A more balanced perspective argues that effort can be costly or valued dependent upon individual and contextual factors (Inzlicht et al., 2018).

General interest in effort, based upon usage of the term in books analysed using Google Ngram over the past ~200 years has increased (figure 1). Scientific interest in effort of all kinds (effort and the related term ‘exertion’, both physical and cognitive task efforts, and both objective/actual and subjective/perceived efforts) appeared to be most intense across the 19th century (figure 2).

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4 The misuse of lower case ‘h’ in referring to God in the original quote was pointed out to me by one of my PhD students, Emily Budzynski-Seymour, for which I am thankful.

5 They actually referred to perceived ‘exertion’ similarly to Borg – see later for a discussion of perceptions of ‘effort’ vs ‘exertion’, in addition to their distinction from ‘heaviness’
Figure 2. Number of articles using the words (top) ‘effort’ and ‘exertion’, (middle) ‘physical AND effort’ and ‘(cognitive OR mental) AND effort’, and (bottom) ‘(objective OR actual) AND effort’ and ‘(subjective OR perceived OR perception of) AND effort’ as a proportion of all articles in Europe PMC (using the “europepmc” package - https://cran.r-project.org/web/packages/europepmc/europepmc.pdf)
After the Second World War there was a decline in productivity, as with many other fields. However, in the past two decades there has been a resurgence and growth of interest. In recent years, effort has been studied across many fields including: philosophy, cognitive and social psychology, neuroscience, clinical symptom testing, economics, ergonomics, project management, translation and editing, speech, language and hearing, robotics and artificial intelligence, and kinesiology (e.g. Rosenbaum & Gregory, 2002; Parfitt and Hughes, 2009; Smirnau et al., 2013; Pageaux, 2014; Fisher and Steele, 2014; Bigler et al., 2014; de Morree and Marcora, 2015; Abbiss et al., 2015; Shepherd, 2016; Cha et al., 2015; Shadmehr et al., 2016; Pageaux, 2016; Steele et al., 2017; Cos et al., 2017; Morel et al., 2017; Shenav et al., 2017; Massin, 2017; Picou et al., 2017; St Clair Gibson et al., 2018; Inzlicht et al., 2018; Charness et al., 2018; Scarton et al., 2019; Andre et al., 2019; Steele et al., 2019; Halperin et al., 2020). Across these disciplines there are similar interests in the role that effort plays, despite the varied tasks to which the idea is applied, for example: which factors determine selection and initiation of behaviour? What determines behavioural persistence in task performance attempts? What are the underlying mechanisms involved in carrying out task performances? How do people adapt to the continued performance of task behaviours? Etc. Further, much of the work in these areas necessarily intertwines with other cognate concepts including ‘trying’, ‘forces’, ‘resistance’, ‘demands’, ‘work’, ‘difficulty’ etc. I note here to begin that it is not my intention to try and ‘explain’ effort in these regards. Instead, my focus is only upon definition, and the value that presents in helping diverse fields further knowledge on ‘effort’.

Considering the diverse interest in the concept of ‘effort’ it has been noted that, though many specific ‘species’ of efforts have sometimes been defined (that is to say, within specific fields and in certain applications or tasks), there are few if any explicit ‘general’ definitions of the term that could be applied across fields (Massin, 2017). I am in agreement with others (Massin, 2017; Bruya and Tang, 2018), who have argued that the lack of such a definition impedes interdisciplinary collaboration and the integration of findings from across fields; and further, has the potential to promote misunderstanding.

Massin (2017) recently took up the effort7 of producing a general definition for ‘effort’. The specifics of his definition and arguments will be touched upon throughout this article where I find myself both in agreement and disagreement in places; I note though that his work is admirable and certainly the first to my knowledge that has attempted such a challenging task. Initially, he notes that some may object to the determination of a definition prior to empirical investigation; though he makes a case for the role of armchair philosophising8 in determining a definition for effort. Some truths about it are clear. For example, he notes several things which to him seem plainly self-evident regarding effort:

- “Effort is not a planet”
- “Efforts are not feelings”
- “Efforts are actions”
- “Efforts can fail or succeed”
- “Efforts are always exerted against some resistance”
- “Efforts are always made to reach some goal”
- “The intensity of efforts is not a function of their failure/success”

He also makes a case for the provision of a definition prior to empirical investigation noting there are concerns with attempting to do the converse (that is empirically investigate before defining what it is we want to investigate):

- The practical impossibility of investigation: How are we to look for something we have no idea about?14

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6 I confess a specifically frustrating example of lack of explicit definition comes in the early work of William James (1880) in The Feeling of Effort. In it he continually refers to “effort properly so called” without any such conceptual or operational definition of the term.

7 Yes, that is intended to be a pun… be prepared for injections of ‘silliness’ in this article including robots, zombies, comic books, wizards, videogame cheats etc.

8 Of the sort I engage in throughout this article, albeit interleaved with reference to empirical work including my own.

9 Though, see later a ‘tongue in cheek’ example wherein we might imagine a planet that could ‘experience’ effort, and may even have a perception of its efforts.

10 As will become clear, I agree with this in the sense that effort is an objectively definable phenomenon which we can, but may not always, have a feeling or perception of.

11 On this I also agree, but caveat that this does not imply they need a conscious actor.

12 Similarly, to footnote 10 this ‘goal’ does not have to be a goal in the sense of that sought by a conscious actor. Just that they are directed at, or toward something.

13 Though it also seems reasonable that in ‘most’ tasks the intensity of effort likely modulates the probability of failure/success

14 He notes “Meno’s paradox” in this regard (Plato, Meno, 80d, in Cooper, 1997: 880)
• The theoretical impossibility of mistake: Whatever is found can be claimed to be exactly what we were looking for.

• The epistemic impossibility of disagreement: If it cannot be characterized independently of varied empirical investigations, no two explanations could ever conflict as no two would be about the same explanandum.

Indeed, without an a priori agreed upon definition of ‘effort’ it will remain a possibility that researchers from different fields, and even within the same field, use the term to refer to distinctly different phenomena (Haslam, 2016; Massin, 2017; Knudson, 2019; Fiske, 2020). Using the Tower of Babel and considering Forscher’s (1963) parable “Chaos in the Brickyard”, Knudson (2019) notes that in kinesiology lack of consistent nomenclature likely results in researchers erecting their own sub disciplinary ‘walls’ or piles of unconnected ‘bricks’. These have little connection to other walls in the tower of the fields knowledge. One might extend the metaphor further to say that they also lack ‘bridges’ between the towers to enable other fields to cooperate with one another in an interdisciplinary fashion.

Particularly for fields that seek to create abstractions to explain reality, common language is a prerequisite for clear communication (Starosta and Petrynski, 2007). Indeed, this is a problem for fields like psychology and other social sciences that deal with malleable concepts; what Hacking (1995) calls ‘human kinds’ as opposed to the ‘natural kinds’ of the ‘harder’ sciences. Such concepts can ‘creep’ in their definitions (Haslam, 2016).

In an attempt to leverage an agreed upon definition it might make sense to begin with the dictionary definitions of the term. Though, as noted, at least those in English appear to be vague in their description. Further, as Fiske (2020) notes in his discussion of the ‘lexical fallacy’ in emotion research:

“... it is not uncommon for psychologists to begin an article by quoting a dictionary definition, as if an entry in a dictionary or vernacular language consisted of a psychologically, socially, or culturally valid construct that extends beyond linguistic usage... lexicographers merely record how people use words; they make no claims about what’s in the real world beyond language.”

I contend most of the fields interested in effort are not interested in the word usage, but instead in understanding ‘effort’ itself. Indeed, though I am reluctant to a priori presume I will be successful in doing so, I am interested, as I believe many others are, in understanding whether or not a concept of ‘effort’ can be produced that describes some a ‘natural kind’15. Thus, though I will refer to others terminology and definitions throughout this article, I aim to try and avoid the ‘lexical hang-ups’ that come with reifying existing word usage merely because it is common. Indeed, Fiske (2020) further points out the ‘linguistic chauvinism’ of assuming that “English, alone among languages, fortuitously captures a scientifically valid taxonomy... Does the English lexicon get [effort] right, cutting nature at its joints, whereas 7000 other languages fail to do so?” [my insertion]. Many languages have words that might be translated to ‘effort’ which may or may not have polysemy, and may or may not have colloquial synonyms: for example, ‘exertion’16. Science is a cross-language and cross-cultural endeavour and the language it uses to communicate must not fall prey to lexical fallacies irrespective of their linguistic origins. In this sense, one could be so bold as to begin by suggesting that we drop the term ‘effort’ entirely choosing a new term that is not marred with historical lexical baggage. Fiske (2020) termed the emotion of his groups research focus kama muta using the dead Sanskrit language to avoid the issues of using an existing vernacular lexeme. For my endeavour, it could be as simple as using a typographical symbol instead to denote the variables (e.g. E, E, ϕ, or μ etc.) which maybe more felicitous. Or similarly to Fiske (2020) we could also use a dead language translation of ‘effort’ (Latin – Comatum; Old English – Anginn; Sanskrit - Htrim), or adopt the term Horne17 in recognition of the Ancient Greek spirit. Though I am inclined towards this idea due my belief that clear definition of the ‘concept’ and ‘construct’ is of greater importance than the label we give to it (Markus, 2008;

15 As Fiske (2020) notes in reference to their work on kama muta “Of course, our stipulation may turn out not to delineate a natural kind, but we hope that explicating the construct as clearly as possible will enable us to find out – and thereby incrementally delineate more valid approximations...”

16 An example of the issues caused specifically in kinesiology regarding recent debates upon perceptions of ‘effort’ or perceptions of ‘exertion’ is noted as a later section.

17 Though the pronunciation is ‘Ormi’, in modern Greek the word means ‘momentum’. Thus to avoid confusion we might instead adopt the word as written in English, Horne, and pronounced with a hard /h/ - as in /hɔːni/
Slingerland, 2003; Fiske, 2020)\(^\text{18}\), there are some practical concerns in following it through (Fiske, 2020). Adopting a novel term potentially limits communication with those who already use the existing terminology, and it is a tall demand to expect researchers across fields to begin to utilise this new term. Thus, though I am partial to adopting the term *Horne*, I will for the sake of ease of communication continue to use the term ‘effort’ in this article; but, I stress that the definition, and not the label, is the more important component.

Unsurprisingly, despite varied folk notions and both colloquial and scientific uses of the term, few have explicitly clarified whether they considered effort as being a fundamentally objective or subjective phenomena: that is, distinguished between actual effort and perception of that effort. Implicitly at least, in many cases effort is typically (though not always) considered as one or the other. Certainly within many fields, effort is often considered as an ordinal variable whereby experimental conditions manipulate the degree of effort required to actually achieve a task without specifically quantifying the intensity of that effort (i.e. high effort, or low effort) nor the perception of it. Yet, it is my experience\(^\text{19}\) that many people upon hearing the term ‘effort’\(^\text{20}\) immediately assume that a feeling or perception is being referred to.

However, I will argue here that the actual effort required (objective effort), and the perception of that effort (subjective effort), are two related yet distinct variables both of which have been inconsistently defined, manipulated, and measured across the fields which study them. This is an issue as without appropriate operational definitions which are agreed upon and accepted by these fields, a scientific understanding of either, and indeed their relation, will remain out of reach.

The overarching aim then of this piece is to consider and define ‘effort’ during task performance in an attempt to bring clarity to the topic and permit unification of the variable across different fields of inquiry. I will draw distinction between the actual effort required (objective effort), and the perception of that effort (subjective effort), and propose appropriate means of defining, and therefore considerations for manipulating and measuring, both. I will focus my definitions following a set theoretical approach for both actual and perceived effort as both constructs and concepts (Markus, 2008); wherein the former refers to a population-dependent definition of the variable and the latter a population-independent definition of the variable. It should be noted in advance that it is not the intention of this article to provide an exhaustive interdisciplinary review of effort. Though I have attempted to draw from as wide a range of fields as possible, it may appear that work from kinesiology is overrepresented; yet, this is to be expected given my background in the field. However, it is from a position of dissatisfaction with how my alma mater has handled the variable, finding existing definitions to be lacking, that I came to expand the breadth of my enquiry. In doing so I like to think that I have identified where there may be opportunities for integration of learnings across disciplines. As such, I aim to present discussion and definitions that are agnostic of the specific task demands being performed (i.e. physical, cognitive, self-control, or a combination of task demands e.g. dual tasks or net task demands\(^\text{21}\)) and which I hope will allow for further understanding of the role of effort and its perception from a broad scientific perspective. At the very least, doing do will provide others with a transparent overview of my own assumptions and aid in the interpretation of my own subsequent empirical work. Indeed, as Massin (2017):

> “...looking for a definition of effort consists in trying to make explicit our pretheoretical understanding of effort; we make a lot of assumptions about efforts in ordinary life and in sciences. By unearthing them, one may hope to arrive at a clear understanding of the nature of efforts.”

**Why separate actual effort (objective) and the perception of that effort (subjective)?**

> “Centuries and centuries of idealism have not failed to influence reality”

(Jorge Luis Borges, 1940. *Tlön, Uqbar, Orbis Terrarius*)

In the short story, *Tlön, Uqbar, Orbis Terrarius*, Borges describes an imaginary world named Tlön wherein the people hold an extreme form of George Berkeley’s subjective idealism or ‘immaterialism’.

\(^\text{18}\) Partly due to the influence of Slingerland’s (2003) discussion of wu wei as a conceptual metaphor. We could call what I intend to define ‘blue elephants’ for all I really care. The definition itself is the more important factor.

\(^\text{19}\) Largely within field of kinesiology and closely related fields.

\(^\text{20}\) In addition to other cognate terms, in particular ‘fatigue’

\(^\text{21}\) It could be argued that dichotomising physical/cognitive tasks, even if merely for simplicity of communication, is inaccurate as any volitional physical task for example will have some cognitive component. It may merely be better to just consider net task demands.
This philosophy in essence denies the existence of matter, with everything existing only as ideas in the minds of perceivers. As such, things cannot exist unless they are perceived. Within the history of research regarding effort there have been many who hold a view, at least of effort, that is in keeping with idealism. In Borges story, the idealism of the inhabitants of Tlön begins to affect reality itself with ideas begetting the production of duplication of objects called hrönir. I interpreted this story as somewhat allegorical regarding the state of thought, at least from some thinkers, regarding ‘effort’. Many early thinkers on the topic explicitly endorsed the view that effort was no more than a feeling. Massin (2017) notes that Maine de Biran explicitly endorsed this view, and that many of those involved in the early debates regarding centralism versus peripheralism spoke regarding effort and the feeling of effort as freely interchangeable; at the least giving the impression that effort is just a feeling. More recent thinkers have noted regarding effort: “If a person feels loaded and effortful, he is loaded and effortful…” (Johanssen, 1979, pp 105); “... there is no objective counterpart to this perceptual phenomenon…” (Gambarelli, 1990); “Effort by definition is an inference or perception” (Kuppuswamy, 2017); and some seem unclear as to whether they consider it as an objective or subjective phenomenon (Hockey et al., 2011).

However, though such thinking has been influential, and indeed I have experienced much of it, not all historical, nor contemporary thinkers hold the view that effort is just a feeling or perception. John Dewey (1897) was at least one early thinker to explicitly differentiate between what he referred to as the ‘fact’ of effort, and the ‘sense’ of effort. Indeed, he noted that “Practically stated, this means that effort is nothing more, and also nothing less than the tension between means and ends in action, and that the sense of effort is the awareness of this conflict.” Some have focused primarily on ‘effort’ as an objective phenomenon. For example, Kahneman’s (1973) conceptualisation of effort was objective, though he and others acknowledged the accompanying subjective experience (Mulder, 1986; Bruya and Tang, 2018). Others clearly differentiate the actual effort and the perception of it (Preston and Wegner, 2009). In philosophy of action, Shepherd (2016) differentiates between the ‘experience of trying’ and ‘actual trying’, and Lafargue and Franck (2009) note that “… one has to consider that an action is always carried out with a certain amount of effort...”. Massin (2017) notes “Pace the primitive-feeling view of effort, the “of” in the “feeling of effort” must be the representational “of” after all: Feelings of effort are feeling-acts directed at efforts as their objects.” In discussing methods for the study of effort in economics experiments, Charness et al. (2018) note the need to differentiate between “stated effort and real effort”. In project management, though more often applying to anticipated effort, there is acknowledgement of the need to differentiate between that and the actual effort required (Höst and Wohlin, 1997; Jørgensen, 2004). Most recently, André et al., (2019) in their integrative model of effortful control, clearly differentiate between effort actually required to perform tasks, and the accompanying feeling of effort.

Intuitively, at least to me24, the separation of the objective and subjective dimensions of ‘effort’ conceptually seems simple. Effort in an objective sense might best be thought of as that which is actually done in attempting to perform a task. Massin (2017) argues that efforts are not veridical, but here the feeling or perception of that effort can be considered as the phenomenology accompanying the ‘attempting’ or ‘trying’ and thus as a likely related, but distinct, veridical phenomena25. The actual effort (objective effort) done in attempt to meet a set of task demands might track closely with our perception of that effort (subjective effort). However, though under most normal circumstances this may be the case, and indeed in populations where this is so we would be justified in treating them as being the same construct (Markus, 2008), their conceptual distinction seems intuitive and indeed there may be instances where the two are incongruent thus representing an actual effort – perception of effort illusion of sorts.

Perceptual illusions have been defined as “…a discrepancy between one’s perceptions of an object or event observed under different conditions…” (Reynolds, 1988). Even when you explain illusions, you often still fall prey to them. Considering the strong effects of

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22 Massin (2017) himself seems to favour a realist view of ‘effort’ being that he opts for a ‘force-based’ account of it, whilst noting his arguments for force realism (Massin, 2009) in opposition to Cartesian and Humean traditions
23 And indeed other cognate concepts such as ‘fatigue’.
24 Though notably I do not expect anyone to also necessarily hold these intuitions.
such visual illusions as the Ebbinghaus’ Tichtener circles, Müller-Lyer lines, and the Necker cube, in addition to exteroceptive illusions regarding our own bodies such as the rubber hand illusion, it should perhaps be uncontroversial to propose that our perceptions of the effort done in attempt to perform a task (the ‘event’\(^{28}\)) may not match the actual effort done in that attempt and may be influenced by other factors (‘conditions’). Given that functionally speaking a ‘sense organ’ is intended to provide some representation of how the world is, it seems reasonable to suggest that interoception such as the perception of effort also operates in such a way (Serban, nd.). It could be considered that interoception, as compared to exteroception is unique in that it is not clear what the reality is we are saying it is intending to represent and thus how can it be said to misrepresent it.\(^{27}\) Can something ‘feel’ effortful but not ‘be’ effortful, or vice versa? If we accept the intuition that actual effort is involved in trying to perform tasks, then I think it is plainly obvious that we can experience interoceptive illusions regarding effort. In fact, the world is rife with examples that illustrate this.

Examples of the incongruence between representation, the perception of effort\(^{28}\), and of what can be said to be objectively happening given that the task is being attempted, the actual effort, are wide. As noted earlier, the Daoist concept of wu wei clearly differentiates the phenomenology from what is actually happening\(^{29}\). Indeed, within the system of conceptual metaphors presented by Slingerland (2003), an actor (person) is commonly considered in two ways; as subject and as self, where ‘subject’ is the locus of consciousness and subjective experience, and the ‘self’ is considered as an object (the body, a location, faculty etc). Under this the use of objective to refer to the actual effort the ‘self’ does in any task attempt, and the subjective to refer to the experience of that effort by the ‘subject’ become clear. Slingerland (2003) clarifies:

“It is important to realize, however, that wu-wei properly refers not to what is actually happening (or not happening) in the realm of observable action but rather to the state of mind of the actor. That is, it refers not to what is or is not being done but to the phenomenological state of the doer.”

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\(^{26}\) Or event(s) given continued or repeated performance of a task and considering each instantaneous moment in time as an ‘event’.

\(^{27}\) For example, it seems easy to catch the intuition that something can ‘look’ red, but may not actually ‘be’ red. However, it is difficult to catch the same intuition about interoceptive senses… can something that ‘feels’ itchy not ‘be’ itchy?

\(^{28}\) Or at the very least, the ‘self-report’ behaviour indicating it – see brief discussion of methods of third person phenomenological inquiry in a later section.

\(^{29}\) Though of interest, in modern practice (at least in Chinese bank managers) the application of this concept has been found to be more akin to finding the path of least resistance and thus perhaps seeking out ways to perform tasks such that they require objectively less effort (Xing and Sims, 2012).
agreement again not necessarily being present (Fleishman et al., 1984). Indeed, in physical tasks people are able to apply greater efforts with the ordinal increase in actual demands, but are still poor at estimating the amount of effort actually required (Richter, 2015; Armes et al., 2020). Though, this lack of congruence is not always present; across different muscle actions and tasks people are sometimes able to match relative force based upon perception of effort (Taylor, 2016). Similar results have been reported for different physical task modalities matched to oxygen costs relative to peak (Shepard et al., 1992). The perception of effort in physical tasks thus seems at least to be directionally accurate, albeit a very coarse representation of the actual effort required most of the time.

An extreme case of the incongruence between actual effort and perception of effort is in the case of schizophrenia. For both physical (Lafargue and Franck, 2009) and cognitive tasks (Gerrans, 2015), schizophrenia is associated with a lack of the sense of agency or ownership of their performance, which is thought to be due to a malfunctioning of the sensory apparatus and processing of sensory stimuli to generate the perception of effort. Yet, even in normal healthy persons, tasks performances that are both unconscious and unintentional still require actual effort as evidenced by capacity limitations (Weingarten et al., 2016; Melnikoff and Bargh, 2018).

Review of studies in project management for software development highlight that findings regarding the congruency of expert estimations of effort are mixed; some showing good agreement, and others poor (Jørgensen, 2004). For consumer responses to loyalty programmes, perception of effort can be manipulated by use of different reference efforts (e.g. what is required of other individuals) such that, despite the same actual demands, peoples perception of effort to meet programme requirements can be higher or lower (Kivetz and Simonson, 2003). Similarly, to the noted coarse-grained representation of effort in physical tasks, the same seems to be the case in economics; the directional relationships of actual effort and perception of effort is often similar, though the degree of congruency between the two is less clear (Charness et al., 2018). This has also been found for post-editing (Moorkens et al., 2015; Scarton et al., 2019) and listening tasks (Moore and Picou, 2018; Picou et al., 2017). In performance of math tasks, despite similar actual demands the degree of interest can also impact the perception of effort (Song et al., 2019). Indeed, Dunn et al. (2016) argue that the perception of effort is a meta-cognitive process involved in the evaluation of task demands (actual effort) and that it is possible manipulate this perceptual and inferential process, even when objective demands remain similar.

The intention of this section was simple; merely to provide examples to convince readers of the need to differentiate the “actual -” and the “perception of -” with respect to “effort”. Given the myriad examples of a lack of congruence (at least a lack of fine-grained accuracy\(^{30}\)), and that we know people’s introspections regarding cognitive processes are sometimes imperfect and often entirely mistaken (Nisbett and Wilson, 1977) it seems difficult to argue otherwise. Indeed, Dewey (1897) went so far as to note “In some cases it seems almost as if the relation between effort as objective fact, and effort a psychical fact, were an inverse one.” In this regard we might consider extensions of Wittgensteinian thought on perception to include effort (Davies, 2011; Campbell and O’Sullivan, 2015; Block, 2007). Could we imagine a person who, much like a blind person has no visual perception, has no conscious perception of the effort required to perform tasks? Most people don’t think that because the blind person cannot see this means light and spatial qualities of objects do not exist; so why would we treat the example of a person who cannot perceive effort any differently? Surely, they still require actual effort to attempt performance of tasks.\(^{31}\) Is there the possibility of aspect perception, similar to the famous duck-rabbit illusion, whereby objectively equal task performances are perceived in different ways? Or the potential for something similar to the idea of spectrum inversion (i.e. red things look green) such that objectively difficult tasks are perceived as ‘easy’ and vice versa?

Though clearly, the perception of effort is unlikely to be merely just for the representation of some objective thing called effort (Preston and Wegner, 2009), this seems likely to be a major function. As noted, debate regarding the neural underpinnings of sensory stimuli for the perception of effort date back some time; though today there is wider agreement on key elements of some sort of efferent-afferent comparator model (Lafargue and Franck, 2009; Gerrans, 2015;

\(^{30}\) Of course, such incongruence may merely result from lack of reliability in either operationalisation of the objective or subjective components, similar to the typical lack of correlation between self-report and behavioural measures (Dang et al., 2020).

\(^{31}\) This strays into the realm of philosophical zombies... and as zombies can be scary (and the cause for much consternation amongst philosophers) we’ll leave it here for now.
What is (perception of) effort? Objective and subjective effort during task performance

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Table 1. Examples of existing definitions of actual (objective) effort.

<table>
<thead>
<tr>
<th>Source</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewey (1897)</td>
<td>“Practically stated, this means that effort is nothing more, and also nothing less, than tension between means and ends in action...”</td>
</tr>
<tr>
<td>Globerson (1983)</td>
<td>“For a given task demand (which is within the capacity limits of the tested children), there should be a negative correlation between the subject’s developmental Ms capacity (structural capacity limit) and mental effort exertion. That is, a child with a larger Ms capacity should exert less mental effort for the same task demand than a child with a smaller Ms capacity.”</td>
</tr>
<tr>
<td>Salomon (1984)</td>
<td>“The number of non-automatic elaborations applied to a unit of material to be learned.”</td>
</tr>
<tr>
<td>Mulder (1986)</td>
<td>“… the active involvement of subjects in the performance of mental tasks.”</td>
</tr>
<tr>
<td>Backs and Seljøs (1994)</td>
<td>“Mental effort is a term used to describe the amount of information processing resources that are allocated during task performance...”</td>
</tr>
<tr>
<td>Jansma et al., (2007)</td>
<td>“We defined effort as the allocation of resources when performing a task...”</td>
</tr>
<tr>
<td>Shenhav et al., (2017)</td>
<td>“… what mediates between (a) the characteristics of a target task and the subject’s available information-processing capacity and (b) the fidelity of the information-processing operations actually performed, as reflected in task performance. The first two factors, task characteristics and capacity, determine what level of performance is attainable in principle.”</td>
</tr>
<tr>
<td>Massin (2017)</td>
<td>“... a motor effort consists of (i) an agent exercising a mechanical force (F_1) on a body in order to make it move or stay at rest and (ii) that mechanical force being at least partly counterbalance by an opposite force (F_2): the resistive force...”</td>
</tr>
<tr>
<td>Inzlicht et al., (2018)</td>
<td>“Effort refers to... the process that mediates between how well an organism can potentially perform on some task and how well they actually perform... [and] is a volitional, intentional process, something that organisms apply, and as such, it corresponds to what organisms are actively doing and not what is passively happening to them.” “Effort is distinguishable from demand [original authors emphasis] or difficulty: effort corresponds to the intensity of mental or physical work that organisms apply towards some outcome, whereas demand of difficulty refers to a property of the ask itself (e.g. holding seven items vs three items in working memory) ...”</td>
</tr>
<tr>
<td>Steele et al., (2019)</td>
<td>“The intensity of effort during exercise can be defined in relation to the current ability to meet the demands of the task being attempted...”</td>
</tr>
</tbody>
</table>

Nevertheless, it is not my intention to review this here. The intention is to merely highlight that, in order to understand such cases when objective and subjective constructs and concepts do and do not relate to one another, and the implications of this in development of theories regarding effort, it is necessary to define separately both the objective, and subjective, constructs of effort.

**Actual (objective) effort**

To begin with I offer an analogy which I feel provides an intuitively simple solution to the definition of objective effort. Within materials mechanics, effort is a variable often referred to denoting the stress that a material experiences as a result of the application of force. Indeed, some dictionaries offer such a technical definition for the term ‘effort’ ("A force exerted by a
machine or in a process ")\textsuperscript{32}; though of course we should be cautious in laying too much credence on this as noted (Fiske, 2020). Similarly, it is often considered relatively with respect to the strength, or maximal capacity, of the material to withstand the imposed force and thus stress. In this field, effort can be objectively defined in terms of the absolute demands imposed upon the material (i.e. Pascals) and often a factor of safety is considered and determined by the maximal strength relative to the absolute demands. The latter could, however, also be expressed such that the absolute demands are expressed relative to the maximal strength and thus reflect the relative demands imposed. Such a seemingly simple approach whereby the effort experienced can be objectively defined as the relative demands presents useful applications for fields interested in intentional task performance.

Massin (2017) also mentions this example: that effort and force are often used equivalently in mechanics. He differentiates between what he refers to as ‘resource/capacity\textsuperscript{33} based accounts and ‘force’ based accounts of effort. Though he notes that these accounts of effort could be considered extensionally equivalent, he dislikes the option of a ‘mixed’ approach that permits the encompassing of both\textsuperscript{34}. Instead he appears to opt for a purely absolute force-based account\textsuperscript{35}. However, I believe it is possible to combine the two in a simple account of effort as being the demands of a task relative to the capacity to meet those demands. In doing so it is possible to retain Massin’s (2017) suggestion that effort is conceptualised as a vector quality with magnitude and direction. Indeed, we can allow for that magnitude to vary not only as a function of changing task demands and that they provide resistance to trying to perform a task, but also if we consider that the capacity need not necessarily be fixed and can differ at any given instant.

Actual effort has sometimes been conceptualised in a manner similar to this, albeit not always explicitly. William James (1880) considered ‘moral’ effort in action wherein the ‘moral motives’ might be likened to a capacity of sorts and effort utilised to overcome ‘sensual motives\textsuperscript{36}. For effort in physical tasks many have considered this idea of task demands relative to capacity (e.g. Gambarale, 1990\textsuperscript{37}; Taylor, 2009; Xia and Frey Law, 2008; Taylor, 2016; Burnley and Jones, 2018; Potvin and Fuglevand, 2017; Steele et al., 2019\textsuperscript{38}). For cognitive tasks and self-control there are several models that are explicit in the consideration of some aspect of ‘capacity’ or ‘resource’ and, though not all conceptualise effort as being determined by task demands relative to capacity, some do (e.g. Pascal-Leone, 1970; Kahneman, 1973; Globerson, 1983; Mulder, 1986; Longo and Barrett, 2010; Kruglanski et al., 2012; Kurzban et al., 2013; Peng et al., 2018; Andre et al., 2019\textsuperscript{39}). Indeed, both task demands and capacity (or ‘ability’) have been considered in discussion of the role

\textsuperscript{32} https://www.lexico.com/en/definition/effort [accessed 2nd June 2020].

\textsuperscript{33} Though, as Massin (2017) notes, these differ with respect to whether they consider ‘capacity’ as being some non-depletable (e.g. Kahneman, 1973; Kurzban et al., 2013) or depletable (Gendolla and Wright, 2009) resource, as well as whether they specify what the resource is: Physiological e.g. glucose (Gaiilot and Baumeister, 2007) or ‘toxic neural waste accumulation’ (Holroyd, 2016); functional e.g. computational capacity (Kahneman, 1973; Kurzban et al., 2013); ‘ego’ (Baumeister et al., 2000); or some ‘non-committal conceptual resource (”Although agents engaging in effortful behaviour can fruitfully be described as if they were allocating some limited resource, this does not entail that there is any finite resource really allocated by the agent.”)

\textsuperscript{34} It is worth noting though that he has more recently noted to me in correspondence, based upon feedback from reading an early draft of this manuscript, that the two accounts should be combined, yet professes to be unsure exactly how best to do so.

\textsuperscript{35} Though he discusses the relativity of subjective efforts.

\textsuperscript{36} Though in his conception ‘moral’ capacity was not sufficient per se and required effort to be added:

“The facts may be most briefly symbolized thus, S standing for the sensual motive, M for the moral and E for the effort:

\[ M \text{ per se } < S \]
\[ M + E > S \]

In other words, if E adds itself to M, S immediately offers the least resistance, and motion occurs in spite of it.”

\textsuperscript{37} Despite Gambarale (1990) noting just prior that “…there is no objective counterpart to this perceptual phenomenon…” he subsequently states “…it also reflects real conditions such as the interplay between the requirements of the physical task and the capacity of the individual.”

\textsuperscript{38} Indeed, Xia and Frew Law (2008) are explicit in their conception of how ‘brain effort’ given to drive motor tasks is a function of the task demands and capacity:

“Residual capacity (RC) is introduced to describe the remaining muscle strength capability due to fatigue, where 0% indicates no strength reserve (not physiological) and 100% indicates full non-fatigued strength (Eq. (3)). This time-varying term can be used as a multiplier to decay maximum strength capabilities. Additionally, the central drive necessary to perform a task is modelled as brain effort (BE, Eqs. (4)), which may be used as a simple estimate of perceived exertion:

\[ RC(t) = M_s + M_r = 100\% - M_r \]  \textsuperscript{(3)}

\[ If TL \leq RC, BE = \frac{TL}{RC} x 100\% \]
\[ If TL > RC, BE = 100\% \]  \textsuperscript{(4)}

\textsuperscript{39} Kruglanski et al (2012) are also quite clear that effort (effective driving force) equals the demands (resistive force) but cannot exceed capacity (potential driving force):

“Postulate 3: The magnitude of the effective driving force \(M_E\) will be equal to magnitude \(M_s\) of the restraining force and lower or (at most) equal to magnitude \(M_{DP}\) of the potential driving force:
of effort in causal ascription of behaviours (Weiner et al., 1972) and in desert (Sher, 1979). A non-exhaustive selection of examples of definitions of actual effort from the literature is presented in Table 1.

An important distinction between the effort experienced by non-conscious objects such as in materials mechanics, and conscious organisms intentionally attempting performance of tasks, has also been noted by many, that it involves intent by an organism i.e. an agentic self. However, I contend that, at least for actual effort, there is no need for a conscious actor to be present. That is to say actual effort is something that can be ‘experienced’ by both conscious and non-conscious things. There merely has to be the directional ‘intent’ of an action towards a goal (i.e. attempted task performance).

I wish to offer an explicit definition which, similarly to in materials mechanics, permits this distinction between absolute task demands and effort (and between actual, and perception of, effort), but holds that absolute task demands relative to current capacity to meet those demands (i.e. relative task demands) are in essence what determine actual effort. As such, when absolute demands increase such that they represent a greater relative demand, or when a reduction in capacity is present, there similarly is an increase in relative task demands and thus the objective effort required also increases.

A definition of ‘actual’ effort

Considering the above distinction, I offer the following definition:

Effort; noun
That which must be done to achieve a particular task demand, or set of task demands, and which is determined by the current task demands relative to capacity to meet those demands, though cannot exceed that current capacity.

This definition is clear in how it presents effort as a variable that relates the absolute task demands to the current capacity to meet those task demands thus in essence equating actual effort to the relative task demands i.e. they are logically interchangeable. Though this definition can in theory be used to determine the actual effort required for a given task a priori, effort by its nature teleological in that no effort is ‘experienced’ unless there is ‘intent’ to complete a task. The definition can be applied to both physical and cognitive tasks (that is to say it is agnostic of the specific nature of the task) and is in essence anchored with a ceiling relating to the point at which, assuming genuine intentional attempts to meet them, it is no longer possible to meet the task demands.

In considering the set theoretical approach suggested by Markus (2008) regarding the definition of variables, we might define actual effort as a construct (that is to say a population-dependent variable) as follows:

Effort (construct)

\[ E_A(i, t, C_A, D_A) \] is the actual effort for any individual \( i \) at time \( t \) where \( C_A(i, t, x_C) \), and \( D_A(i, t, x_D) \) are the actual capacity and actual demands respectively, and \( x_C \) and \( x_D \) are the magnitudes of those respectively for individual \( i \) at time \( t \).

In essence, any given individual at any given time only has one effort level (which is comprised of their capacity and the task demands), but more than one person can share the same effort level. Markus (2008) notes that “...the definition of a construct necessitates the stipulation of an origin, however arbitrary to identify the scale of the construct. It then becomes possible demanding controlled information processing, and 2) a person’s requirement to change their current energy resource state towards that which is optimal for the task. However, in the context of effort within a capacity model (i.e. that as a relative variable it can only be allocated up to and not exceeding 100%), these two ‘types’ might instead be considered as separate task demands that both require effort to achieve.

Indeed, in Massin’s (2017) definition of a ‘force’ based account he argues that this, along with ‘goal-directedness’ and ‘resistance’, are key ingredients of efforts. But he extends ‘force’ to include physical and cognitive forces. Thus, to my interpretation, he appears to be using all of these terms in a non-committal agnostic manner. A number of others also imply that effort is a universal applied to various task performances (Dietrich, 2003; Dietrich and Sparling, 2004; Franconeri et al., 2013; Preston and Wegner, 2009).
to give a construct a formal definition." This definition is, by its nature, a ratio given that capacity and demands have natural origins: capacity can be zero, as can demands. In fact, it could be expressed as a percentage:

\[
D_A \leq C_A \rightarrow E_A = \left(\frac{D_A}{C_A}\right) \times 100\%
\]

\[
D_A > C_A \rightarrow E_A = 100\%
\]

Equation 1.

The construct of actual effort (E_A) defined above is referred to as being population-dependent in that the set describing it includes only combinations of all individuals, times, capacities and demands that exist empirically. However, we can conceptually extend this to be a set of hypothetically infinite size that describes all possible efforts; it could be expressed from 0 to 100% to any degree of precision imagined. Conceptually then we can denote the set as: E_A(i, t, C_A, D_A, w), where the ` denotes a new variable and w denotes all possible states of affairs i.e. combinations of i, t, C_A, and D_A. Together, these construct and concept sets not only include the variables as they extend over given populations, but also to projections of all possible populations. Further, we could add a term to our conceptual set such that it is intensional to all possible types of tasks (e.g., I_Aany). As such, the capacity is always defined in relation to the nature of the task being attempted. In a way this deals with the issue faced by many resource or capacity based models of effort in determining what the ‘resources’ or ‘costs’ of effort are. The task demands may be a combination of physical, cognitive, or self-control based and thus we might consider the ‘net’ demands and the ‘net’ capacity to meet them. Either way, they are always specific to the given task, and effort is merely the ratio of specific task demands to the capacity to meet those specific demands.

For example, in a physical task the role of differential demands and capacity are considered in that actual effort is determined by the task demands relative to the current capacity to meet task demands. As such, if two individuals were attempting to pick up the same specific absolute load (e.g. 80 kg) the stronger of the two would initially require less actual effort to complete this task. If they had both performed prior tasks that had resulted in a reduction in their maximal strength, then each would require a greater actual effort to complete the task than compared with when their capacity was not reduced. And further, if both continued performing repetitions of this task their maximal strength might continue to reduce insidiously to continued attempts to maintain a particular absolute demand, and thus require an increasingly greater actual effort with every individual or continued attempt to meet the task demands. Correspondingly, if the absolute task demands where increased then both individuals would also require greater actual effort to complete the task. Yet for both the continued performance of the task with fixed absolute demands and insidious reduction of capacity, or the increase of absolute demands, task performance would be capped by their maximum capacity at which maximum effort is required. With training though that maximum strength might be increased such that a given absolute task demand now represents relatively less and so required less actual effort. Further, biomechanical alterations to the task might reduce the absolute demands and thus the actual effort.

Similar examples could be provided for cognitive tasks. For example, if two individuals were attempting to hold a fixed number of items in their working memory, the one who has the larger working memory of the two would require less actual effort to complete this task. However, both individuals would again require greater actual effort to do so in the presence of lingering reduction in cognitive capacity from prior tasks, or from continued attempts to meet the task demands, or from increased absolute task demands (i.e. more items to be held in working memory). Again, training may also improve maximal capacity. Also, cognitive processing alterations (i.e. heuristics; Shah and Oppenheimer, 2008) might reduce task demands and thus the actual effort.

Some have suggested that certain tasks might not be considered effortful even though they are difficult; at least when difficulty is considered as the probability of success. For example, Westbrook and Braver (2015) offer the example of trying to hit a bullseye. Massin (2017) rightly points out that, though efforts are accompanied by success/failure conditions, these do not determine the magnitude of those efforts. It is possible to subsume even this example into the current definition of actual effort. Arguably, one could try harder; that is to say employ more actual effort (concentrate more, apply greater control over fine motor action etc.) which might arguably strain the limit of their ability (capacity) to perform the task and thus make it require more actual effort. But, though such effort might increase the probability of their success (or not), if they

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44 It is worth being explicit here; even though some use ‘resources’ and ‘capacity’ differently, I am in essence treating them as synonyms.

45 In fact, Skott (1997) has argued “The analysis of the component of effort can proceed on the basis of any given cardinal representation of effort” even in the “absence of natural units”.
have a particularly low ability their probability of success will still likely be low.

Indeed, by way of demonstrating its task agnostic nature further, it could even be applied to tasks performed in imaginary worlds as permitted by our conceptual definition. For example, McCoy and Ullman (2019) recently considered people’s judgments of the effort that might be required for wizards casting spells in a world where spells required an amount of ‘magic points’ to be cast. Each spell was judged to require a specific absolute number of magic points with some spells being judged as requiring less effort than others. But, it could also be said that people would likely judge more powerful magic users (for example an arch-mage) with greater capacity for magic points, to require less effort to perform any given spell compared to a weaker magic user (for example a neophyte) with lesser capacity for magic points (Ullman, 2019 – personal communication). Returning to Massin’s (2017) suggestion that “Effort is not a planet”; though I agree, we could imagine a planet that ‘experienced’ effort. In the Marvel Comics universe there is a character called (somewhat aptly given the present topic) Ego the Living Planet. He is incredibly powerful, albeit limited in his capacity. As such, his attempts to perform tasks (e.g. control and transform his atmosphere or surface, generate energy blasts etc.) must place demands on him that cannot exceed his capacity, but could be expressed relative to his capacity. Thus, we could imagine Ego as ‘experiencing’ actual effort. 

Massin also argues that “Spontaneous muscle contractions, such as cramps, or externally generated muscle contractions, do not count as efforts...”. Yet, I would disagree that, while such actions generate an accompanying perception of effort (Pageaux et al., 2015) these do not require actual effort; the task is actually attempted and performed by the stimulated muscle, and cannot be performed in a manner that exceed the capacity of that which performs it.

Considering these examples, and if we grant an assumption of a proportional relationships between the derivative of capacity (\( \frac{dC}{dt} \)) and effort at the preceding time (\( E_{At-1} \)), we could graphically depict the relationships between task demands and effort at a given time (t), as well as the change in capacity and thus effort across given static absolute task demands over time. Figure 3 shows: (A) the increased effort required with increased task demands (note the example assumes a capacity of 100 AU); (B) the increase in effort with continued time attempting the task at those fixed absolute demands; and (C) the drop in current capacity to meet those demands (i.e. ‘fatigue’ which in essence could be considered merely the change in capacity of the opposite sign). Thus, relative task demands become progressively greater (hence the increased effort), due to the decrease in capacity, up to the point of momentary task failure. However, effort cannot exceed 100% and so, when attempting a task of demands equal to capacity (in this example an initially maximal demand

46 Arguably as a conscious being we could also imagine him having a corresponding perception of that effort, if he had the appropriate system to produce such a phenomenon,

47 In a brief discussion of effort and fatigue (at least in reference to the limitations of ‘resource based accounts’), Massin (2017) suggests that we should not prejudge a relationship between the two in any definition of effort. He offers an example of a being with an “infinite amount of energy at his disposal – a being who therefore never gets tired” and that such a being, while empirically impossible, should not be metaphysically impossible or precluded by a definition of effort. But such a being is possible with my definition. Their actual effort for continued performance of any given task would remain constant with time as their capacity never reduced. We might liken them to a videogame character who has a ‘power bar’ representing their capacity to perform special actions and which depletes each time they use one. A cheat code might enable them to perform such actions without the power bar ever reducing. But low-level special actions are still relatively speaking low effort, and vice versa.

48 Note that here I have explicitly chosen to use the term ‘fatigue’. In fact, at least with respect to actual fatigue I feel it is very appropriate given that the term is also used in materials mechanics and is thus similar to the analogy provided regarding effort (https://uk.comsol.com/multiphysics/material-fatigue [accessed 2nd June 2020]). I am aware of the contention regarding the definition and use of this term, and the adoption of terms such as ‘performance fatigability’ to refer to this objective drop in capacity, whereas ‘perceived fatigability’ is used to refer to the sensory and phenomenological state associated with it (Kluger et al., 2013; Enoka and Duchateau, 2016). Personally, I find the inclusion of the suffix “ability” to add confusion as, at least to me; it implies the ‘susceptibility’ to the original noun to which it was attached. Thus, I interpret the term (at least independent of any explicit definition) to refer to tendency for an individual’s capacity to reduce either in terms of magnitude, or magnitude over time (i.e. rate). Indeed, some have considered this interpretation (Hunter, 2018). Nevertheless, I will sometimes opt to use the term actual ‘fatigue’ (and the accompanying perception of fatigue with the same considerations for the need to separate them with the separation of actual and perceived effort) and argue that it should just be preceded by ‘magnitude’ or ‘rate’ if that is what is being referred to. When I use the term however, I am merely alluding to a reduction in the capacity to meet a given task demand, or set of demands, and will more often than not use that language explicitly.

49 Note that there is a need to differentiate between ‘fatigue’ and ‘failure’ which, at least in kinesiology, is not often done (Enoka and Duchateau, 2008; Steele et al., 2017). Failure occurs at the point at which task demands exceed current capacity. Fatigue, conversely, is the reduction in the capacity to perform the task. Thus, while fatigue maybe an ongoing process, failure is better considered and event. Further, reaching task failure does not mean that fatigue is maximal, nor even substantial.
What is (perception of) effort? Objective and subjective effort during task performance

Available at: doi: 10.31234/osf.io/kbyhm

Figure 3. The relationships between demands, capacity, time, and effort, given the definition proposed across varying fixed absolute task demand examples (10%-90% of initial capacity) and an initially maximal task. Panel (A) shows the relationship between demands and effort; Panel (B) shows the change in effort over time given continued attempt to perform a task of fixed absolute demands; Panel (C) shows the change in capacity over time given continued attempt to perform a task of fixed absolute demands (note, where absolute task demands remain fixed, the increase in effort results from the decrease in capacity over time); and Panel (D) shows these relationships four-dimensionally. Note, the derivatives of demands ($\frac{dD_A}{dt}$), capacity ($\frac{dC_A}{dt}$), and effort ($\frac{dE_A}{dt}$) with respect to time are as follows: ($\frac{dD_A}{dt}$) is a constant (=0); ($\frac{dC_A}{dt}$) is $-\left(k \times E_{AC} - 1\right)/100$ i.e. [0,-1] where $k$ is maximum capacity; and ($\frac{dE_A}{dt}$) is $\frac{dD_A \times C_A - dC_A \times dD_A}{C_A^2}$

The decay in capacity becomes linear as it is proportional to the effort required. Figure 3D shows the four-dimensional relationships between capacity, demands, time, and effort. Considering the example of an initially maximal demand task, as capacity drops the demands that can be met also reduce; theoretically a maximal task could be continued until capacity is equal to zero. Similarly, we could consider a ‘supramaximal’ task (i.e. one with demands greater than capacity) could be attempted and would indeed result in a maximal effort; but the task demands would not be met and thus the task would not be performed.

I argue that this definition is useful particularly as it permits a starting point in reality for consideration of where our perception of such effort might diverge from that which can be objectively defined to have been actually done. It should be noted that, based upon this definition, without an individual actor performing an initially maximal task or continuing to the point of momentary task failure (or indeed not putting forth any effort at all – a minimum or maximum) it is difficult, and perhaps impossible, to actually know during task performance at any given point in time precisely what a person’s required actual effort is. Without the ability to continuously monitor during tasks the relationships between initial capacity to meet task demands, and the magnitude and rate of change in that capacity, we may never really know empirically what the actual effort required is in this relative sense. However, at present I see this is a technological limitation and, given the conceptual definition offered, think that it is uncontroversial to work within the model that actual effort is in essence a latent variable that is determined by actual capacity and actual demands even if we can’t measure them directly yet.

I don’t think that the definition of actual effort in this manner is necessarily unique. As noted, many have at least alluded to the relationships between task demands, capacity, and effort. However, I feel that the

\[50\] Indeed, knowing this initial capacity (or capacity at any point in time), though less of a problem when considering simple physical tasks (e.g. maximum force production, maximum speed etc.), is perhaps more of an issue as task complexity increases (even the simplest physical task can often be broken down into numerous degrees of freedom) and even more so with the complexity of most cognitive tasks and their processes. That being said, if we are good materialists, we can at least grant the assumption that even cognitive capacity has to be limited… but we could imagine something (a ‘smart drug’ perhaps) that might enable that capacity to be increased and thus the concept is still valid in such examples.
specific definition provided here could be said to be ‘cleaner’ and I hope leaves less room for misinterpretation due to its explicit nature. The application of this definition might assist researchers in better manipulating the actual effort required during tasks to better understanding the role that effort as a construct plays in determining behaviours and responses across fields of inquiry. Indeed, effort is often considered as an ordinal variable and manipulated as such in experimental studies. However, understanding effort objectively as a continuous ratio variable might allow for a finer grained understanding of where, when, and why discordance exists between this and the subjective experience (perception) of that effort. Further, not only does a clear definition of actual effort permit greater ability to understand its role in behaviour and responses, it allows consideration of the combined and differential influences that both actual effort, and the perception of it, impart.

Having offered a definition, I now move away from the actual effort required and done for task performance and to the phenomenology, the qualia, of that construct for conscious actors. However, before doing so it is necessary to highlight the distinction between sensation and perception as it could be said the former bridges the concepts of actual - and perception of - as we discuss them here.

**Sensation and perception**

Many people when referring to ‘effort’ use either ‘sensation of’ or ‘perception of’ seemingly under the assumption that these are terms that might be used interchangeably. I argue this is not the case and as such, prior to moving to discuss a definition of perception of effort it is necessary to highlight the difference between ‘sensation’ and ‘perception’. Michel Cabanac, in his essay “What is sensation? Gnothi se auton” (Cabanac, 1995), discussed the difference between these two concepts referring to definitions from Levine and Shefner (1981) as follows:

> “[sensation is]... the process of detecting a stimulus (or some aspect of it) in the environment...”

And,

> “[perception is]... the way in which we interpret the information gathered (and processed) by the senses...”

Summing this up they suggest that “In a word, we sense the presence of a stimulus, but we perceive what it is.” For reasons that will become clear in the following discussion and will hopefully convince the reader this is more than simply a semantic issue, I consider the conscious experience of effort to be a perception that likely arises from a myriad of underpinning physiological sensations which in many cases relate to the actual effort required, though as I have noted may not always exist in congruence – that is to say, the sensory stimuli resultant from some actual effort, may or may not result in a perceptual representation of that effort which is accurate.

To illustrate the relationships between the variables we are defining and discussing here – actual effort, sensations or the detection of effort being made, and perception of effort – I offer the analogy of an unconscious robot actor\(^{51}\) who can ‘experience’ the former two though cannot ‘interpret’ them, compared to a conscious human actor who experiences these in addition to conscious awareness of effort being exerted (figure 4). The unconscious robot may have a maximum capacity to perform a particular task, for example lifting a weight or recalling from memory. The robot may also be programmed to attempt to perform this task. That is to say it intentionally does so (even though it is not conscious of this intent which is programmed). The actual effort required by the robot to perform the task is a function of the task demands relative to its capacity. Further, similarly to a conscious human actor, the robot can be programmed as such that its maximum capacity reduces as it continues to perform a task over time (i.e. it fatigues). As such, with time on task whereby the absolute demands remain the same, the relative demands will increase and thus the actual effort required will increase. We can consider this example with (e.g. the robot may have some sensors monitoring demands and changes to capacity resultant from fatigue, and thus have a composite signal generated for the relative demands ‘experienced’ at any given point during task performance i.e. actual effort) or without ever invoking any sensory apparatus to detect the stimulus that the intentional task performance produces, and certainly

\(^{51}\) If you’re a fan of philosophical zombies feel free to swap out the robot for that instead. The point made remains the same.
What is (perception of) effort? Objective and subjective effort during task performance

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Perception of effort

Unlike actual effort which can be objectively defined independently of any conscious actor, the perception of effort requires a conscious organism to experience “something it is like” to experience effort (Nagel, 1974). Therefore, though actual effort can be determined objectively, even a priori to intentional task performance, given we know the task demands and capacity of the actor, the perception of effort is unknown (though can of course be anticipated and predicted) until it is experienced by a conscious organism. Some have argued that phenomenal experiences, including that of effort or even consciousness itself, do not require explanation; they are merely epiphenomenal to other biological activity (Kinsbourne, 1996; Pinker, 1997). But, as Preston and Wegner (2009) have noted, there are functional benefits to this phenomenological experience of effort; feedback on task difficulty, prompting behaviour changes, indication of authorship of actions etc. Further, there is no need to understand the underlying biology that gives rise to such ‘epiphenomena’ if we are content to be operationalist in this regard and any psychological constructs are instead thought of merely as placeholders for neurophysiological mechanisms (Rorty, 1977). Though some researchers are interested in uncovering these mechanisms that ‘translate’ the objective reality of effort into its phenomenology, many researchers are interested in both objective and subjective effort without the need to know what’s going on in the ‘black box’. They wish to understand the functional relationships between the objective and the subjective, in addition to their independent and joint effects on behaviours, adaptations etc. So, it is not my intention here to discuss how actual effort during tasks gives rise to a perception of that effort; responsibilities such as this and discussion of how other conscious content arises can be left to others (Searle, 1998; Morsella et al., 2016; Humphrey et al., 2020). Instead, again I merely intend to provide some definition of the variables such that we have a start and end point within a system that might not only assist those interested in examining that ‘black box’ of mechanisms, but the body had been easier to understand, nobody would have thought that we had a mind”.

Figure 4. The unconscious robot in this example, despite ‘experiencing’ the same actual effort as the conscious human, does not have a perceptual experience of the intentional performance of the task e.g. lifting the weight, or recalling from memory. Note, quotes are taken from Levine and Shelnier (1981).
that a definition of perception of effort might better assist those interested in understanding that phenomenology specifically.

One issue we face with the consideration of the perception of effort is that, though we might be able to ‘know’ that actual effort is occurring even as third person observers, the precise phenomenology and magnitude to any third person observer remains unknown until that experience is communicated behaviourally. Thus, we must have some approach to taking such ‘first person’ behavioural data, such as self-reports or other behavioural consequences, and from them interpreting from a third person perspective to draw inferences regarding phenomenology. Daniel Dennett (1991; 2003) has called such a method Heterophenomenology ("phenomenology of another, not oneself") wherein ‘... basically, you have to take the vocal sounds emanating from the subjects’ mouths (and your own mouth) and interpret them!’ He states that “You are not authoritative about what is happening to you, but only about what seems to be happening in you, and we are giving you total, dictatorial authority over the account of how it seems to you, and what it is like to be you.” Dennett dislikes the use of ‘lone wolf autophenomenology’ where the subject and the experimenter are one and the same person. Others such as Max Velmsans (2006) have proposed an approach called Critical Phenomenology which is reflexive, unlike Dennett’s approach, and he argues that even third person reports from experimenters are ultimately based upon their first-person experiences. Instead, he argues first- and third-person methods should be employed conjointly to provide triangulation of evidence; indeed, Velmsans argues that experimenters do this frequently particularly in psychology:

“Do psychologists ever use first-person methods (in isolation, or in combination with third-person methods)? Of course we do. When setting up a laboratory experiment, say on perception, the very first thing one usually does is to try the experiment on oneself.”

I must confess, I feel some affinity with this approach similarly to the affinity I feel with Massin’s (2017) armchair philosophising; that is to say, in thinking through this topic I have done much of this self-experimentation myself. Gualtiero Piccinini (2010) has attempted to improve upon Dennett’s method of Heterophenomenology to incorporate the self-measurement of first-person data. He argues that scientists should in essence use the best evidence they have which might include first-person data, but that we should be cautious and reserved in what we can infer from it:

“According to the self-measurement methodology of first-person data, scientists treat subjects issuing first-person behaviours as a self-measuring instrument. It is the scientist’s responsibility to insure that the instrument is calibrated and set up properly and that the measurement is carried out correctly. It is also the scientist’s responsibility to determine what can and cannot be reliably measured by the instrument under the relevant circumstances. That being said, heterophenomenology got two important points right: first-person behaviours are not always a reliable window into the mind, and their use as evidence ought to be a form of third-person science.”

As such, not only do we need to carefully consider a definition of the perception of effort, but we need to consider the approach taken to measure this, and thus the ‘training’ involved in eliciting first-person data regarding it whether this is as a third-person observer, or from self-measurement. These considerations may be particularly important given that it is not immediately obvious whether perceptual phenomenology is ‘thin’ or ‘thick’; that is to say either exhausted by low-level properties directly sensed, or whether it includes higher level properties such as potentials, causal relations, kinds, and functions (Masrour, 2011; Nanay, 2012). Considering the lack of consensus on the precise neurophysiological mechanisms that might give rise to a perception from sensory information that accompanies actual effort, it is difficult to say which of these, ‘thin’ or ‘thick’, effort might fall under. Yet, it has been argued that even conceptual experiences that are initially post-perceptual, could become part of the perceptual experience (Nanay, 2012). Such, cognitive

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54 Note, a ‘self-report’ need not be a verbal report, nor does it even need to be communicated in any specific lexicon. In fact, Dennett (1991) suggests we must grant that some aspects of ‘what it is like to be you’ may be ineffable: ‘What better grounds could we have for believing that you are unable to describe something than that (1) you don’t describe it, and (2) confess that you cannot? Of course you might be lying, but we’ll give you the benefit of the doubt.” (Dennett, 1991, pp 96-97)

55 Arguably this suggests he is in favour of simple first-person experiments and the use of intuitions regarding perceptual phenomena

56 Recall that Dunn et al. (2016) have suggested effort is a metacognitive evaluation.

57 Nanay (2012) gives the example of a chess master who has spent such time training the conceptualisation of a particularly strategy for an opening that it becomes automatic and part of their perceptual experience of the board.
infiltration has implications relating to the instruction and training of subjects to elicit first-person data regarding their phenomenological experience. I, for example, have spent many years thinking about this topic of effort and trying to attend very closely to the phenomenological experience during tasks of all kinds; thus, it might not be surprising that it is now a quite salient part of my perceptual phenomenology.

Though, even if such ‘cognitive infiltration’ is not something which happens and effort indeed falls within our perceptual experiences, our gestalt phenomenology is filled with many qualia at any given instant. Yet, given aspect perception, though they may fill our ‘perceptual field’ we may experience each with differing degrees of salience (Davies, 2011)\(^5\). Thus, though some may have interest in understanding this gestalt whole, there must also be consideration of the separation of each quale within the phenomenological experience in order to obtain first-person data of the greatest ‘precision’ and understand the composition of the whole\(^6\).

Similar to other conscious personal experiences such as taste, pleasure/pain, and wellbeing (Moskowitz & Meiselman, 1977; Bartoshuk, 2014; Krueger & Stone, 2014), psychophysical approaches have been used in attempts to relate these subjective personal experiences to objective physical processes (Borg, 1998). However, due to the fact that self-report or other behaviours are the data generated from this, it is not possible to completely ascertain the extent to which any measure of perception of effort obtained is truly reflective of the perceptual or conceptual processes underlying the experience of the actual effort required or done (Gameberale, 1990). Because of this required step in the process of measuring perception of effort (a subject providing a rating), careful consideration must be given to exactly how a definition of it is formed. The subject must understand what it is they are being asked to provide a rating of, or attend to, in order for that to be a valid reflection of the desired variable i.e. perception of effort (Moore et al., 2018; Halperin and Emanuel, 2020). Further, considering additionally the nature of our definition of actual effort, and the relation of this to perception of that effort through sensory apparatus, it seems that any definition of the perception of effort (particularly because it must be provided to subjects or at least encapsulated in what a subject is asked to provide a rating of) should as closely as possible reflect this pathway and thus the subjective nature of the specific objective construct. Thus, in this section I will first discuss existing definitions of the perception of effort, in addition to some discussion of scales and instructions often used in intentional task performances both physical and cognitive, noting what I believe are some of the issues they produce. Then I will offer my definition of the perception of effort which I feel is an appropriate extension of the definition of actual effort. I will note here in advance that I think this definition of perception of effort is inherently weaker that the one offered for actual effort by dint of the fact that it is defining an aspect of phenomenology.

**Existing definitions of ‘perception’ of effort**

Various definitions for the perception of effort during both physical and cognitive tasks have been offered from a range of authors and some of the most prominently used and cited have been included in Table 2. While many offer value when it comes to the understanding and measurement of someone’s perception of effort, I feel that many suffer from shortcomings that might impact their use. Many of these issues are particularly evident from examination of the approaches used in combination with such definitions, to measure perception of effort.

As noted already there is the issue of some referring to a ‘sense of’ effort when it is perhaps more appropriate to refer a ‘perception of’ effort. Secondly, there is the issue of the terms ‘effort’ and ‘exertion’ being used interchangeably (as evident from some even using the terms in description of one another). In fact, sometimes these definitions are used to refer to effort and in others exertion, or even both within the same text. This presents issues particularly for those for whom English is not their first language and in an extension of the lexical fallacy arguments could create a case for dropping the terms in favour of a new label (e.g. Horme). There is also the issue of descriptions including reference to things such as ‘heaviness’, ‘fatigue’, ‘self-efficacy’, or things that could perhaps be grouped as ‘discomfort’ (i.e. ‘strain’). Indeed, many definitions appears to describe some gestalt experience. However, as noted, though humans experience multiple perceptions simultaneously during task performance, they are evidently capable of differentiating these as separate dimensions of their overall experience.

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\(^{5}\) In physical tasks the notion of whether perception of effort can be considered ‘gestalt’ has been specifically questioned (Hutchinson and Tenenbaum, 2006).

\(^{6}\) Though, if the phenomenology of perception during task performance is similar to that of visual perception, binocular rivalry might suggest that we cannot actually perceive this gestalt whole at any given instance.
### Table 2. Existing definitions of perceived (subjective) effort

<table>
<thead>
<tr>
<th>Source</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borg (1962)</td>
<td>“the feeling of how heavy, strenuous and laborious exercise is”</td>
</tr>
<tr>
<td></td>
<td>And,</td>
</tr>
<tr>
<td></td>
<td>“the sensation from the organs of circulation and respiration, from the muscles, the skin, the joints and force”</td>
</tr>
<tr>
<td>Gamberale (1990)</td>
<td>“…the perception of effort should be interpreted as constituting a ‘summing up’ of the influence on the organism from all structures under stress during physical work.”</td>
</tr>
<tr>
<td>Noble and Robertson (1996)</td>
<td>“the subjective intensity of effort, strain, discomfort, and/or fatigue that is experienced during exercise”</td>
</tr>
<tr>
<td>Burgess and Jones (1997)</td>
<td>“Effort as an efferent perception may be defined as how hard one tried when carrying out a motor task.”</td>
</tr>
<tr>
<td>Taylor (2009)</td>
<td>“…the sense of effort gives a perception of the strength of muscle contraction relative to the total strength of the muscle.”</td>
</tr>
<tr>
<td></td>
<td>And,</td>
</tr>
<tr>
<td></td>
<td>“…a perception of the proportion of total muscle strength being used.”</td>
</tr>
<tr>
<td>Preston and Wegner (2009)</td>
<td>“The particular feeling of energy that is being exerted... accompanied by a sense of strain and labour, that intensifies the harder a person tries”</td>
</tr>
<tr>
<td>Marcora (2010)</td>
<td>“the conscious sensation of how hard, heavy, and strenuous a physical task is”</td>
</tr>
<tr>
<td>Kirschner and Kirschner (2012)</td>
<td>“…how hard a person tried to actively process presented information... a combination of perceived demand characteristics, perceived self-efficacy, and level/depth of information processing such that the first two influence the last which determines the amount of invested mental effort”</td>
</tr>
<tr>
<td>Dunn et al. (2016)</td>
<td>“…conceptualizing effort is to liken it to a type of general metacognitive evaluation of perceived task demand... In this vein, we can consider an individual’s metacognitive evaluation of demand as akin to a type of metacognitive experience (e.g. perceived effort)”</td>
</tr>
<tr>
<td>Taylor (2016)</td>
<td>“…sense of effort, which reflects the relative strength of a muscle contraction as a proportion of that muscle’s maximum force output...”</td>
</tr>
<tr>
<td>Radel et al. (2017)</td>
<td>“Mental effort is a feeling of strain occurring while investing a limited energetic resource to perform a mental task, due to the mobilization of controlled cognitive processing.”</td>
</tr>
<tr>
<td>Halperin and Emanuel (2020)</td>
<td>“The process of investing a given amount of one’s perceived physical or mental resources out of the perceived maximum to perform a specific task”</td>
</tr>
</tbody>
</table>
Thus, here as mentioned I wish to focus my definition on the perception of ‘effort’ and how it is independent of other perceptions and will briefly highlight some of the issues caused by the conflations included in many existing definitions.

Perception of ‘exertion’ or ‘effort’?

This problem of synonymy is one that is particularly evidenced in the field of kinesiology and in the study of physical task performance. In fact, this internal debate could be argued to be a major barrier in the advance of interdisciplinary work between kinesiology and other fields interested in effort. Abbiss et al. (2015) have argued that perception of ‘exertion’ and perception of ‘effort’ are not interchangeable terms, defining the former as “the amount of heaviness and strain experienced in physical work”, and the latter as “the amount of mental or physical energy being given to a task.” However, I believe an issue arises with insistence on using both terms, despite offering differing definitions of them, when considering that in many languages the two translate as synonyms. Table 4 presents translations of either term in 88 different languages highlighting where they do, and do not, translate from English as synonyms in the target language.

For example, although English is my first language, for many researchers with whom I have collaborated regarding effort in physical task performance it is not. These interactions have highlighted the issues of translation into their own languages. For example, in Portuguese both ‘exertion’ and ‘effort’ translate as ‘esforço’. In French, both translate to ‘effort’. In Italian, both translate as ‘sforzo’. In German, both translate to a ‘anstrengung’; and further, I am informed, to add to the potential confusion, ‘schwer’ is a word often used interchangeably to refer to something requiring a high actual and/or perception of ‘effort’ or that is particularly ‘heavy’ – a problematic conflation that is explained further below. The use of the terms as synonyms in some languages might create issues in attempting to measure either described variable, or indeed in the interpretation of the literature pertaining to either, when this involves those whose language treats the words as such. Pageaux (2016) has argued that, considering many within the literature do in fact use the two terms as synonyms already, and that many languages do the same, it may be best to instead use the terms interchangeably. Instead, the descriptors of other phenomenological aspects associated with exercise (such as ‘strain’) might be better termed as ‘pain’ or ‘discomfort’. Following from this disagreement within the literature my research group has also suggested a combined approach to the terminology should be used (Steele et al., 2017b). As ‘effort’ and ‘exertion’ are used by some interchangeably, but by others they are not, avoidance of such an approach might avoid confusion in communication. However, as most consider perception of ‘effort’ to refer in some way to the subjective component relating to the attempt to meet the demands of a task (whether physical or cognitive), and that ‘exertion’ appears to be often used in reference to the perception of other aspects during those attempts, the term ‘effort’ might be more felicitous with respect to the former (but that ‘exertion’ not be used interchangeably with it), and ‘discomfort’ (or another contextually appropriate term e.g. ‘pain’, ‘fatigue’, ‘force/load/weight/demand’) for the latter. This approach deals with the potential practical issues of separating the two variables for measurement, and in such a way as to avoid issues in certain languages upon translation; and, would assist in avoiding unnecessary confusion in interpretation of the literature around this area.

Further problems with definitions, and measures, of perception of effort: Descriptors and anchors.

As noted above, many of the definitions offered for perception of effort utilise other terms as descriptors that could cause confusion for those being asked to offer an appraisal of this; and indeed, may be separate perceptions entirely. Further, many of these descriptors have been utilised in self-report tools (and their instructions) used to measure perception of effort.

60 A point that Abbiss et al. (2015) raise and then appear to promptly ignore.

61 Once upon a time I spoke some remedial French and am currently learning Japanese.

62 He also suggests utilising the definition provided by Marcora (2010); though, both I and others (Halperin and Emanuel, 2020) find this definition to include unnecessarily misleading terms.

63 Although, ‘pain’ has been reported as perceptually distinct from ‘discomfort’ during exercise (Hamilton et al., 1996) and so the latter may be preferable for such exercise induced perceptions unless injury itself has occurred.

64 Indeed, even for recent texts where the authors note this apparent distinction between ‘effort’ and ‘exertion’ the terms are still used interchangeably without sufficient care as to when either is supposed to be appropriate (Hutchinson and Tenenbaum, 2019).

65 I first became cognizant of many of these issues in the work on resistance training that my research group conducts (Steele, 2014; Steele et al., 2017b).
## Table 3. Translations of ‘effort’ and ‘exertion’ across different languages.

<table>
<thead>
<tr>
<th>Language</th>
<th>Ways to say effort</th>
<th>Ways to say exertion</th>
<th>Match O/X</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>European Languages</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albanian</td>
<td>përpjekje</td>
<td>tendosje</td>
<td>X</td>
</tr>
<tr>
<td>Basque</td>
<td>ahalegin</td>
<td>exertion*</td>
<td>N/A</td>
</tr>
<tr>
<td>Belarusian</td>
<td>навука</td>
<td>напружанне</td>
<td>X</td>
</tr>
<tr>
<td>Bosnian</td>
<td>napor</td>
<td>усилее</td>
<td>O</td>
</tr>
<tr>
<td>Bulgarian</td>
<td>yuskaze</td>
<td>усилее</td>
<td>O</td>
</tr>
<tr>
<td>Catalan</td>
<td>esforç</td>
<td>esforç</td>
<td>O</td>
</tr>
<tr>
<td>Croatian</td>
<td>napor</td>
<td>напор</td>
<td>O</td>
</tr>
<tr>
<td>Czech</td>
<td>snaha</td>
<td>námaha</td>
<td>X</td>
</tr>
<tr>
<td>Danish</td>
<td>indsats</td>
<td>anstrengelse</td>
<td>X</td>
</tr>
<tr>
<td>Dutch</td>
<td>inspanning</td>
<td>inspanning</td>
<td>O</td>
</tr>
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<td>Estonian</td>
<td>pingutus</td>
<td>pingut</td>
<td>O</td>
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<td>ponnitus</td>
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<td>effort</td>
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<td>προσπάθεια (prospátheia)</td>
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<td>Irish</td>
<td>iarracht</td>
<td>exertion*</td>
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<td>напряга (napruha)</td>
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<td>ymdrech</td>
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<td>י&quot;ע</td>
<td>י&quot;ע</td>
<td>X</td>
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<td>X</td>
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<td>səy</td>
<td>güv</td>
<td>X</td>
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<td>উচ্চহ</td>
<td>দুখ</td>
<td>X</td>
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<td>Chinese Simplified</td>
<td>努力 (gōngfū)</td>
<td>用力 (yònglì)</td>
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<tr>
<td>Chinese Traditional</td>
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<td>用力 (yònglì)</td>
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<td>ძალისხმევა</td>
<td>დაძაბვა</td>
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No. Matches (O) 29
No. Differences (X) 54
Percentage of Languages with Matches 34.94%

Note: Translations were drawn from [https://www.indifferentlanguages.com/](https://www.indifferentlanguages.com/)

Some languages most commonly adopt the English word as a 'loan word' and these are indicated by *

### ‘Heavy’, ‘Heaviness’, or perception of absolute task demands

Use of the term ‘heavy’ is a particular issue for physical task performances which often involve actually lifting weights of different magnitudes. Many definitions used in fields studying these tasks, along with the tools used to elicit self-reports⁶⁶ utilise descriptors that could be interpreted by someone as referencing perceptions of weight, or load, experienced⁶⁷. Considering the definition of actual effort proposed, we can of course acknowledge that an increase in the weight used in a physical task will mean a greater effort is required and thus likely elicit a greater perception of effort. In fact, these scales have good construct validity when considered with reference to the weight/load used unsurprisingly (Andersen et al., 2010; Buckley & Borg, 2011; Colado et al., 2012; Hollander et al., 2015; Lins-Filho et al., 2012; Pincivero, 2011; Gearhart et al., 2001; Gearhart et al., 2002; Lagally et al., 2002a)⁶⁸.

However, as mentioned, the actual effort required to complete a task also rises over time, even when an absolute submaximal demand (e.g. weight/load/power/speed) is used, due to a reduction in the capacity to meet task demands (i.e. fatigue). Indeed, studies show that for physical tasks this also manifests in an increased perception of effort over time (Hortman et al., 1979; Noakes, 2004; Marcora & Staiano, 2010; Buckley & Borg, 2011; Pincivero, & Gear, 2000; Pincivero et al., 2004; Testa et al, 2012). Indeed, this increasing perception of effort with continued time on

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⁶⁶ For example, the Borg 6-20 Category Scale, Borg Category-Ratio-10 Scale, OMNI scale etc.

⁶⁷ For example, Borg’s scale (1998) uses “Hard (heavy)”, “Weak (light)”, “Strong (heavy)” and the adult OMNI Scale, developed for use specifically with resistance training, adds to this by using specific images which depict an increasingly heavier load on the barbell being held by the avatar (Robertson et al., 2003).

⁶⁸ And also, other physiological measures such as electromyographic amplitude, heart rate, and blood lactate when performing resistance training (Andersen et al., 2010; Hollander et al., 2015; Pincivero, 2011; Lagally et al., 2002b; Colado et al., 2012; Robertson et al., 2003).
task also occurs in cognitive tasks performed at fixed absolute demands due to the reduction in capacity (i.e. fatigue) that occurs (Wright et al., 2008; Hockey et al., 2013; Richter et al., 2016; Bijleveld, 2018; Bambrah et al., 2019). As such, we would expect actual, and thus perception of, effort to differ independently of the sub-maximal absolute demands of the task as a result of the reduction in capacity (fatigue) experienced during continued task performance.

Indeed, for example, a single instantaneous task attempt performed with say, 80% of a person’s maximum capacity, will require a greater actual effort, and likely produce a greater perception of effort, compared to a single instantaneous task attempt performed at 50% of their maximum capacity. However, if the task attempt with 50% were repeated or continued to a point of momentary task failure (i.e. the point at which, despite attempting to do so, a person can no longer meet the task demands), we would expect a greater actual effort to be required, and thus likely a greater perception of effort, than that produced by the single task attempt at 80%. The reduction of capacity that occurs with continued task attempts influences the actual effort required and thus should influence the perception of effort experienced. Yet if descriptors relating to the absolute task demands (e.g. weight/load in the case of a physical task) are used when attempting to measure perception of effort we may instead be asking persons to rate the perception of absolute demands being used in the task instead (i.e. its ‘heaviness’).

‘Fatigue’, ‘Self-efficacy’, and perception of capacity to meet task demands

As already noted, fatigue is a term often used for the reduction in capacity to meet task demands and which interacts with absolute task demands to determine the actual effort required. The perception of effort is directionally (albeit seemingly coarsely) related to this and, during continued task attempts at fixed absolute demands, increases as a function of time due to the reduction in capacity that occurs (i.e. fatigue). Actual fatigue is merely capacity to meet task demands expressed with an opposite sign (i.e. a decrease in the capacity to meet task demands of a certain magnitude is the same as an increase in fatigue of a certain magnitude), and thus perception of fatigue is the perception of this changed capacity.

However, a related variable is ‘self-efficacy’ which refers to an individual’s belief in his or her capacity to execute behaviours necessary to meet specific task performance demands (Bandura, 1977; 1986; 1997). Indeed, self-efficacy is essentially the perception of an individual’s capacity to meet task demands. Thus, ‘perception of fatigue’ and ‘self-efficacy’ are extensionally equivalent in that they both refer to the same variable: perception of capacity to meet task demands.

During continued task performance the change in capacity to meet task demands and effort are related; but, upon task disengagement the actual effort, and also the perception of effort, experienced drop immediately to zero; whereas, the reduction in capacity to meet task demands, although often transient, may actually, and be perceived to, last past this point. Thus, though effort, both actual and the perception of, is influenced by the capacity to meet task demands, they are not the same thing. Indeed, the perception of capacity to meet task demands (whether termed ‘fatigue’ or ‘self-efficacy’) should be considered distinct from the perception of effort.

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69 Though, in certain cognitive tasks there can be a short-term reduction in perceived effort with time on task which is thought to be due to a ‘learning’ effect, and development and application of heuristics to reduce processing demands (Shah and Oppenheimer, 2008; Bambrah et al., 2019).

70 Further reason to argue against the inclusion of descriptors relating to the ‘heaviness’ of task demands when attempting to define perception of effort, at least for physical task performance, is that not only is the actual task demand (i.e. weight/load) independent of the actual and perceived effort, but also that the perceptions of effort, force, and heaviness are phenomenologically distinct and indeed neurophysiologically distinct mechanisms exist for the sensory stimuli that the latter perceptions represent (Taylor, 2009; Taylor, 2016; Proske and Allen, 2019). In fact, interesting work has shown this distinction using the size-weight illusion (Burgess and Jones, 1997; Buckingham et al., 2014).

71 Note, I am aware here that, with respect to task performance by conscious actors such as humans, this ‘momentary task failure’ may or may not actually coincide with the intersection of actual task demands and actual task capacity. Indeed, many argue that in such conscious actors it is more likely that task disengagement (i.e. the voluntary withdrawal of ‘trying’) occurs prior to this and instead when the actor reaches the level of perception of effort they are willing to put forth (which may or may not be maximal), or perceives their capacity has reached its limit relative to the task demands (Wright, 2008; Marcara and Staiano, 2010; Richter et al., 2016).

72 Hysteresis models are also of interest to consider here. For example, in a stepwise or ramp task whereby absolute demands increase up to a point, and then following this reverse (i.e. the absolute task demands decrease symmetrically), on the latter stage the perception of effort is higher than during the former due to the residual drop in capacity that occurred (Montull et al., 2020).

73 Wright et al. (2018) also appear to allude to this equivalency, albeit not explicitly.
Perception of fatigue is something that is often measured as a state variable in response to, or during, task performance and indeed is often related to perception of effort; that is to say the greater the perception of fatigue, the greater the perception of effort (Benoit et al., 2019; Mickelwright et al., 2017; Milyavskaya et al., 2018; Greenhouse-Tucknott et al., 2019; Fernandez et al., 2020; Whitaker et al., 2019). Similarly, self-efficacy has been examined and found to be related to perception of effort as a trait variable (i.e. typically the greater the self-efficacy, the lower the perceived effort; Kukla, 1972; Ford and Brehm, 1987; McAuley and Courneya, 1992; Rudolph and McAuley, 1996; Pender et al., 2002; Sarrazin et al., 2002; Yoshida et al., 2002; Hu et al., 2007; Pinxten et al., 2014; Malik et al., 2020); though has sometimes been measured as a state variable which reduces in response to continued task performance (Hall et al., 2005; Wrightson et al., 2019) and has also been manipulated where studies have found increasing/decreasing self-efficacy decreased/increased perception of effort (and even volitional performance) respectively (Weinberg et al., 1979; 1980; 1981; Feltz and Riessinger, 1990; Fitzsimmons et al., 1991; Hockey, 1997; Kivetz and Simonson, 2003; Muraven et al., 2006; Hutchinson et al., 2008; Cameron et al., 2019; Mlynski et al., 2020). Indeed, further highlighting the extensional equivalence between these two constructs, several studies show that fatigue and self-efficacy are also associated; though in clinical populations and looking at ‘state’ measures (Findley et al., 1998; Akin and Guner, 2019). However, Stephan et al. (2016) have posed an ‘allostatic self-efficacy’ model whereby perception of fatigue, particularly chronic fatigue and depression, is viewed as a metacognitive phenomenon: “…a set of beliefs held by the brain about its own functional capacity...”.

Of course, actual capacity influences perception of effort (Rudner et al., 2012) which is perhaps to be expected if we assume that people’s perceptions of their capacity are related to their actual capacity. However, despite people’s perceptions of capacity being directionally associated with their actual capacity, these also seem to be rather coarse grained for both maximal capacity (Wisen et al., 2002; Bindemann et al., 2014; Brewer and Olsen, 2016; Gjestvang et al., 2017) and in predictions of remaining capacity during task performance (at least for physical tasks; Steele et al., 2017a; Hackett et al., 2012; Hackett et al., 2016; Altoe Lemos et al., 2017; Zourdos et al., 2019; Armes et al., 2020; Emmanuel et al., 2020).

‘Strain’, ‘Discomfort’, ‘Pain’

As noted earlier, at least lexically, the perception of effort should also be considered differently from perception of discomfort during task performance. Indeed, where scales, and their instructions, are used for self-reporting perceptions of effort that do not make explicit this distinction there is the potential for individuals to mar their reports with the discomfort experienced. Yet, in both physical tasks and cognitive tasks individuals are able to differentiate and separately attend to the perceptions of effort and discomfort experienced (Tenenbaum et al., 1999; Steele et al., 2017b; Fisher et al., 2017a; Fisher et al., 2017b; Hsu et al., 2017; 2018; Stuart et al., 2018; Fisher et al., 2018; Bambrah et al., 2019). Indeed, with appropriate scales and descriptions, even the perception of effort due to the task of performing respiration can be differentiated from the unpleasant discomfort associated with perception of air hunger or breathlessness (Lansing et al., 2000).

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74 It is worth noting that there is considerable variation across studies in how ‘self-efficacy’ has been measured; some clearly ask regarding perceived capacity to meet task demands, others ask questions that would be perceived as expected to identify other perceptions experienced during task performance like discomfort. It is commonly defined with respect to degrees of pleasure or displeasure (Schroeder, 2004); but this is not the only way of conceptualising it and some have defined it as purely an indicator/representation of value (Carruthers, 2011). Nevertheless, irrespective of the framework chosen for its conception, it isn’t clear whether valence falls within our interoceptive phenomenology as what we experience itself; or, if instead it is more a colour of how we value what we do experience (Serban, nd.).

75 Perhaps more akin to initial ‘rested’ maximal capacity to meet task demands.

76 It is worth noting that there is considerable variation across studies in how ‘self-efficacy’ has been measured; some clearly ask regarding perceived capacity to meet task demands, others ask questions that would be perceived as expected to identify other perceptions experienced during task performance like discomfort. It is commonly defined with respect to degrees of pleasure or displeasure (Schroeder, 2004); but this is not the only way of conceptualising it and some have defined it as purely an indicator/representation of value (Carruthers, 2011). Nevertheless, irrespective of the framework chosen for its conception, it isn’t clear whether valence falls within our interoceptive phenomenology as what we experience itself; or, if instead it is more a colour of how we value what we do experience (Serban, nd.).
A definition of ‘perception of’ effort

As a result of many of these considerations, I have attempted to offer a definition of perception of effort that addresses the issues raised, and that is in keeping with what I feel this perception is likely attempting to provide; that is, in essence, a conscious representation of the actual effort involved in task performance. My current definition of perception of effort is thus:

Perception of effort; noun
The perception of that which must be done in attempting to achieve a particular demand, or set of demands, and which is determined by the perception of current task demands relative to the perception of capacity to meet those demands, though cannot exceed that current perception of capacity.

I believe that this definition overcomes many of the issues noted whereby prior definitions, and the tools produced from them, have often been marred by inappropriate descriptors. As a phenomenological variable I feel it is appropriate in that it possesses:

- Quality; meaning that, though it may be related to, it is distinct from other concepts (e.g. perception of task demands, perception of capacity to meet task demands, perception of discomfort etc.).
- Intensity; meaning that it has a magnitude.
- Direction; meaning that it is ‘aimed’ at the task being attempted.
- Duration; meaning that it can be experienced over time.
- Hedonicity/affectivity; meaning that it can elicit emotions.
- Valence; meaning that it can have either a positive or negative value ascribed to it.

This definition relates to the definition offered for actual effort. Indeed, it could be said that it is merely the perceptual form of our actual effort definition i.e. the perception of task demands relative to the perception of capacity to meet those task demands. Thus, we could follow the same set theoretical approach (Markus, 2008) and define it as a construct:

Perception of effort (construct)
\( E_p(i, t, C_p, D_p) \) is the perception of effort for any individual \( i \) at time \( t \) where \( C_p(i, t, x_C) \), and \( D_p(i, t, x_D) \) are the perception of capacity and perception of demands respectively, and \( x_C \) and \( x_D \) are the magnitudes of those respectively for individual \( i \) at time \( t \).

Further, this can be extended to a conceptual definition – \( E_p'(i, t, C_p, D_p, w) \) - merely by again adding \( w \) to denote a new variable and \( w \) to denote all possible states of affairs i.e. combinations of \( i, t, C_p, \) and \( D_p \). Of course, also making this intensional to all possible types of tasks (e.g. \( t_{any} \)) which of perception of capacity (and perception of demands) is always defined in relation to the nature of the task being attempted. Again, this definition is, by its nature, a ratio given that perception of capacity and perception of demands have natural origins, and thus it could be expressed as a percentage:

\[
D_p \leq C_p \rightarrow E_p = \left( \frac{D_p}{C_p} \right) x 100\%
\]
\[
D_p > C_p \rightarrow E_p = \ 100\%
\]
Equation 2.

All of the examples I offered in the section regarding actual effort and its definition can be extended here with actual merely replaced by perception of. Equally, so too can figure 3. However, as noted the perception of effort appears at best a coarse-grained representation of actual effort which is probably a result of the introduction of ‘noise’ into the signal from both the sensory systems, and the perceptual system. As such, although the directional patterns of perception of effort with other variable often follow those we would expect based upon actual effort, they are ‘fuzzy’ and inaccurate representations of reality\(^{59}\) (figure 5).

Similarly, to the definition of actual effort provided, this definition of perception of effort is by no means unique as for both physical (Halperin and Emmanuel, 2020) and cognitive tasks (Kirschner and Kirschner, 2012) there have been similar definitions provided. Nevertheless, I hope that this definition is again very clear in its derivation and assumptions, and

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\(^{59}\) As this piece is already long enough, I’ll let you, the reader, imagine that for yourself and save the space on the page.

\(^{50}\) Which could stem from inaccurate representations of actual demands and actual capacity in perception leading to the inaccuracy in perception of effort as a representation of actual effort.
Further thoughts on measuring perception of effort

As noted, a critical lens must be applied to any first-person data (Dennett, 1991; 2003; Velmans, 2006; Piccinini, 2010). Definitions are of particular importance when generating self-reports given that, absent the provision of a clear definition from the researcher, people often apply their own idiosyncratic definitions (Dunning et al., 1989; Dunning and McElwee, 1995). Further, with respect to perception of effort, as highlighted people can often conflate other salient perceptions in their self-reported ratings. In addition, despite the effort of task performances being independent of their success/failure (Massin, 2017), people often apply substitution heuristics whereby they answer regarding their perception of how well they perform (Picou et al., 2017; Moore and Picou, 2018). The observer’s sex may also impact upon ratings of perception of effort (Winchester et al., 2012). Indeed, it is unknown if the mere act of asking someone to provide rating of their phenomenology actually changes the experienced phenomenology (Ariely, 1998); thereby invalidating the self-report for its presumably intended purpose before it is even made. Researchers should probably consider whether capturing measurements of the perception of effort are in the interest of understanding effort phenomenology specifically, or in gaining a measurement that is a ‘proxy’ indicator of the actual effort required. Evidently, it is impossible for us to ever know the phenomenology of anyone other than ourselves. But there are likely things that can be done to ‘calibrate’ our self-reporting instruments (participants) as best as possible such that they provide the best measurements of the phenomena we are interested (Piccinini, 2010).

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81 There is a beautiful irony in this: because answering regarding the perception of effort is difficult (the meta-cognitive process of relating perception of demands and perception of capacity is likely inherently ‘costly’ itself), a more accessible and easier question is asked in order to reduce the effort.

82 Winchester et al. (2012) found that men performing the same absolute demand treadmill task (20 minutes at 60% of their peak treadmill speed) reported higher ratings of perception of effort when observed by a male, and lower when observed by a female, compared to a control condition. Considering the task performed meant that the actual effort required was the same every time it seems that either the observer did genuinely influence participant’s perceptions of effort such that they no longer were accurate reflections of the actual effort required, or that participants were dishonest in their reporting for psychosocial reasons relating to the observer.

83 In this respect it is worth noting that, though it has been said that “Psychophysical measures are inherently subjective and therefore are suspected to lack validity...” (Hutchinson and Tenenbaum, 2019); indeed, I have previously thought that they can really only be known to lack validity if the intention is to measure something other than the subjective experience; there is arguably no guarantee either that the ‘rating’ we obtain is in fact a valid reflection of the phenomenology it is intended to represent. In all regards, caution in interpretation is encouraged when it comes to phenomenology. That being said, practically, and from the considering of the two ‘construct’ definitions I have provided, it is possible, given that they are both ratios for perfect collinearity along the identity with the same mean and standard deviation. If this were the case empirically in a given population then we would be able to say that both actual and perception of effort has strong identity. The more coarsely grained collinearity between the two constructs however that has been observed empirically, at least up until now, could be said to reflect weak identity (Markus, 2008). As long as researchers are openly aware of this limit, I have no real issue with using perceptual reports as coarse proxies for actual effort.
Considering the definition provided, I would argue that appropriate instruction and anchoring is required as some minimum for accurate measurement of perception of effort. Hopefully it has been made clear that, without instruction, persons typically anchor their perception of effort upon their other salient perceptions substituting or mixing the ratings provided. An appropriate definition of maximal effort in relation to the absolute task demands is likely needed and I would contend that anchoring should be performed in relation to the task demands using either descriptive explanation, past experience and memory, experimental procedures, or all of these. If the task is to maintain a particular absolute demand for an extended period of time for example this might require some explanation of the notion of ‘task failure’ (i.e. the point at which despite attempting to do so you can no longer maintain the task demands) again specifying what those demands are.

If it is of interest to also examine other perceptions (i.e. ‘heaviness’, ‘fatigue’, ‘discomfort’) then these should be appropriately differentiated from perceived effort and full details provided of their application. However, if applying several scales consideration should be made for issues of scale burden and how this may impact ratings given by participants. I would encourage instead replication of individual perception of effort response effects with certain experimental conditions before then applying that experimental paradigm to examine new perceptual measures as dependent variables. That way you can have at least some confidence of the stability of the perception of effort under those experimental conditions and then examine other perceptions in relation to them.

In some cases, researchers may be interested in capturing measures of first-person perceptions of third-persons. For example, it may be of interest to understand how well not only our own perceptions of effort are reflective of the actual effort required for tasks, but also our perceptions of others (Steele et al., 2017b; Ibbotson et al., 2019). Another interest might be in the prediction, anticipation, or remembering of task performances and their phenomenology (Höst and Wohlin, 1997; Hsu et al., 2018; Dunn et al., 2017; Bambrah et al., 2019).

Lastly, irrespective of exactly how perceptions are captured by researchers I would strongly encourage fully reporting the scale used and the administration procedures, including anchoring, instructions to participants, and the timings and environments when ratings were captured, so that readers can fully understand exactly what was measured and how. Independently of the considerations discussed in this paper, open and transparent reporting would likely result in far clearer interpretations of research going forwards, be a big step towards improving our understanding of these areas, and may aid in the development of better psychophysical scales for the measurement of perception of effort across task modalities.

Summary and Conclusion

Considering the historic and recently renewed growth in interest regarding ‘effort’, the purpose of this manuscript was to consider and define ‘effort’ during task performance; hopefully, in a successful attempt to bring clarity to the topic, and permit unification of the variable across different fields of inquiry. In doing so I have argued for a distinction between the actual effort required, and the perception of that effort, during intentional performance of tasks. Further, I have followed a set theoretical approach to defining both actual effort and perception of effort as both constructs and concepts. Lastly, I have offered what small advice I can to aid researchers in applying these definitions and in particular in measurement of perception of effort. Hopefully, one personal goal has also been achieved in producing this manuscript: I have made my own current conceptualisation and understanding of effort clear to myself, and to other researchers. At the very least, my own subsequent empirical work on the topic can be considered in light of it.

In terms of future research regarding actual effort and perception of effort, the definitions and considerations for measurement presented might better enable an understanding to be developed of where perceptions are, or are not, accurate reflections of reality, the reasons for this and the implications of this. Further, researchers might explicitly look to understand both the independent and combined impacts of both objective

84 An example might be asking participants to imagine the most demanding version of the specific task they think they would be capable of doing and then to consider how demanding it is to complete the task in relation to that.

85 Relatedly, research has examined people’s perceptions of others capacities (i.e. team self-efficacy; Feltz et al., 1989; Parker, 1992) and people’s perceptions of the capacity of robots compared to their actual capacity (Cha et al, 2015).
and subjective dimensions of effort in: selection and initiation of behaviour (i.e. task attempts); behavioural persistence in task performance and task attempt cessation\textsuperscript{88}; the underlying mechanisms involved in carrying out task performances; how people adapt to the continued performance of task behaviours etc.

References

\textsuperscript{88} The wording task ‘attempt’ cessation is deliberately chosen here such that, when considering conscious actors, it makes more sense to speak in this way to differentiate the questions “why did they stop?” and “why couldn’t they continue?”. The former here is framed as being a question of the actors choice to cease the task attempt, whereas the latter is such that the task was still being attempted but they could no longer meet its demands and is a question about what led to a reduction in capacity such that this was the case.


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Email for correspondence: james.steele@solent.ac.uk