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Fatigue and the Intensity of Behavioral Restraint – Considering Significance for Health and Self-Control[1]

Abstract: *We describe an emerging analysis of fatigue influence on behavioral restraint and consider its potential significance for two central concerns of contemporary restraint investigators: (1) adverse health effects of restraint, and (2) fatigue influence on self-control. Regarding health, the analysis provides a conceptual framework for anticipating restraint intensity and therefore possible risk. It also draws attention to a pathological pathway through which restraint could generate some adverse health outcomes. Regarding self-control, the analysis conveys a perspective that could markedly improve our prediction of relevant outcomes and has focused significance for crises that have been identified in relation to the influential limited resource analysis of self-control developed by Baumeister and colleagues. Crisis concerns have led some to conclude that the limited resource analysis should be discarded. The present behavioral restraint analysis goes against this grain, suggesting that the limited resource analysis might wisely be retained and afforded the chance to mature – among other things, incorporating elaborated effort components.*

Keywords: *Fatigue, Resource Depletion, Self-Control, Restraint, Cardiovascular Response*

This article describes an emerging conceptual analysis of fatigue influence on the intensity of behavioral restraint that is guiding current research in our laboratory (Wright & Agtarap, 2015). The emerging analysis defines behavioral restraint as active resistance against a behavioral urge or impulse and derives from a general analysis of fatigue influence that has been guiding research in our laboratory for over fifteen years now (Wright, 2014; Wright & Stewart, 2012). It can appropriately be characterized as an extension of the original – general – fatigue formulation.

Because the general fatigue analysis is foundational, we begin by describing it and presenting a sampling of relevant empirical evidence. We then (1) describe the behavioral restraint extension, (2) discuss evidence relevant to it, and (3) consider the extension's potential significance for two central concerns of contemporary restraint investigators. One concern is adverse health effects of restraint (Pennebaker, 1995; Pennebaker, Kiecolt-Glaser, & Glaser, 1988; Polivy, 1998). The other is fatigue influence on self-control (Clarkson, Otto, Hassey, & Hirt, 2016; Hofmann, Friese, & Strack, 2009).

In considering the potential significance of the behavioral restraint extension for fatigue influence on self-control, we focus on how the extension could help resolve recent "crises" that have been identified in relation to another restraint analysis – the highly influential limited resource analysis of self-control by Baumeister and colleagues (Baumeister & Heatherington, 1996; Muraven & Baumeister, 2000). Crisis concerns have led some investigators to conclude that it is time to discard the limited resource analysis. The present behavioral restraint extension goes against this grain, suggesting that the analysis might wisely be retained and afforded the chance to mature – among other things, incorporating elaborated effort components.

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General Fatigue Analysis

Our general fatigue analysis begins with a well--worn and well-supported hypothesis in cardiovascular psychophysiology. The hypothesis is that certain cardiovascular responses – specifically those linked to beta-adrenergic sympathetic nervous system stimulation of the heart – vary with effort, or "active coping" (Obrist, 1976, 1981). More intense effort (active coping) is expected to generate stronger beta-adrenergically mediated cardiovascular responses. In using the expression "cardiovascular responses", we refer to cardiovascular adjustments relative to resting states. These adjustments function to coordinate tissue blood flow with tissue need. Tissue need accelerates as the difficulty of imminent or ongoing activity increases, with different classes of behavior calling for different blood flow distributions. Regarding the latter, for example, a behavior like running calls for extensive flow distribution in large muscle groups, whereas a behavior like memorizing does not. In using the expression "generate" we imply a causal influence, with greater effort producing greater beta-adrenergic sympathetic nervous system activation.

The general fatigue analysis continues by adapting the idea from motivation intensity theory (Brehm & Self, 1989; Brehm, Wright, Solomon, Silka, & Greenberg, 1983; Wright & Brehm, 1989) that effort should be determined directly (proximally) by the difficulty of meeting an immediate performance challenge. In theory, effort should correspond to challenge difficulty as long as success is perceived as possible and worthwhile, considering driving motives – that is, reasons to perform (Wright, 2016). If success is perceived to be impossible or too difficult considering its importance, effort should be low. In context of this reasoning, success importance is understood to determine effort *in*directly (distally) by setting the upper bound of what performers will be willing to do to succeed.

A third component of our general fatigue reasoning concerns fatigue influence on ability and therefore appraisals of task difficulty. We assume (1) that fatigued performers are less capable in the relevant performance realm than are rested performers (Ackerman, 2011; Fairclough & Graham, 1999; Hockey, 1997), and (2) that less capable performers should appraise relevant performance challenges as more difficult than should more capable performers (Wright, 1996, 1998; Wright & Kirby, 2001).

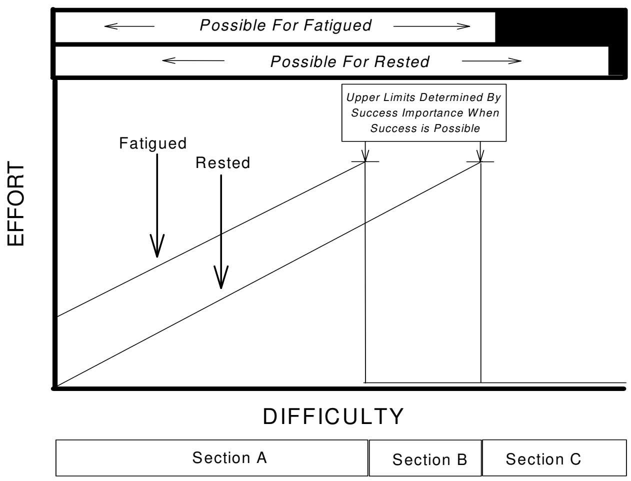
In relation to the above, multiple points are of note. First, our fatigue reasoning construes fatigue as involving temporary depletion of performance resources within a bodily system. It does not delineate biological bases, but assumes that they exist, e.g., in association with oxygen supply and waste accumulation in relevant tissues (Newsholme, Blomstrand, & Ekblom, 1992). Second, the reasoning assumes that fatigue varies in degree, depending on the extent to which there is performance resource depletion. Third, the reasoning assumes that fatigue reduces objective performance capacity, e.g., muscular strength – not just capacity perception. Fourth, the reasoning assumes that fatigue influences can be localized to a particular performance system or expansive, involving multiple systems. Fifth, the reasoning assumes that fatigue influences can be fleeting or enduring. It is reasonable to suppose that fleeting influences are procured through curtailment of immediately available resources, whereas enduring influences are procured through curtailment of stored resources available for conversion and transfer. Sixth, the reasoning assumes that fatigue can, but will not necessarily, be consciously identified (Schachter & Singer, 1962). Thus, for example, people might sometimes feel physically lethargic without linking those feelings to the fatigue concept (Mlynski, Wright, Agtarap, & Rojas, 2017).

Implications and Evidence

Figure 1 displays a model of effort deployment that follows from the general fatigue analysis, with associated cardiovascular responses following (for related models, see also Kukla, 1972; Meyer, 1987). The model includes both fatigued- and rested performers and highlights four key implications that have at this point been discussed in multiple publications.

Figure 1. Effort deployment as a function of fatigue, difficulty, and success importance

(adapted from Figure 1 in Wright & Franklin, 2004)



1. Fatigued performers should exert more effort and have stronger associated cardiovascular responses than rested performers so long as they view success as both possible and worthwhile (Section A).
2. Fatigued performers should withhold effort at lower objective task difficulty levels than rested performers. Fatigued performers should do so because they should conclude more readily (at lower difficulty levels) that success is either excessively difficult (given success importance) or impossible. At difficulty levels where (a) rested performers view success as possible and worthwhile, and (b) fatigued performers do not, effort and associated cardiovascular responses should be greater for the rested group (Section B).

3. If a task is (objectively) difficult enough, even rested performers should withhold effort. This means that fatigue should be unrelated to effort and associated cardiovascular responses if requirements to meet a performance challenge exceed the upper bound of what both rested- and fatigued performers can or will do. Specifically, effort and associated cardiovascular responses should be low for both performer groups (Section C).

4. As long as both fatigued- and rested performers view success as possible, success importance should moderate the relation between fatigue status, on the one hand, and effort and associated cardiovascular responses, on the other. Possible relations are as follows: (a) If importance is high enough to justify effort requirements for both performer groups, effort and associated cardiovascular responses should be greater for those who are fatigued; (b) If importance is high enough to justify effort requirements for the rested group, but not for the fatigued group, effort and associated cardiovascular responses should be greater for those who are rested; (c) If importance is so low that it does not justify effort requirements for either performer group, then effort and associated cardiovascular responses should be low for those who are rested as well as for those who are fatigued.

The preceding implications have received compelling empirical support in cardiovascular response studies that have evaluated fatigue influence under different performance conditions (for recent literature reviews, see Gendolla, Wright, & Richter, 2012; Richter, Gendolla, & Wright, 2016; Wright, 2014; Wright & Stewart, 2012). Consider for example an experiment that (1) first required participants to perform an easy- (low fatigue) or difficult (high fatigue) counting task, and then (2) presented participants math problems with instructions that they could earn a modest prize by attaining a low- (30^{th} percentile) or high (80^{th} percentile) performance standard (Wright, Martin, & Bland, 2003). As predicted, analysis of cardiovascular responses assessed during work indicated a fatigue x difficulty interaction for systolic blood pressure (the maximum pressure following a heartbeat), with similar patterns emerging for diastolic blood pressure (the minimum pressure following a heartbeat) and mean arterial pressure (the average pressure across a beat-to-beat cycle). Whereas responses tended to be greater for high fatigue participants when difficulty was low, they were the reverse of this when difficulty was high.

Elaborating on the above, the crossover response pattern was expected for systolic blood pressure because systolic pressure responses tend to increase with heart contraction force, which is considered to be an especially sensitive – “gold standard” – index of beta-adrenergic sympathetic nervous system activation (Brownley, Hurwitz, & Schneiderman, 2000; Kelsey, 2012). On a given beat-to-beat cycle, systolic blood pressure should be determined by two factors, (1) the force of the immediately preceding heart contraction, and (2) vascular resistance – that is, resistance to the flow of blood in peripheral arterial vessels, determined by considerations such as vessel caliber and blood viscosity. The more forceful the heart contraction and the greater vascular resistance, the greater should be systolic blood pressure. This means that systolic blood pressure should increase with beta-adrenergic sympathetic nervous system activation unless a sympathetic discharge yields an offsetting decrease in vascular resistance – for example, due to massive vasodilation in large muscles. Thus, in short, the gold standard beta-adrenergic index is considered to be heart contractility. However, systolic blood pressure is a reasonable secondary – downstream – beta-adrenergic sympathetic nervous system index because it should rise with heart contractility unless a special offsetting resistance effect occurs.

Consider also an experiment that used a very different task and method of fatigue induction (Wright, Shim, Hogan, Duncan, & Thomas, 2012, Experiment 1). It first required participants to walk on a treadmill for 10 minutes while wearing a vest fitted with either 5- (low fatigue) or 25 (high fatigue) pounds of weight. After the 10 minutes, participants transferred to a stationary bicycle and pedaled for an additional 10 minutes with instructions that they would receive a modest prize if they maintained an easy cycling speed (40 rpm) or a difficult cycling speed (60 rpm). Once again, analysis of systolic blood pressure responses assessed during work indicated an interactional pattern, in this case with heart rate responses following in close order. Whereas responses were greater for high fatigue participants when difficulty was low, they were greater for low fatigue participants when difficulty was high.

Addressing the fourth implication above, consider an experiment that included a manipulation of success importance (Stewart, Wright, Hui, & Simmons, 2009; see also Wright, Patrick, Thomas, & Barreto, 2013). The study manipulated mental fatigue by first requiring participants to perform a simple- (low fatigue) or demanding (high fatigue) version of a paced scanning task (Brickenkamp, 1981). Once fatigue groups were formed, the study presented mental arithmetic problems with instructions that participants would earn a high (98%) or low (2%) chance of winning a modest prize if they did as well as or better than 50% of those who had performed previously. Investigators assumed that extra effort requirements associated with fatigue would be justified when the chance of winning (i.e., success importance) was high, but not low. Consequently, they anticipated that fatigue would augment effort and associated cardiovascular responses under high, but not low, chance conditions. Systolic blood pressure responses during the math performance period supported expectations, with diastolic blood pressure and mean arterial pressure responses following. Responses rose with fatigue where the chance was high and tended weakly (non-reliably) to decline with fatigue where the chance was low.

Extension to Behavioral Restraint

Extension of the general fatigue analysis to behavioral restraint – that is, active resistance against a behavioral urge or impulse – assumes that restraint involves expending oneself to meet a performance challenge and that one can restrain in different measures. People resisting an urge have a task to accomplish and can apply themselves more or less intensively to it (Higgins, 2006; Kahneman, 1973). Following these assumptions and the general fatigue analysis logic, it stands to reason that three factors should play roles in determining restraint intensity and associated cardiovascular responses. The three factors are: (1) the magnitude of the behavioral urge being resisted, (2) the value or importance placed on restraint success, and (3) the level of fatigue.

Urge magnitude should play a role in determining restraint intensity and associated cardiovascular responses because it sets the objective difficulty of a behavioral restraint challenge. Strong urges are harder to resist than weak urges. The value placed on restraint success should play a role in determining these outcomes because it determines how powerfully people are willing to resist, that is, the upper bound of what they are willing to do to achieve success. When importance is high enough to justify requirements of a restraint challenge that is perceived to be possible, effort and associated cardiovascular responses should be proportional to urge magnitude – the difficulty of the challenge. When importance is not high enough to justify the requirements, effort and associated cardiovascular responses should be low. Fatigue should play a role in determining the outcomes because it should determine restraint capacity and consequently restraint difficulty appraisals at different urge levels.

The resulting model of fatigue influence on restraint intensity can be visualized by viewing Figure 1 (1) relabeling the difficulty axis as "Urge Magnitude", (2) relabeling the effort axis as "Restraint Intensity", and (3) construing success importance in terms of the importance of restraint success. A large-scale indication is that fatigue should not have a single influence on restraint intensity and cardiovascular responses following from it. Rather, fatigue should have a multifaceted influence that is dependent on the magnitude of the urge experienced and the importance of resisting it. Focused implications include:

1. Fatigued performers should evince stronger restraint intensity and associated cardiovascular responses so long as they view success as possible and worthwhile.
2. Fatigued performers should refrain from restraining (i.e., give in) at a lower level of urge magnitude than should rested performers. At urge magnitude levels where rested performers see success as possible and worthwhile and fatigued performers do not, restraint intensity and associated cardiovascular responses should be greater for the rested group.
3. If the magnitude of an urge is great enough, even rested performers should refrain from restraining. When this holds true, fatigue should bear no relation to restraint intensity and associated cardiovascular responses. Both rested and fatigued performers should give in.
4. As long as both rested- and fatigued performers view restraint success as possible, success importance should moderate the relation between fatigue, on the one hand, and restraint intensity and associated cardiovascular responses, on the other.

Evidence for the Extension

Whereas empirical indications pertaining to the general fatigue analysis are abundant and collectively persuasive, those pertaining to the behavioral restraint extension are limited and more suggestive than definitive. The most telling evidence is from an experiment that tested an interactional extension implication that is peripheral to fatigue (Agtarap, Wright, Mlynski, Hammad, & Blackledge, 2016). Specifically, the experiment tested the implication that restraint success importance should combine with urge magnitude to determine restraint intensity, with associated cardiovascular responses following. If importance is high enough to justify the effort required to restraint, restraint intensity should correspond to urge magnitude. If importance is not high enough to justify the effort required to restraint, restraint intensity should be low.

The experiment tested the interactional implication in context of a protocol that directed participants to inhibit responses to a video that was more or less emotionally evocative (e.g., Gross, 1998). Participants were presented a mildly- or strongly evocative violent film clip and asked to refrain from showing any facial response, operating under conditions designed to make success more or less important. Investigators expected that beta-adrenergic influence would be proportional to the evocativeness of the film clip (i.e., urge magnitude) when importance was high, but low regardless of clip evocativeness when importance was low. Findings for systolic blood pressure were supportive. A special 3 versus 1 contrast on change scores was significant, with means in the expected order. A test of the residual sum of squares did not approach significance, indicating that the contrast accounted for all reliable variance.

Results from the preceding experiment support the broad structure of the behavioral restraint extension. They also extend findings from other relevant cardiovascular investigations that support the extension suggestions that (1) active restraint should increase cardiovascular responsiveness, and (2) cardiovascular responses should sometimes be stronger under high- as compared to low urge magnitude conditions (Davidson, 1993; Gross, 1998; Gross & Levenson, 1993, 1997). However, neither they nor the results of the other cardiovascular investigations address the critical role of fatigue.

Moving beyond cardiovascular responses, secondary evidence for the behavioral restraint extension comes from a set of experiments that evaluated fatigue influence on self-control under conditions where restraint should have been more or less important (Kelly, Crawford, Gowen, Richardson, & Sünram-Lea, 2017; Muraven & Slessareva, 2003). As we will discuss further shortly, data from these experiments are relevant if one assumes that self-control outcomes associated with fatigue should depend heavily on whether fatigued restrainers (1) augment, or

(2) withhold, their effort (Ackerman & Kanfer, 2009). If fatigued restrainers augment, they should sometimes be able to maintain control, performing as well as rested counterparts. If the restrainers withhold, control should suffer. This assumption follows the idea that effort should improve the chance of resisting an urge in the same way that it should improve the chance of lifting a weight or maintaining a grip. To be clear, we are not suggesting that restraint augmentation will guarantee restraint success. People can fail when exerting high effort to restraint just as they can fail when exerting high effort to lift (weight) or maintain (grip). Our suggestion is simply that the chance for restraint success should be greater when compensatory effort is deployed than when effort is withheld.

Illustrative of experiments in the preceding set is one that required participants to perform a more or less depleting mental task and then presented them a restraint challenge involving puzzle performance with instructions that performance (1) would (success importance high), or (2) would not (success importance low) impact the development of new Alzheimer's dementia therapies (Muraven & Slessareva, 2003, Experiment 1). As might be expected, depleted (fatigued) participants showed puzzle performance deficits when success importance was low, but not when success importance was high. Taking the present behavioral restraint extension perspective, the suggestion could be that high importance participants augmented their restraint in the face of their fatigue, whereas low importance participants withheld their restraint in the face of this fatigue.

Potential Significance

Clearly, there is much empirical work yet to do in relation to our general fatigue analysis extension to behavioral restraint. Evidence exists, but it is limited and more suggestive than definitive. Nonetheless, it is not too early to consider the extension's potential significance. In the sections below, we consider significance relating to two central concerns of contemporary behavioral restraint investigators: (1) adverse health effects of restraint, and (2) fatigue influence on self-control. In discussing significance relating to fatigue influence on self-control, we focus on how the extension might help resolve crises that have been identified in relation to the influential limited resource analysis of self-control developed by Baumeister and colleagues (e.g., Muraven & Baumeister, 2000).

Health

On the topic of health, restraint investigators have long suspected that risk for unfavorable outcomes increases the more frequently and intensively people restrain (e.g., Polivy, 1998). Suspicions along these lines have highlighted the need for conceptual frameworks that allow prediction of the presence and power of restraint – and thus, presumably, health risk. In this regard, it is noteworthy that the intensity aspect of the behavioral restraint extension constitutes a highly elaborated conceptual framework that meets this need. The framework has three notable strengths. First, it includes a role for fatigue, which has received wide attention in relation to illness within the health research community (e.g., Basu et al., 2016). Second, it construes fatigue as an ability factor. This is important because it implies that other ability factors – such as ones involving skill derived from training (Mischel, 2015) – should function in a similar fashion. Third, the framework takes into account the influence of two factors that have been largely overlooked within the behavioral restraint research community: urge magnitude and success importance. Following conventional restraint suspicions, one can think of the intensity aspect of the behavioral restraint extension as a health risk roadmap of sorts. The roadmap includes familiar and unfamiliar elements and conveys distinctive suggestions about personal qualities and circumstantial considerations that could be injurious or protective.

The cardiovascular aspect of the behavioral restraint extension has health significance because it draws attention to a pathological pathway through which restraint could generate some adverse health outcomes. The pathway follows from contemporary psychosocial health models, which assume that persistently elevated cardiovascular responses confer risk for disease endpoints associated with compromised cardiovascular function (Krantz & Manuck, 1984; Smith & Ruiz, 2002). Discussions of mechanism typically involve a three-step process. First, increased cardiovascular responsiveness promotes damage to inner walls of key arteries, including the coronary arteries. Second, arterial wall damage promotes inflammation and the emergence of fatty deposits that develop into plaques. Third, plaque development narrows arterial openings, resulting in system failures and sometimes death.

Addition of the pathological pathway immediately above to the general health risk roadmap provided by the intensity aspect of the behavioral restraint extension offers a means of refining health risk prediction. Specifically, it suggests that the risk roadmap might be most predictive of adverse outcomes intimately linked to cardiovascular dysfunction.

Self-Control

On the topic of self-control, a prevailing view has been that depletion of performance resources diminishes restraint capacity, with reduced self-control following. Impetus has derived heavily from the Baumeister limited resource analysis. The analysis' well-known premise is that the inhibitory (behavioral restraint) system might function like a muscle drawing on a limited, and possibly tailored, performance resource. This suggests that short-term restraint should deplete the resource (i.e., induce regulatory fatigue) and impair inhibitory (regulatory) control. By contrast, long-term restraint should improve inhibitory (regulatory) strength and facilitate such control.

The Baumeister analysis has inspired copious research, but also met with sharp criticism, with the bulk of the criticism being focused on the analysis' centerpiece suggestion that self-control should be diminished under high- as compared to low-fatigue conditions (Carter, Kofler, Forster, & McCullough, 2015; Carter & McCullough, 2013; Clarkson, Hirt, Chapman, & Jia, 2011; Clarkson, Hirt, Jia, & Alexander, 2010; Hagger, Chatzisarantis, Alberts, Angonno, Batailler, Birt et al., 2016; Inzlicht & Schmeichel, 2012, 2016; Kurzban, Duckworth, Kable, & Myers, 2013; Lurquin & Miyake, 2017). Three main concerns have come to the fore. One is a troubling number of failures to replicate early demonstrations of the centerpiece depletion effect on restraint performance (e.g., Carter & McCullough, 2013). Another is evidence that performance incentives can moderate fatigue influence on self-control performance (e.g., Kelly et al., 2017). The third is evidence that performance resource perceptions can sometimes be more determinant of self--control outcomes than performance resource realities (e.g., Clarkson et al., 2010). These and other concerns have led to the identification of the crises mentioned earlier – ones pertaining to replication consistency and conceptual clarity.

Our behavioral restraint extension presents an alternative perspective on fatigue influence, assuming that self-control outcomes can vary depending on whether fatigued restrainers augment or withhold their effort (Ackerman & Kanfer, 2009). Specifically, the extension indicates that performance resource depletion (i.e., fatigue) should increase the difficulty of behavioral restraint, *but not necessarily yield a reduction in self-control*. In theory, difficulty appraisal increases have potential for leading restrainers to either augment or withhold. If the restrainers augment, they should sometimes be able to maintain control. If they withhold, control should suffer.

The alternative perspective above is significant on its face insofar as it holds potential for improving markedly our capacity to predict self-control outcomes. Moreover, it has focused significance for the crises that have been identified in relation to the Baumeister limited resource analysis of self-control. One reason is because it addresses directly the first two main crises concerns, those pertaining to replication and performance incentive moderation. Regarding the first of these, whereas the limited resource analysis implies that fatigue should impair self-control, the present reasoning implies that it might or might not do so, depending on fatigued restrainers' effort responses. Fatigued restrainers' effort responses, in turn, should depend on what the restrainers believe can, will, and must be done in the restraint situation. Taking the current restraint extension perspective, one would *expect* inconsistencies in replication of the centerpiece limited resource analysis depletion effect as long as investigators do not take into account considerations such as the difficulty of their restraint challenge and the importance of meeting it. By this way of thinking, replication failures are not necessarily contrary to the foundational idea that performance resource depletion reduces regulatory strength. The failures could be fully legitimate outcomes following from nuanced restraint process underpinnings that heretofore have not been widely considered.

Regarding the second concern, as discussed earlier, the present reasoning implies that performance incentives *should* sometimes moderate fatigue influence. Performance incentives should sometimes moderate because they should help determine (1) the importance of restraining successfully, and therefore (2) the upper bound of what fatigued restrainers will be willing to do. As long as restraint is possible, incentives should be central in determining whether fatigued restrainers augment- or withhold their effort. If the fatigued restrainers augment, they should sometimes maintain regulatory control; if they withhold, control should suffer. A crucially important caveat is that incentive moderation should *not* be found if a restraint challenge is so great that it cannot be met. If an urge is powerful enough, resistance should be impossible and restraint intensity low irrespective of fatigue or success importance.

The alternative perspective above also has focused significance for the crises that have been identified because it suggests a means of addressing the third main crisis concern, that pertaining to resource perception. The third concern could be addressed through consideration of the role perception plays in determining behavioral restraint responses, understanding that different restraint responses (augmenting versus withholding) have potential for generating different self-control outcomes. To our knowledge, the Baumeister analysis includes no role for perception. However, the analysis could be adapted in this regard. Adaptation could follow the longstanding line of reasoning that led to the present behavioral restraint extension. This line has consistently assumed that subjective appraisals (e.g., of ability) usually, if not always, take precedence over objective realities in generating effort outcomes (Wright, 1998; Wright & Franklin, 2004). Early experiments evaluated this assumption explicitly, producing supportive results (Wright & Dill, 1993; Wright & Dismukes, 1995; Wright, Murray, Storey, & Williams, 1997; Wright, Wadley, Pharr, & Butler, 1994). If the limited resource analysis were expanded to accept a role for perception influence on restraint responses, criticism related to resource perception could be assuaged.

To recapitulate, our behavioral restraint extension presents a distinctive alternative perspective regarding performance resource depletion (fatigue) influence on self-control. The perspective suggests that fatigue should increase the difficulty of behavioral restraint, but might or might not impair control. In theory, restraint performance outcomes should depend on restrainers' effort responses to fatigue – augmenting versus withholding. The perspective is significant on its face insofar as it holds potential for improving markedly our capacity to predict self-control outcomes. It also has focused significance for crises that have been identified in relation to the Baumeister limited resource analysis of self-control. The perspective has focused significance in part because it addresses directly two of the three main crisis concerns – those pertaining to replication and performance incentive moderation of fatigue influence. It also has significance because it suggests a means of addressing the third main crisis concern, pertaining to performance resource perception.

Summary and Parting Thoughts

We have described an emerging analysis of fatigue influence on behavioral restraint and considered its potential significance for two central concerns of contemporary restraint investigators: (1) adverse health effects of restraint, and (2) fatigue influence on self-control. Regarding health, the intensity aspect of the behavioral restraint extension constitutes an elaborated conceptual framework – or roadmap – for anticipating restraint intensity and therefore health risk. The cardiovascular aspect of the analysis draws attention to a pathological pathway through which restraint could generate some health outcomes. In doing so, it offers a means of refining health risk prediction through application of the restraint intensity roadmap. Regarding self-control, the behavioral restraint extension conveys a distinctive perspective on fatigue influence that (1) holds potential for improving markedly our capacity to predict self-control outcomes, and (2) has focused significance for crises that have been identified in relation to the influential limited resource analysis of self-control developed by Baumeister and colleagues. The perspective addresses directly two of three main crisis concerns and suggests a means of addressing the third.

In concluding, we might convey a set of parting thoughts. One pertains to our present focus on behavioral restraint extension implications for health and self-control. These implications are important, but not the only ones that could be considered. By way of example, the cardiovascular aspect of the extension implies that targeted cardiovascular assessments might be used to track behavioral restraint covertly. Covert tracking of restraint could have practical value in a variety of contexts. An obvious case in point would be research contexts. Additional cases might be educational contexts, work contexts, and clinical settings (e.g., allowing improved assessments regarding chronic fatigue).

A second, related, parting thought pertains to the proposed link between behavioral restraint and beta-adrenergic cardiovascular responsiveness. There are firm grounds for expecting this. However, the link has yet to be persuasively demonstrated and it is doubtful that beta-adrenergic cardiovascular adjustments will ever be shown to be infallible restraint markers. Cardiovascular adjustment is enormously complex and numerous complexities are not fully understood, including ones involving non-sympathetic nervous system influence. Proper interpretation of cardiovascular responses in restraint contexts will always require at least modest biological sophistication as well as appreciation of relevant autonomic and hemodynamic processes (Gendolla, 2017; Inzlicht & Marcora, 2016).

A third parting thought pertains to the specificity of fatigue influence in relation to behavioral restraint. As discussed earlier, we assume that fatigue influences have potential for being localized or expansive. This is not to say though that we favor the Baumeister suggestion that inhibitory system fatigue influence might be highly specific, with short-term restraint increasing the difficulty of resisting new impulses, but not the difficulty of achieving other purposes. To our knowledge, evidence relevant to this suggestion is mixed, at best. Further, the idea is difficult to test in light of ambiguities that have been identified regarding what does and does not constitute an inhibitory (regulatory) challenge, following the original Baumeister limited resource reasoning (Lurquin & Miyake, 2017). Experiments in our laboratory have not focused on this issue, but have occasionally crossed the regulatory-nonregulatory boundary in evaluating fatigue influence – employing challenges with weaker or stronger inhibitory components (Stewart et al., 2009; Wright, Stewart, & Barnett, 2008). To date, findings have converged in indicating non-specificity. That is, they have converged in indicating that mental fatigue has the same influence on cardiovascular response regardless of how it was induced and regardless of the inhibitory character of the follow-up mental challenge. In light of these and other findings, we believe that the original suggestion regarding the specificity of inhibitory system fatigue influence was likely misguided. However, additional studies with sharper, more definitive procedures could prove us wrong.

A final parting thought pertains to the future of the Baumeister limited resource analysis. Crisis concerns have led some investigators to conclude that it is time to discard the analysis, e.g., chalking its empirical support up to limited study designs, misguided interpretation, and a measure of publication bias. The present behavioral restraint extension goes against this grain. It suggests that the analysis might wisely be retained and afforded the chance to mature – among other things, incorporating elaborated effort components. Maturation could allow the limited resource analysis not only to survive, but to thrive, approaching more closely its productive potential.

References

Ackerman, P.L. (2011). *Cognitive fatigue: Multidisciplinary perspectives on current research and future applications*. Washington DC: APA Press.

Ackerman, P.L. & Kanfer, R. (2009). Test length and cognitive fatigue: An empirical examination of effects on performance and test-taker reactions. *Journal of Experimental Psychology: Applied*, *15*, 163–181. doi: 10.1037/a0015719

Agtarap, S.D., Wright, R.A., Mlynski, C., Hammad, R. & Blackledge, S. (2016). Success importance and urge magnitude as determinants of cardiovascular response to a behavioral restraint challenge. *International Journal of Psychophysiology*, *102*, 18–24. doi: 10.1016/j.ijpsycho.2016.03.004

Basu, N., Yang, X., Luben, R.N., Whibley, D., MacFarland, G.J., Wareham, N.J., Khaw, K., & Myint, P.K. (2016). Fatigue is associated with excess mortality in the general population: Results from the EPIC-Norfolk study. *BMC Medicine*, *14*, 122 doi: 10.1186/s12916-016-0662-y

Baumeister, R.F., & Heatherington, T.F. (1996). Self-regulatory failure: An overview. *Psychological Inquiry*, *7*, 1–15.

Brehm, J.W., & Self, E. (1989). The intensity of motivation. In: M.R. Rozenweig and L.W. Porter (Eds.), *Annual Review of Psychology* (pp. 109–131). Palo Alto: Annual Reviews, Inc. doi: 10.1146/annurev.ps.40.020189.000545

Brehm, J.W., Wright, R.A., Solomon, S., Silka, L., & Greenberg, J. (1983). Perceived difficulty, energization, and the magnitude of goal valence. *Journal of Experimental Social Psychology*, *19*, 21-48. doi: 10.1016/0022-1031(83)90003-3

Brickenkamp, R. (1981). *Test d2* (7th ed.) Göttingen, Germany: Hogrefe.

Brownley, K.A., Hurwitz, B.E., & Schneiderman, N. (2000). Cardiovascular psychophysiology. In: J.T. Cacioppo, L.G. Tassinary, G.G. Berntson, *Handbook of Psychophysiology* (pp. 224–264). New York: Cambridge.

Carter, E.C., Kofler, L.M., Forster, D.E., & McCullough, M.E. (2015). A series of meta-analytic tests of the depletion effect: self-control does not seem to rely on a limited resource. *Journal of Experimental Psychology: General*, *144*, 796–815. doi: 10.1037/xge0000083

Carter, E.C., & McCullough, M.E. (2013). Is ego depletion too incredible? Evidence for the overestimation of the depletion effect. *Behavioral and Brain Sciences*, *36*, 683–684. http://dx.doi.org/10.1017/S0140525X13000952

Clarkson, J.J., Hirt, E.R., Chapman, D.A., & Jia, L. (2011). The impact of illusory fatigue on executive control: Do perceptions of depletion impair working memory capacity? *Social Psychological and Personality Science*, *2*, 231–238. doi: 10.1177/1948550610386628

Clarkson, J.J., Hirt, E.R., Jia, L., & Alexander, M.B. (2010). When perception is more than reality: The effects of perceived versus actual resource depletion on self-regulatory behavior. *Journal of Personality and Social Psychology*, *98*, 29–46.

Clarkson, J.J., Otto, A.S., Hassey, R.V., & Hirt, E.R. (2016). Perceived mental fatigue and self-control. In: E.R. Hirt, J.J. Clarkson, & L. Jia (Eds.), *Self-regulation and ego control*. New York: Elsevier.

Davidson, K.W. (1993). Suppression and repression in discrepant self-other ratings: Relations with thought control and cardiovascular reactivity. *Journal of Personality*, *61*, 669–691.

Fairclough, S.H., & Graham, R. (1999). Impairment of driving performance caused by sleep deprivation or alcohol: A comparative study. *Human Factors*, *41*, 118–128.

Gendolla, G.H.E. (2017). The psychophysiology of motivation: Body and brain in action. *International Journal of Psychophysiology*, in press.

Gendolla, G.H.E., Wright, R.A., & Richter, M. (2012). Effort intensity: Some insights from the cardiovascular system. Chapter in: R.A. Ryan (Ed.), *Oxford handbook of human motivation* (pp. 420–438). New York: Oxford University Press. doi: 10.1093/oxfordhb/9780195399820.013.0024

Gross, J.J. (1998). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology*, *74*, 224–237. doi: 10.1037/0022-3514.74.1.224

Gross, J.J., & Levenson, R.W. (1993). Emotional suppression: Physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology*, *64*, 970–986. doi: 10.1037/0022-3514.64.6.970

Gross, J.J., & Levenson, R.W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. *Journal of Abnormal Psychology*, *106*, 95–103.

Hagger, M.S., Chatzisarantis, N.L.D., Alberts, H., Angonno, C.O., Batailler, C., Birt, A., et al. (2016). A multi-lab pre-registered replication of the ego-depletion effect. *Perspectives in Psychological Science*, *11*, 546–573. doi: 10.1177/1745691616652873

Higgins, E.T. (2006). Value from hedonic experience and engagement. *Psychological Review*, *113*, 439–460.

Hockey, G.R.J. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive–energetical framework. *Biological Psychology*, *45*, 73–93.

Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual systems perspective. *Perspectives on psychological science*, *4*, 162–176.

Inzlicht, M. & Marcora, S.M. (2016). The central governor model of exercise regulation teaches us precious little about the nature of mental fatigue and self-control failure. *Frontiers in Psychology*, *7*, 656–660.

Inzlicht, M. & Schmeichel, B.J. (2012). What is ego-depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives of Psychological Science*, *7*, 450–463.

Inzlicht, M., & Schmeichel, B.J. (2016). Beyond limited resources: Self-control failure as the product of shifting priorities. In: K. Vohs & R. Baumeister (Eds.), *Handbook of self-regulation* (pp. 165–181) (3rd edition). New York: Guilford Press.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice-Hall.

Kelly, C.L., Crawford, T.J., Gowen, E., Richardson, K. & Sünram-Lea, S.I. (2017). A temporary deficiency in self-control: Can heightened motivation overcome this effect? *Psychophysiology*, *54*, 773–779.

Kelsey, R.M. (2012). Beta-adrenergic cardiovascular reactivity and adaptation to stress: The cardiac pre-ejection period as an index of effort. In: R.A. Wright & G.H.E. Gendolla (Eds.), *How motivation affects cardiovascular response: Mechanisms and applications* (pp. 43–60). Washington DC: APA Press. doi: 10.1007/978-1-4613-9564-5_10

Krantz, D.S. & Manuck, S.B. (1984). Acute psychophysiologic reactivity and risk of cardiovascular disease: A review and methodologic critique. *Psychological Bulletin*, *96*, 435–464. http://dx.doi.org/10.1037/0033-2909.96.3.435

Kukla, A. (1972). Foundations of an attributional theory of performance. *Psychological Review*, *79*, 454–470.

Kurzban, R., Duckworth, A.L., Kable, J.W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioral and Brain Sciences*, *36*, 661–679.

Lurquin, J.H., & Miyake, A. (2017). Challenges to ego-depletion research go beyond the replication crisis: A need for tackling the conceptual crisis. *Frontiers in Psychology*, *8*, 568–572. https://doi.org/10.3389/fpsyg.2017.00568

Meyer, W.U. (1987). Perceived ability and achievement-related behavior. In: F. Halisch & J. Kuhl (Eds.). *Motivation, intention, and volition*. Berlin: Springer-Verlag.

Mischel, W. (2014). *The marshmellow test*. New York: Little-Brown.

Mlynski, C., Wright, R.A., Agtarap, S.D., & Rojas, J. (2017). Naturally occurring fatigue and cardiovascular response to a simple memory challenge. *International Journal of Psychophysiology*, in press.

Muraven, M.B., & Baumeister, R.F. (2000). Self-regulation and the depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin*, *126*, 247–259.

Muraven, M.B., & Slessareva, E. (2003). Mechanisms of self-control failure: Motivation and limited resources. *Personality and Social Psychology Bulletin*, *29*, 894–906. doi: 10.1177/0146167203029007008

Newsholme, E.A., Blomstrand, E., & Ekblom, B. (1992). Physical and mental fatigue: Metabolic mechanisms and importance of plasma amino acids. *British Medical Bulletin*, *48*, 477–95.

Obrist, P.A. (1976). The cardiovascular-behavioral interaction as it appears today. *Psychophysiology*, *13*, 95–107. doi: 10.1111/j.1469-8986.1976.tb00081.x

Obrist, P.A. (1981). *Cardiovascular psychophysiology: A perspective*. New York: Plenum Press. doi: 10.1007/978-1-4684-8491-5

Pennebaker, J.W. (1995). *Emotion, disclosure and health*. Washington DC: American Psychological Association. doi: 10.1037/10182-015

Pennebaker, J.W., Kiecolt-Glaser, J.K., & Glaser, R. (1988). Disclosure of traumas and immune function: Health implications for psychotherapy. *Journal of Consulting and Clinical Psychology*, *56*, 239–245. doi: 10.1037/0022-006X.56.2.239

Polivy, J. (1998). The effects of behavioral inhibition: Integrating internal cues, cognition, behavior, and affect. *Psychological Inquiry*, *9*, 181–204. doi: 10.1207/s15327965pli0903_1

Richter, M., Gendolla, G.H.E., & Wright, R.A. (2016). Three decades of research on motivational intensity theory: What we have learned about effort and what we still don't know. *Advances in motivation science*, *3*, 149–186. doi: 10.1016/bs.adms.2016.02.001

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, *69*, 379–399.

Smith, T.W., & Ruiz, J.M. (2002). Psychosocial influences on the development and course of coronary heart disease: Current status and implications for research and practice. *Journal of Consulting and Clinical Psychology*, *7*, 548–568.

Stewart, C.C., Wright, R.A., Hui, S.A., & Simmons, A. (2009). Outcome expectancy as a moderator of mental fatigue influence on cardiovascular response. *Psychophysiology*, *46*, 1141–1149. doi: 10.1111/j.1469-8986.2009.00862.x

Wright, R.A. (1996). Brehm's theory of motivation as a model of effort and cardiovascular response. In: P.M. Gollwitzer & J.A. Bargh (Eds.), *The psychology of action: Linking cognition and motivation to behavior* (pp. 424–453). New York: Guilford.

Wright, R.A. (1998). Ability perception and cardiovascular response to behavioral challenge. In: M. Kofta, G. Weary, & G. Sedek (Eds.), *Control in action: Cognitive and motivational mechanisms* (pp. 197–232). New York: Plenum. doi: 10.1007/978-1-4757-2901-6_8

Wright, R.A. (2014). Presidential address: Fatigue influence on effort – considering implications for self-regulatory restraint. *Motivation and Emotion*, *38*, 183–195. doi: 10.1007/s11031-014-9406-5

Wright, R.A. (2016). Motivation theory essentials: Understanding motives and their conversion into effortful goal pursuit. *Motivation and Emotion*, *40*, 16–21. doi: 10.1007/s11031-015-9536-4

Wright, R.A. & Agtarap, S.D. (2015). The intensity of behavioral restraint: Determinants and cardiovascular correlates. Chapter in: G.H.E. Gendolla, S. Koole, & M. Tops, (Eds.), *Biobehavioral foundations of self-regulation*. New York: Springer.

Wright, R.A., & Brehm, J.W. (1989). Energization and goal attractiveness. In: L.A. Pervin (Ed.), *Goal concepts in personality and social psychology.* Hillsdale, NJ: Erlbaum.

Wright, R.A., & Dill, J.C. (1993). Blood pressure reactivity and incentive appraisals as a function of perceived ability and objective task demand. *Psychophysiology*, *30*, 152–160.

Wright, R.A., & Dismukes, A. (1995). Cardiovascular effects of experimentally-induced efficacy (ability) appraisals at low and high levels of avoidant task demand. *Psychophysiology*, *32*, 172–176.

Wright, R.A., & Franklin, J. (2004). Ability perception determinants of effort-related cardiovascular response: Mood, optimism, and performance resources. In: R.A. Wright, J. Greenberg, & S.S. Brehm (Eds.), *Motivational analyses of social behavior: Building on Jack Brehm's contributions to psychology*. Hillsdale, NJ: Erlbaum.

Wright, R.A., & Kirby, L.D. (2001). Effort determination of cardiovascular response: An integrative analysis with applications in social psychology. In: M.P. Zanna (Ed.), *Advances in experimental social psychology* (vol. 33, pp. 255–307). San Diego, CA: Academic Press.

Wright, R.A., Martin, R.E., & Bland, J.L. (2003). Energy resource depletion, task difficulty, and cardiovascular response to a mental arithmetic challenge. *Psychophysiology*, *40*, 98–105.

Wright, R.A., Murray, J.B., Storey, P. & Williams, B.J. (1997). Ability analysis of gender relevance and sex differences in cardiovascular response to behavioral challenge. *Journal of Personality and Social Psychology: PPID*, *73*, 405–417.

Wright, R.A., Patrick, B.M., Thomas, C., & Barreto, P. (2013). When fatigue promotes striving: Confirmation that success importance moderates resource depletion influence on effort-related cardiovascular response. *Biological Psychology*, *93*, 316–324. dx.doi.org/10.1016/j.biopsycho.2013.02.016

Wright, R.A., Shim, J.J., Hogan, B.K., Duncan, J. & Thomas, C. (2012). Interactional influence of fatigue and task difficulty on cardiovascular response: Demonstrations involving an aerobic exercise challenge. *Psychophysiology*, *49*, 10–49–1058. doi: 10.1111/j.1469-8986.2012.01390.x

Wright, R.A. & Stewart, C.C. (2012). Multifaceted effects of fatigue on effort and associated cardiovascular responses. Chapter in: R.A. Wright & G.H.E. Gendolla (Eds.) *How motivation affects cardiovascular response: Mechanisms and applications*. Washington DC: APA Press.

Wright, R.A., Stewart, C.C., & Barnett, B.R. (2008). Mental fatigue influence on effort-related cardiovascular response: Extension across the regulatory (inhibitory)/non-regulatory performance dimension. *International Journal of Psychophysiology*, *69*, 127–133. doi: 10.1016/ijpsycho.2008.04.002.

Wright, R.A., Wadley, V.G., Pharr, R.P., & Butler, M. (1994). Interactive influence of self-reported ability and avoidant task demand on anticipatory cardiovascular responsivity. *Journal of Research in Personality*, *28*, 68–86.