CHAPTER FIVE

Three Decades of Research on Motivational Intensity Theory: What We Have Learned About Effort and What We Still Don't Know

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Contents

Abstract

Brehm's motivational intensity theory has been a fruitful conceptual framework for research on effort during the last three decades. Researchers have used the theory to address various effort-related phenomena, like the impact of ability, affect, and

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fatigue on effort mobilization. In this chapter, we provide an overview of development in the last 10 years focusing on research that has addressed (1) the energy conservation principle, (2) ability and fatigue effects, and (3) the impact of mood, dysphoria, and primed affect. We point out that most of the research has supported the predictions of the theory and its extensions and applications. However, we also elaborate on empirical findings that do not fit the theory and discuss open questions that need to be addressed in future research.

1. INTRODUCTION

Motivation science is concerned with the processes and mechanisms underlying the initiation, direction, persistence, and intensity of behavior (Geen, 1995). Three questions broadly define its scope: Which factors and mechanisms determine the selection and initiation of behavior? Which determine task persistence and task disengagement? Which underlie the investment of resources to carry out behavior? Jack Brehm's motivational intensity theory (Brehm, 1975; Brehm & Self, 1989; Wright & Brehm, 1989) addresses the last question. The theory's predictions regarding effort mobilization have been extensively examined in the last 30 years using various types of manipulations, tasks, and measures. The first 20 years of research were mainly concerned with the theory's basic predictions and have been reviewed in other publications (eg, Gendolla, Wright, & Richter, 2012; Wright, 1996; Wright & Kirby, 2001). In this chapter, we provide an overview of more recent developments. After introducing the theory and discussing the role of cardiovascular measures in the empirical research on it, we discuss recent research on the impact of ability and fatigue on effort, research on the impact of affective states and implicit affect–related stimuli on effort, and research that tested motivational intensity theory's predictions with regard to a physical task.

2. MOTIVATIONAL INTENSITY THEORY

Motivational intensity theory (Brehm & Self, 1989; Wright & Brehm, 1989; see also Wright, 2008; and Richter, 2013; for recent discussions of the theoretical aspects of the theory) explains effort mobilization in goal pursuit. Brehm defined effort as the investment of resources that enable the execution of behavior, arguing that it functions to sustain activity that is needed for goal attainment. He also suggested that effort investment is primarily governed by a resource (or energy) conservation principle: given that resources are important for survival, individuals are motivated to avoid wasting them and aim at investing only those that are required for successful task execution. That is, people seek to avoid investing more than is required because this would waste resources. Motivational intensity theory derives from this fundamental prediction specific hypotheses for effort in situations (1) where task difficulty is known, (2) where it is unknown, and (3) where it can be chosen by the individual.

2.1 Effort in Tasks With Known and Fixed Difficulty

Individuals aiming to conserve resources need an indicator of the amount of resources required for successful task execution. According to motivational intensity theory, task difficulty provides this information: the higher the difficulty, the higher the amount of required resources. Individuals should thus use task difficulty information to estimate the required resources and effort should be a function of perceived task difficulty.

Using task difficulty to determine resource requirement does not, however, guarantee that no resources are wasted. If one invests effort in a very difficult task where success is impossible, resources would be wasted. The same holds if one invests effort in a task where the costs outweigh the potential benefits (ie, if the importance of task success is not high enough to justify the required effort). It is evident that the resource conservation principle requires a limitation of the proportional relationship between task difficulty and effort. Motivational intensity theory consequently predicts that effort is only a function of task difficulty if task success is possible and if the required effort is justified by success importance (the theory uses the term potential motivation to refer to the maximum amount of effort that is justified for task success). As displayed in Panels A and B of Fig. 1, effort should always be a direct function of task difficulty. Success importance—and any variable like need or incentive value that affects success importance—should not have a direct impact on effort. It should only define the range of difficulty levels within which the proportional relationship between task difficulty and effort holds.

Given that individuals can only use task difficulty as an indicator of required effort if difficulty information is available, the described predictions only apply to effort investment in tasks where difficulty information is at hand. Motivational intensity theory's predictions for tasks where difficulty is unknown differ.

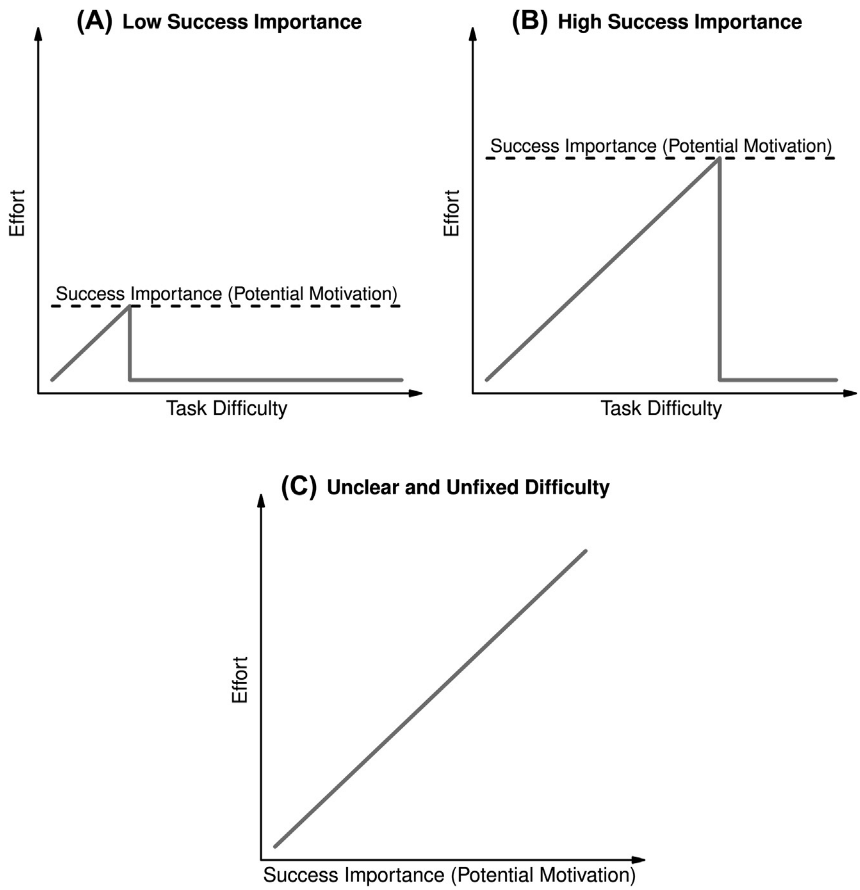

Figure 1 Motivational intensity theory's predictions for tasks with known and fixed difficulty (Panels A and B) and for tasks with unknown and unfixed difficulty (Panel C).

2.2 Effort in Tasks With Unknown (Unclear) Difficulty

As noted, task difficulty is supposed to be a determinant of effort because it enables individuals to avoid wasting resources by providing information about the resources required for task success. If information about task difficulty is lacking—that is, if task difficulty is unknown or unclear—individuals are in need of another indicator that allows them to respect the resource conservation principle. According to motivational intensity theory, success importance constitutes this indicator. Using success importance to govern effort mobilization does not enable individuals to avoid investing more than is required, but it enables them to avoid investing more than is justified. Motivational intensity theory therefore predicts that success importance should determine effort if no task difficulty information is available: the higher success importance, the higher the mobilized effort. Panel C of Fig. 1 shows this prediction.

2.3 Effort in Tasks Where the Individual Can Choose Task Difficulty (Unfixed Difficulty)

In the two task situations described previously, task difficulty was supposed to be fixed at a certain level. Task outcome is dichotomous in these tasks. One can either succeed by attaining the difficulty standard or fail by falling short of it. It makes no difference if one just attains the difficulty standard or if one largely exceeds the standard. The German theoretical driving license exam constitutes an example for a task with a fixed difficulty. If one does not correctly answer the required number of questions, one fails. If one correctly answers the required number, one passes. It does not matter if one correctly answers all questions or only the required number. There is no driving license "with honors."

There are, however, tasks where it is up to individuals to set their own performance standard. In these tasks, difficulty is not fixed but can be chosen by the individual. University exams constitute an example. There is a cutoff that determines if students pass, but it is up to students to decide if they strive for a very good grade or only for a good grade. Motivational intensity theory provides hypotheses for this kind of task by extending its basic predictions through an additional assumption. Brehm postulated that individuals aim in general at attaining their best performance if task difficulty is unfixed. However, given that individuals also aim at avoiding the waste of resources, they should not go for the highest performance level that is possible, but rather for the highest performance level that is both possible and worthwhile (given the level of success importance). They should not set a performance goal for themselves that requires more effort than is justified.

After setting a performance goal, individuals should invest the effort that is required to attain the chosen goal (Brehm & Self, 1989; Eubanks, Wright, & Williams, 2002; Wright, Killebrew, & Pimpalapure, 2002). Task difficulty (ie, the difficulty of attaining the chosen performance goal) is thus the direct determinant of effort—as under conditions of fixed and known task difficulty. However, given that the performance goal is chosen by comparing required effort with success importance, motivational intensity theory predicts that effort is a function of success importance: the higher success importance, the higher the set performance goal (difficulty level) and the higher the effort. The final predictions for tasks with unfixed difficulty are thus similar to the predictions for tasks with unknown difficulty but the underlying mechanisms are different. Motivational intensity theory's predictions for unfixed task difficulty are shown in Panel C of Fig. 1.

2.4 The Origin of Motivational Intensity Theory

A point of historical note is that motivational intensity theory was not developed originally to predict effort. Brehm originally intended to predict changes in the valence of task outcomes (eg, Brehm, 1975; Brehm, Wright, Solomon, Silka, & Greenberg, 1983; Wright & Brehm, 1984, 1989). He hypothesized that the level of energization—the amount of energy mobilized to execute a task—directly determines goal valence (ie, the positive or negative subjective value of the action outcome). The more energy one invests to attain an outcome, the more attractive it is. The more energy one invests to avoid an outcome, the more aversive it appears. The level of energization in turn should be a function of task difficulty, success importance, clarity of task difficulty, and task type as described previously. The theory's predictions on effort mobilization were thus as clear as they are now but effort was not the dependent variable of primary interest in the original formulation of the theory. Rather, effort was an intervening variable, linking task characteristics to goal valence—a process that was rediscovered in social psychology (Higgins, 2006). A summary of the empirical tests of the original theory can be found in Wright and Brehm (1989); see also Wright (2011). However, over the years, researchers—like the authors of this chapter—became more interested in investigating the effort implications of motivational intensity theory than in testing its goal valence predictions.

2.5 Cardiovascular Measures as Indicators of Effort Mobilization

Most of the research on effort mobilization conducted in the context of motivational intensity theory has used indicators of sympathetic impact on the heart to test the theory's predictions. The underlying rationale draws on seminal work by Wright (1996). Wright had studied the work of Obrist (1981), who showed that the sympathetic nervous system responded when individuals actively engaged in tasks where they could control the task outcome by performing well (*active coping tasks* in Obrist's terms). Drawing on Obrist's findings, Wright suggested that increased sympathetic myocardial activity in active coping tasks reflects increased effort investment. Following Wright, most researchers testing motivational intensity theory manipulated parameters of active coping tasks while assessing myocardial sympathetic activity as indicator of changes in effort mobilization.

The notion that effort mobilization is reflected in sympathetic activity on the heart implies that the quality of a cardiovascular measure as an indicator of effort mobilization depends on the link between the cardiovascular measure and myocardial sympathetic activity. Measures that strongly depend on myocardial sympathetic activity are better indicators than measures that are only loosely connected to sympathetic impact. The sympathetic innervation of the heart principally affects two parameters of cardiac performance. First, increases in sympathetic activity increase the pace at which the heart contracts. The heart's pace depends, however, not only on sympathetic activity but also on parasympathetic activity. Consequently, heart rate (HR) is a poor indicator of sympathetic activity (and effort). Increases in HR may be due to increased sympathetic activity but they may also be the result of decreased parasympathetic activity. Moreover, effects of increased sympathetic activity on HR may be masked by parallel, counteracting increases in parasympathetic activity. The second parameter of cardiac performance that is affected by sympathetic activity is the contraction force of the heart muscle. Increased sympathetic activity results in stronger contraction. Given that the impact of the parasympathetic system on the force of myocardial contraction is very weak, assessing myocardial contraction force provides a good indicator of myocardial sympathetic activity (The parasympathetic nervous system contributes significantly to the contraction force of the atria, but atria contribution to cardiac work is negligible under most conditions.).

Researchers examining motivational intensity theory's predictions have consequently relied on cardiovascular measures that reflect the force of myocardial contraction. To date, most studies have used changes in systolic blood pressure (SBP)—the maximum pressure in the vascular system between two consecutive heart beats—to assess effort investment. Blood pressure is a function of HR, stroke volume—the amount of blood ejected with a single heart beat—and total peripheral resistance. As noted, increases in myocardial sympathetic activity lead to increases in myocardial contraction force. If the heart contracts more strongly, more blood is ejected with each heart beat and, consequently, stroke volume increases. The rise of stroke volume leads in turn to increased blood pressure. The effect of the sympathetic-driven increase in stroke volume on blood pressure can, however, be masked by two parallel changes. First, parallel increases in parasympathetic activity may decrease HR and the HR decrease may counteract the effect of the increased stroke volume. Second, decreases in peripheral resistance may also counteract the effect of increased stroke volume and mask increases in myocardial sympathetic activity. Given that SBP is less affected by changes in peripheral resistance than diastolic blood pressure (DBP) — the minimum pressure in the vascular system between to heart beats—(Segers, Steendijk, Stergiopulos, & Westerhof, 2001), SBP is a more sensitive indicator of changes in myocardial sympathetic activity than DBP.

More recent studies on motivational intensity theory have used cardiac pre-ejection period (PEP) to assess myocardial sympathetic activity and effort. PEP—the time interval between the onset of ventricular depolarization and the opening of the aortic valve—is probably the most reliable noninvasive indicator of sympathetic impact on the heart that is currently available. It is a direct indicator of changes in the force of myocardial contraction (Newlin & Levenson, 1979; Sherwood et al., 1990) and depends far less on parasympathetic impact or peripheral resistance than blood pressure. Increases in myocardial sympathetic activity increase the force of contraction and decrease PEP.

3. EMPIRICAL RESEARCH ON THE THEORY

Empirical research on motivational intensity theory can be grouped into two categories. Some studies were concerned with basic predictions focusing on (1) the impact of task difficulty under situations of clear and fixed task difficulty, (2) the joint impact of task difficulty and success importance under conditions of clear task difficulty, and (3) the impact of success importance under conditions of unclear and unfixed task difficulty. A second group of studies was concerned with the application of the theory to various phenomena. The common element of these extensions of motivational intensity theory is that they examined variables that exert their impact on effort by means of changing task difficulty or success importance.

3.1 Studies on the Theory's Basic Predictions

A large portion of the existing cardiovascular studies on the basic predictions have already been extensively reviewed (Brehm & Self, 1989; Gendolla & Wright, 2005; Gendolla & Richter, 2009; Gendolla, Wright, et al., 2012; Richter, 2012; Wright, 1996). We therefore only briefly describe exemplary work for the cardiovascular research on the basic predictions, and discuss in more detail a recent development that draws on muscle force data to test motivational intensity theory's predictions.

3.1.1 Cardiovascular Studies

A study by Richter, Friedrich, and Gendolla (2008) provides an example of the research that demonstrated that effort mobilization is determined by task difficulty if this difficulty is known and fixed. Participants performed a modified Sternberg short-term memory task while cardiovascular activity was assessed. During the task, four random capital letters were presented on the screen for 1000 ms (easy condition), 550 ms (moderately difficult condition), 100 ms (difficult condition), or 15 ms (impossible condition). After the presentation of the four letters, a single letter was presented and participants had to decide if this letter was included in the preceding four letters series. Before performing the critical task trials, participants performed practice trials to learn about the difficulty of the task. The results showed that PEP and SBP reactivity—the change from rest to task performance—increased across the first three difficulty levels. In the impossible condition, PEP and SBP reactivity were low and task-related PEP and SBP values did not differ from values at rest. Richter and colleagues' results thus supported motivational intensity theory's prediction that effort increases as a function of task difficulty if task success is possible but drops if task success is impossible.

An empirical demonstration of the interaction between task demand and success importance can be found in Wright, Shaw, and Jones (1990, Experiment 1). Participants could avoid a mild noise (low importance) or severe noise (high importance) by memorizing two or 14 nonsense trigrams, respectively, in 2 min. Blood pressure and HR were assessed immediately before and during the memory task period. Analysis revealed the predicted interaction between difficulty and importance. If the noise was severe (and success importance high), SBP and HR responses rose from the easy to the difficult memory task condition. However, if the noise was mild (and success importance low), these responses were low irrespective of memory task difficulty.

Evidence supporting motivational intensity theory's predictions for tasks with unclear difficulty can be found in Richter and Gendolla (2009). The authors asked participants to perform a delayed-matching-to-sample task. Participants had to memorize a pattern of light gray dots and compare it to a second pattern of light gray dots. The number of gray dots varied from trial to trial making it impossible for participants to know the difficulty of the next trial. Participants also learned that they could earn 1 Swiss franc (about 1 US dollar), 15 Swiss francs, or 30 Swiss francs by successfully performing the task. To make the difficulty of the task unclear, investigators informed participants that the number of correct trials required for earning the monetary reward would be determined randomly and could range between 1 and 28 (100%) trials. PEP, SBP, DBP, and HR were assessed at rest and during task performance. PEP (and to a lesser extent SBP) showed the predicted effect of reward value: the higher the reward value, the higher the PEP (SBP) reactivity.

Another experiment, by Wright, Killebrew, and Pimpalapure (2002, Experiment 2), provided evidence for the predicted impact of success importance under conditions of unfixed task difficulty. Participants performed a letter-scanning task where they could earn either 0.01 or 0.05 US dollar for every two "E"s correctly identified. Participants received sheets containing upper-case letters arranged in blocks and were instructed to either circle exactly one "E" when a tone was presented (fixed task difficulty condition) or to circle "E"s as long as the tone was presented (unfixed difficulty condition). SBP reactivity differed as a function of reward value in the unfixed difficulty condition. In the fixed task difficulty condition, SBP reactivity was low and independent of reward value.

3.1.2 Hand Grip Studies

Richter (2013, 2015) pointed out that one of the basic predictions of motivational intensity theory has not been addressed by the cardiovascular studies. According to the resource conservation principle, individuals should invest exactly the amount of resources that are required for task success. They should not invest more—because this would waste resources—and they should not invest less—because in this case they would not be able to successfully execute the task. Empirical research has not directly addressed this hypothesis, so far. One reason for the lack of research activity is the cardiovascular measures that have been used in most relevant studies. A test of the hypothesis that only the required effort is invested calls for a comparison of the invested effort with the required effort. Cardiovascular measures enable the assessment of invested effort, but they do not enable the quantification of required effort. If one observes in a task that a participant has a PEP decrease of 10 ms, it is unclear if this decrease was required or if the participant would also have been able to succeed with a less strong decrease.

There is, however, an alternative paradigm that enables the comparison of required and invested resources. The muscle force that is exerted in isometric tasks (ie, tasks where muscle length does not change during contraction) is proportional to the amount of adenosine triphosphate (ATP) that is used for muscle contraction (eg, Boska, 1994; Jeneson, Westerhoff, Brown, Van Echteld, & Berger, 1995; Potma, Stienen, Barends, & Elzinga, 1994; Russ, Elliott, Vandenborne, Walter, & Binder-Macleod, 2002; Szentesi, Zaremba, van Mechelen, & Stienen, 2001). Given that ATP is the primary fuel of muscle contraction, assessing the force exerted in such tasks provides information about the amount of invested resources. If a participant exerts in one trial a force of 90 N and in the next trial—under the same conditions—a force of 120 N, it is likely that she or he consumed more ATP in the second trial than in the first trial. Moreover, if an exerted force of 90 N would have been sufficient to succeed in the second trial, the participant exerted a higher force and more energy than required. Comparing exerted force with the force required for task success thus enables a comparison of invested and required resources and, correspondingly, a critical test of motivational intensity theory's prediction that individuals only invest the effort that is required.

In one of the first studies that employed this new paradigm, Richter (2015) asked participants to imagine that the dynamometer that was used to assess exerted muscle force represented a clogged ketchup bottle and that they would receive a small monetary reward of 0.05 Swiss francs (about 0.05 US dollar) for each trial if they exerted enough force on the ketchup bottle—the dynamometer—to free the bottle. Depending on the respective condition, the force required to free the bottle was either 60, 90, 120, or 150 N. After 20 practice trials that allowed participants to acquire information about exerting the force required to free the bottle, participants performed 30 trials of the ketchup task. If the exerted force during a period of 2 s reached or exceeded the required force, the trial counted as a success and participants received positive feedback—a picture of a bottle ejecting ketchup. The results of this study are displayed in Fig. 2. Replicating the findings of studies on motivational intensity theory that employed cardiovascular measures, effort investment (exerted force) was a function of task difficulty: the higher the required force, the higher the exerted force. However, in contrast to motivational intensity theory's predictions, participants invested considerably more effort than required. This difference was the most visible in the 60 N condition. The required force was 60 N but participants invested more than twice the required force.

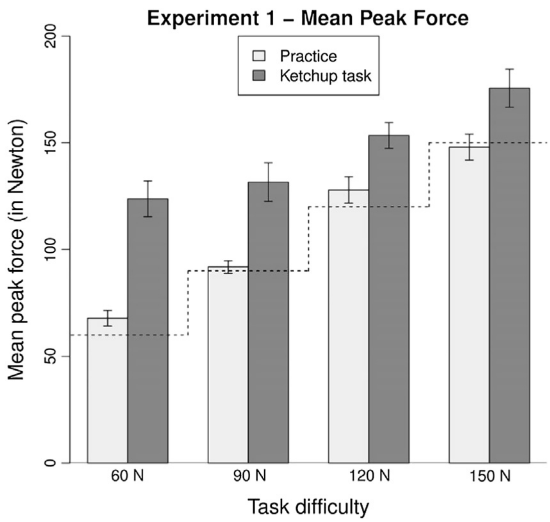

Figure 2 Exerted hand grip force in Study 1 of Richter. *Reprinted from Richter, M. (2015). Goal pursuit and energy conservation: energy investment increases with task demand but does not equal it.* Motivation and Emotion, 39, *25–33. http://dx.doi.org/10.1007/s11031-014-9429-y. Copyright 2015 by Springer. Reproduced with permission.*

Follow-up studies replicated and extended this finding (Richter, 2015; Stanek & Richter, 2015a, 2015b). For instance, Stanek and Richter (2015a, Study 3) compared effort investment in possible and impossible hand grip task trials. In this study, each participant performed five blocks of 20 ketchup task trials. In each block, 15 trials asked for a possible force of 50, 100, or 150 N, whereas five trials had an impossible force standard of 500 N. Exerted muscle force in the last 20 trials of the −100 ketchup task trials, provided mixed evidence for motivational intensity theory. Supporting the theory, participants increased their force across the three possible conditions (from 50 to 150 N). Furthermore, they invested less force in the impossible 500 N condition than in the difficult 150 N condition. The hand grip force data thus showed the sawtooth pattern predicted by motivational intensity theory. However, participants invested considerably more force than required and they reduced effort, but did not really disengage in the impossible condition. Even after having acquired considerable information about task demand by performing 80 trials, participants decided to invest more than required and to engage in impossible trials.

The ketchup task paradigm has also been used to examine the hypothesis that individuals disengage when success importance is not high enough to justify the required effort. In one of these studies (Stanek & Richter, 2015b; Study 4) participants performed the ketchup task under different reward and task difficulty conditions. Participants performed five blocks of 20 ketchup task trials. In each trial, they could earn a reward of 0.01 Swiss francs (low reward, about 0.01 US dollar) or 0.10 Swiss francs (high reward) by successfully attaining a force standard of 130 N (medium difficulty) or 180 N (high difficulty). It was expected that the low reward of 0.01 Swiss francs would not warrant the energy required to successfully perform the 180 N trials—180 N was close to the maximum grip strength of many of the participants—and that participants would therefore disengage and not invest any energy in these trials. The data did not, however, provide evidence for a disengagement. Instead of disengaging, participants invested a considerable amount of energy in the low-reward 180 N trials (mean exerted force was 163 N). It is of note that the hypothesis that participants did not disengage because the required energy was justified in all reward conditions did not provide a satisfactory explanation of the data. The exerted force data provided better evidence for an additive effect of reward value and task difficulty than for the difficulty-main-effect model that motivational intensity theory would predict. According to the theory, task difficulty should be the sole direct determinant of effort if the required effort is justified. Reward value should not have an impact.

In sum, research that has employed the hand grip paradigm to test motivational intensity theory's predictions has provided mixed results. It replicated the task difficulty effects found in preceding research on the theory: exerted force increased as a function of task difficulty if task success was possible, and dropped if task success was impossible. However, the hand grip studies also provided results that challenge motivational intensity theory and preceding research on the theory. First, all 10 conducted hand grip studies (Richter, 2015; Stanek & Richter, 2015a, 2015b) failed to provide evidence for the prediction that individuals invest only the required energy and not more. Participants exerted in most conditions a force that was considerably higher than the required force.

Second, the five hand grip studies on the joint impact of task difficulty and success importance did not show the predicted disengagement when low success importance was combined with extremely high task difficulty. This is in sharp contrast to most of the cardiovascular studies that have examined the impact of task difficulty and success importance (eg, Brinkmann & Gendolla, 2008; Freydefont, Gendolla, & Silvestrini, 2012; Gendolla & Krüsken, 2002a, 2002b; Gendolla & Richter, 2006a; Richter, Baeriswyl,

& Roets, 2012; Wright, Murray, Storey, & Williams, 1997; Wright et al., 1990; Wright, Williams, & Dill, 1992). These studies found reduced cardiovascular reactivity in the low-reward–high-difficulty conditions. No empirical research has examined the reasons for this difference between the cardiovascular studies and the hand grip studies, so far. We discuss potential explanations in Section 4.

3.2 Extensions and Applications of Motivational Intensity Theory

Extensions and applications of motivational intensity theory can be grouped into three categories. First, there are extensions that focused on variables that exert their impact on effort by means of influencing subjective task difficulty. Wright and colleagues' research on the impact of ability and fatigue (see Wright, 1998; Wright & Barreto, 2012; Wright & Kirby, 2001; Wright & Stewart, 2012; for overviews), Gendolla and colleagues' research on the influence of conscious and implicit affect (see Gendolla, 2012; Gendolla & Brinkmann, 2005; Gendolla, Brinkmann, & Richter, 2007; Gendolla, Brinkmann, & Silvestrini, 2012; Gendolla & Richter, 2004; for overviews), and Brinkmann and colleagues' research on the link between dispositional dysphoria and effort (see Brinkmann & Franzen, 2015; Gendolla, Brinkmann, et al., 2012, for reviews) fall into this category. Second, there is research on variables (ego-involvement, observation, self-awareness, mood regulation, hedonic incentive) whose impact on effort is mediated by success importance. In addition to these two categories of extensions and applications of motivational intensity theory that are in line with the theory's basic predictions described in Section 2, there is also research that has been inspired by this approach, but that does not fit exactly with the theory's framework. The research examining the impact of mood and dysphoria under conditions of unfixed task difficulty and the research on action primes' effect on effort are included in this third category.

3.2.1 Extensions Related to Variables That Affect Task Difficulty

3.2.1.1 Ability and Fatigue Extensions

Wright (Wright, 1998, 2014; Wright & Kirby, 2001) suggested that perceived ability and fatigue have an impact on subjective task difficulty. Individuals who believe they have a high ability in a behavioral area or who experience a low level of fatigue will estimate a certain level of task difficulty as lower than individuals with a low subjective ability or a high level of fatigue. If you are good in math, solving math tasks feels easier and you need less effort to succeed. If you are exhausted, concentrating on a task seems to be more difficult and you need more effort to succeed. Wright suggested that ability and fatigue determine, together with objective task difficulty, how demanding a task appears: the higher the objective task difficulty, the lower the ability, and the higher the level of fatigue, the higher the subjective task difficulty. Following the predictions of motivational intensity theory, effort mobilization for tasks with fixed and clear task difficulty should then be a function of subjective task difficulty as long as the required effort is justified and task success is possible. Fig. 3 displays this prediction.

Representative of studies that have examined ability influences on effort and associated cardiovascular responses is an early experiment that manipulated ability appraisals. Wright and Dill (1993) used a performance feedback procedure to persuade participants first that they had a low- or high-scanning ability. Then the authors presented the participants a related task and told them they could earn a prize by meeting a low- or high-performance (percentile) standard. As expected, SBP responses measured just before and during work were in a crossover interactional pattern, with DBP responses tracking in close parallel. Pressure responsiveness was greater for low-ability participants when the standard was low, but greater for high-ability participants when the standard was high.

Representative of fatigue studies that have been conducted are later experiments by Wright, Martin, and Bland (2003) and Stewart, Wright,

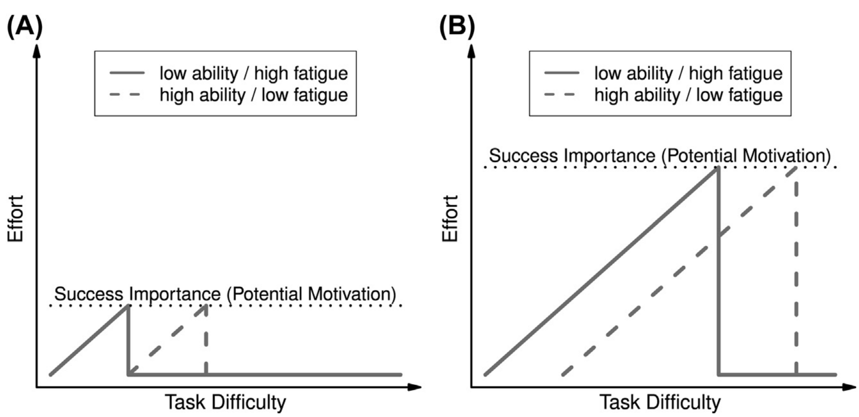

Figure 3 Theoretical predictions for the impact of ability and fatigue on effort under conditions of known and fixed difficulty. (A) Low success importance. (B) High success importance.

Hui, and Simmons (2009). Wright et al. (2003) first had participants perform an easy (fatigue low) or difficult (fatigue high) counting task and then presented the participants mental arithmetic problems with the chance to earn a prize if they attained a low- or high-performance (percentile) standard. Analysis of cardiovascular responses during work revealed a fatigue x standard (difficulty) interaction for SBP, with means in the expected crossover pattern. As expected, responses were stronger for more fatigued participants where difficulty was low, but stronger for less fatigued participants where difficulty was high. In this case, results were similar for mean arterial pressure (MAP—average pressure across a heart cycle) as well as for DBP.

Stewart et al. (2009) first required participants to perform an easy (fatigue low) or difficult (fatigue high) scanning task and then presented them mental arithmetic problems with instructions that they would earn a low (success importance low) or high (success importance high) chance of winning a prize if they did as well as 50% of those who had performed previously. Investigators assumed that extra effort requirements associated with fatigue would be justified when outcome expectancy was high, but not when it was low. Accordingly, they anticipated fatigue augmentation of effort and associated cardiovascular responses under high, but not low, expectancy conditions. Analysis of work responses confirmed this for SBP and revealed similar response patterns for DBP and MAP.

3.2.1.2 Mood and Affect Knowledge Extensions

Similar to Wright's ability and fatigue extensions, Gendolla elaborated on a variable that should exert its impact on effort by affecting subjective task difficulty. He posited in his mood–behavior model (Gendolla, 2000) that moods can influence effort mobilization because of their informational impact—people use their mood as a piece of information and integrate it with all other available information into their behavior-related judgments. He suggested that the use of mood as information to evaluate task difficulty leads to a mood congruency effect: individuals in a negative mood judge task difficulty as higher than individuals who are in a positive mood. Recently, Gendolla (2012) suggested in his implicit-affect-primes-effort model that the mere activation of affect knowledge leads to similar effects. The main difference between the two models is the type and origin of affect-related information that influence subjective task demand. The mood–behavior model applies to experienced feelings and predicts that mood is directly used as information for difficulty judgment. The implicit-affect-primes-effort model applies to stimuli (primes) that activate affect-related knowledge, which then implicitly influences subjective demand.

According to the implicit-affect-primes-effort model, individuals learn that coping with challenges is easier in some affective states than in others. Consequently, performance ease and difficulty become features of peoples' mental representations of different affective states—their emotion concepts (see Niedenthal, 2008). Rendering this knowledge accessible leads to experiences of low or high task demand. More specifically, people should have learned that it feels relatively easy to work on a task if one is happy or angry (high coping potential), while it feels relatively difficult to do so when one feels sad or fearful (low coping potential). That way, ease becomes a feature of people's mental representation of happiness and anger, while difficulty should become a feature of the representations of sadness and fear. Implicitly processed emotional cues that activate these mental representations should thus render the ease and difficulty features accessible, resulting in lower or higher subjective task demand.

Independent of the type and origin of affect-related information, both models draw on motivational intensity theory to predict effort mobilization under conditions of clear and fixed difficulty. Effort should be a direct function of subjective task difficulty—influenced by experienced mood or activated affect-related knowledge—as long as success is possible and the required effort is justified (Fig. 4 shows these predictions).

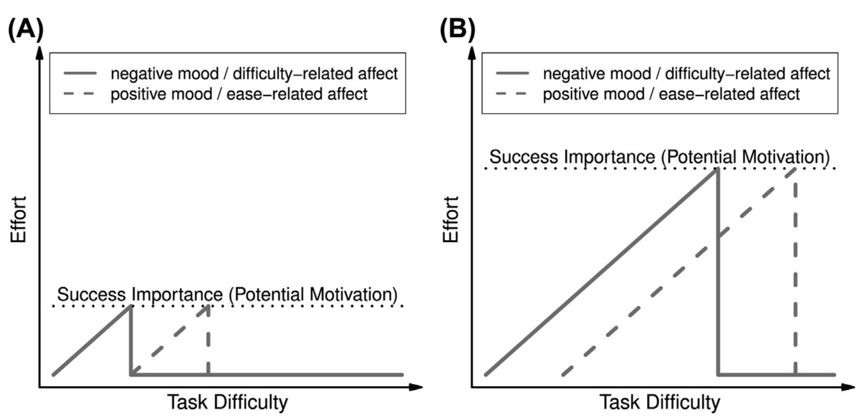

Figure 4 Theoretical predictions for the impact of mood and affect-related knowledge on effort under conditions of known and fixed difficulty. (A) Low success importance. (B) High success importance.

Several studies have tested and supported the extensions made by the mood–behavior model and the implicit-affect-primes-effort model. The first wave of research tested the informational mood impact in studies with manipulated, transient mood states. After assessment of cardiovascular baseline values in a habituation period, participants were first induced into positive or negative moods, using video excerpts, music, or autobiographical recollection of pleasant or unpleasant live events. Next, they worked on a cognitive challenge, typically an attention or memory task. In summary, it was found that moods themselves did not influence cardiovascular reactivity until they could be used as diagnostic information for behavior-related judgments. That is, according to mood manipulation checks, mood was efficiently induced, but did not result in differences in cardiovascular response between the positive and negative mood conditions. This is in line with the mood–behavior model idea that moods themselves are not motivational states and that they thus do not mobilize resources to prepare and carry out actions. However, once participants were confronted with a task and asked to evaluate subjective task demand, mood had the expected informational effects.

When participants performed tasks with fixed performance standards, they used both their mood and the performance standard to appraise demand, resulting in a crossover pattern of mood and difficulty (Gendolla & Krüsken, 2001a). That is, mood had a similar shifting effect on subjective task demand as ability and fatigue in the above-discussed research by Wright and colleagues. More specifically, when being confronted with an objectively easy task, participants showed a stronger SBP response in a negative mood than in a positive mood. This occurred, because subjective demand was evaluated as being higher in a negative mood, resulting in higher effort. By contrast, in objectively difficult tasks, people in a positive mood mobilized more effort than those in a negative mood. This occurred because subjective demand was high but feasible in a positive mood, but excessively high in a negative mood. The excessive subjective demand led to disengagement and thus effort withdrawal.

In studies on the implicit-affect-primes-effort model, participants worked on cognitive tasks during which they processed very briefly flashed pictures of emotional expressions to activate implicit affect. In support of the model, processing sadness primes and fear primes online during performance led to stronger cardiac PEP response than processing happiness primes and anger primes (eg, Gendolla & Silvestrini, 2011; Lasauskaite, Gendolla, & Silvestrini, 2013).

Fig. 5 shows the results of an experiment by Chatelain and Gendolla (2015), in which participants were exposed to pictures of very briefly flashed facial expressions of fear, sadness, or anger during an attention task. As depicted there, implicit fear and sadness led to higher effort (ie, shortened PEP) during task performance than implicit anger.

Beside these simple affect prime effects, it was also found that implicit affect's impact is not stable and can be moderated by task context variables, such as objective difficulty (Chatelain, Silvestrini, & Gendolla, 2016; Freydefont et al., 2012; Lasauskaite Schüppbach, Gendolla, & Silvestrini, 2014; Silvestrini & Gendolla, 2011a; see also Blanchfield, Hardy, & Marcora, 2014): in objectively easy tasks, sadness or fear primes led to stronger PEP responses than happiness or anger primes. However, in objectively difficult tasks, this pattern turned around and processing anger or happiness primes resulted in stronger PEP reactivity than sadness or fear primes. Moreover,

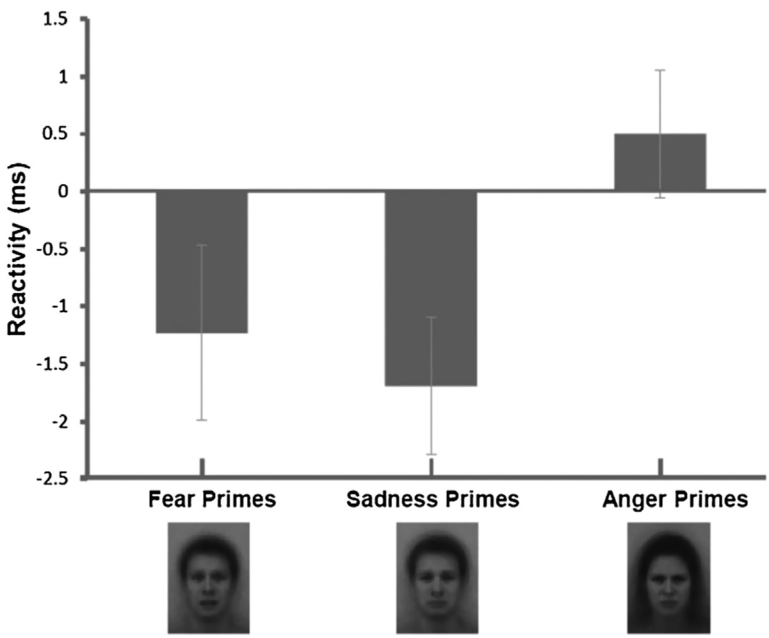

Figure 5 Responses of cardiac pre-ejection period (PEP) during performance of an attention task under exposure to briefly flashed facial expressions of fear, sadness, or anger in Experiment 2 by Chatelain and Gendolla. *Reprinted from Chatelain, M., & Gendolla, G.H.E. (2015). Implicit fear and effort-related cardiac response.* Biological Psychology, 111, *73–82. http://dx.doi.org/10.1016/j.biopsycho.2015.08.009. Copyright by Elsevier. Reproduced with permission.*

high success incentive could eliminate the effort mobilization deficit of people working on an objectively difficult task while being primed with sadness (Chatelain & Gendolla, 2016; Freydefont & Gendolla, 2012).

There is an important difference between the studies on conscious mood states and those on implicit affect. In the latter, there was no evidence that the affect primes that were processed during the tasks induced conscious feelings or that participants were aware of the affect primes' emotional content. That is, the affect primes apparently influenced effort mobilization automatically, without awareness.

3.2.1.3 Dysphoria Extension

Brinkmann and colleagues (Brinkmann & Franzen, 2015; Brinkmann & Gendolla, 2007) applied the reasoning of the mood—behavior model about the impact of experienced mood on effort to analyze the impact of depressive symptoms, especially dysphoria, on effort mobilization. Given that a persistent negative mood is a core symptom of depression, Brinkmann and colleagues hypothesized that the impact of depressive symptoms on effort mobilization is mediated by mood-congruent appraisals of task demand. Dysphoric individuals should in general evaluate task demand as higher than non-dysphoric individuals. This should lead dysphoric individuals to mobilize more effort for easy tasks than non-dysphoric individuals (if the difficulty of a task is known and fixed). However, due to the increased subjective difficulty, dysphoric individuals should disengage at a lower objective difficulty level than non-dysphoric individuals. Consequently, non-dysphoric individuals should mobilize more effort in difficult tasks than (disengaged) dysphoric individuals. Fig. 4 shows these theoretical predictions.

Brinkmann and Gendolla (2008) examined the predicted impact of dysphoria on subjective task demand and effort in two studies. In these studies, dysphoric and non-dysphoric participants performed either an objectively easy or a difficult version of an attention or memory task. The results revealed the expected crossover interaction pattern: in the easy condition, dysphoric participants showed stronger SBP reactivity than non-dysphoric participants. In the difficult task condition, this pattern turned around and non-dysphoric participants showed stronger SBP reactivity than dysphoric participants (Fig. 6). Moreover, demand appraisals assessed before performance indicated that dysphoric participants perceived the memory task as more difficult. In summary, these findings show that depressive symptoms are not necessarily associated with a motivational deficit in effort mobilization and that task difficulty plays an important

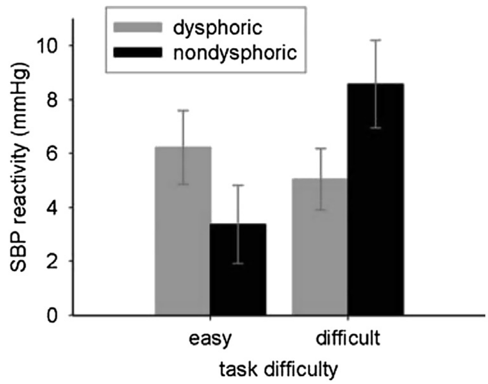

Figure 6 Responses of systolic blood pressure (SBP) during performance on an easy versus difficult memory task in non-dysphoric versus dysphoric individuals in Study 2 by Brinkmann and Gendolla. *Reprinted from Brinkmann, K., & Gendolla, G.H.E. (2008). Does depression interfere with effort mobilization? Effects of dysphoria and task difficulty on cardiovascular response.* Journal of Personality and Social Psychology, 94, *146–157. http://dx.doi.org/10.1037/0022-3514.94.1.146. Copyright by American Psychological Association. Reproduced with permission.*

role in determining whether depression leads to enhanced or attenuated cardiovascular response: when task difficulty is unfixed or easy, dysphoric individuals mobilize even more effort than non-dysphoric individuals. Interestingly, this might explain why people suffering from depressive symptoms sometimes show blunted cardiovascular reactivity and sometimes not (see Salomon, Bylsma, White, Panaite, & Rottenberg, 2013; Schwerdtfeger & Rosenkaimer, 2011).

Brinkmann and colleagues also applied motivational intensity theory to examine the role of reward and punishment in depression. Research on responsiveness to reward and punishment suggests that incentives may not justify high effort in people suffering from depressive symptoms (eg, Henriques & Davidson, 2000). That is, the effects of reward (and punishment) on effort mobilization may differ between dysphorics and non-dysphorics. Integrating the literature on reward and punishment with motivational intensity theory's predictions for unclear task difficulty, Brinkmann and colleagues predicted that non-dysphoric individuals should show stronger effort-related cardiovascular responses than dysphoric individuals in response to rewards offered for success in tasks with unclear difficulty.

Brinkmann, Schüppach, Joye, and Gendolla (2009) conducted two studies that examined the impact of reward and punishment in dysphoria. In the first study, participants could either gain 10 Swiss francs for success (reward) or lose previously received 10 Swiss francs in case of failure (punishment) in a visual attention task. Additionally, there was a control condition without performance-contingent consequences. Results showed that participants' depression scores moderated the effect of the incentive manipulation on SBP reactivity. Low depression scores were associated with increased reactivity in the reward and punishment conditions—with, however, stronger effects of punishment. By contrast, SBP reactivity was modest in general when participants scored high in depression—suggesting insensitivity to anticipated reward and punishment. In the second study, participants could gain a monetary reward or nothing for success on an arithmetic task. Results showed that depression scores again moderated the effect of the incentive manipulation: participants with low depression scores showed stronger reactivity of PEP, SBP, DBP, and HR if they could gain a monetary reward than if they could not. However, participants with high depression scores were insensitive to reward and showed modest cardiovascular responses.

Franzen and Brinkmann (2014) conceptually replicated these studies and found significant reward and punishment effects on PEP and HR during a memory task in non-dysphorics, but not in dysphorics. Another study by Brinkmann and Franzen (2013) focused on monetary reward and found corresponding results: non-dysphoric participants' reactivity of PEP and HR increased with the extent of monetary incentive of success in a short-term memory task of unclear difficulty. By contrast, dysphorics were not sensitive to the reward and showed a modest cardiac response in general. Besides this insensitivity to monetary reward in dysphorics, Brinkmann, Franzen, Rossier, and Gendolla (2014) found that dysphorics were also insensitive to social reward in terms of social approval. While non-dysphorics showed stronger SBP, DBP, and HR reactivity during a cognitive task when they expected to be allowed to enter their name into a "best list" if they performed well, dysphorics did not.

Taken together, these studies suggest that individuals with depressive symptoms cannot be as easily motivated to mobilize effort in order to cope with challenging demands as non-dysphorics. Apparently, increasing the importance of success by reward and punishment is an efficient strategy for motivating nondepressed individuals. But this seems not to work for depressed individuals.

3.2.2 *Extensions Related to Variables That Affect Success Importance*

Applying motivational intensity theory, independent lines of research have examined the impact of ego-involvement, observation, self-awareness, affect regulation, and positive hedonic consequences on effort (see Gendolla & Richter, 2010; Silvia, 2015; for overviews). The common element in this research was that the variables of interest were supposed to exert their impact on effort by means of changing success importance—which in turn should then influence effort mobilization either indirectly (under conditions of known and fixed difficulty) or directly (under conditions of unclear and unfixed difficulty).

Gendolla and Richter (eg, Gendolla, 1998, 1999; Gendolla & Richter, 2005, 2006a) showed that more effort is justified when performance has direct consequences for individuals' self-esteem—for example, if individuals believe that their performance indicates an important ability. Under such conditions, they mobilize high effort for difficult tasks and tasks without fixed performance standard. The same effect occurred when individuals' performance was merely observed (Gendolla & Richter, 2006b) or explicitly socially evaluated (Wright, Dill, Geen, & Anderson, 1998; Wright et al., 2002). Finally, a series of studies investigated effort mobilization under self-evaluation, that is, when people were induced into states of objective self-awareness (Duval & Wicklund, 1972), which typically leads to comparisons of the self with relevant behavioral standards (see Silvia, 2015 for a more detailed overview). Individuals who were reminded of themselves by exposure to a picture of themselves during task performance (Gendolla, Richter, & Silvia, 2008; Silvia, McCord, & Gendolla, 2010; Silvia, Moore, & Nardello, 2014) or who were dispositionally self-conscious (Silvia, Jones, Kelly, & Zibaie, 2011; see also Silvia, Kelly, Zibaie, Nardello, & Moore, 2013) were willing to invest more effort under unfixed or difficult performance conditions than people who were not self-aware. Recently, this effect was extended to implicit self-awareness. People who were exposed to their briefly flashed name during performance showed the same effects as those who were explicitly self-aware (Silvia, 2012).

The role of affect regulation and hedonic consequences was examined by Gendolla and colleagues drawing on the mood–behavior model (Gendolla, 2000). According to this approach, positive and negative mood intensity determines the strength of a hedonic motive, directed to hedonic affect regulation (the directive mood impact). That is, people in an intense negative mood should be interested in mood repair, and people in an intense positive mood should be interested in mood maintenance. This hedonic motive should influence behavioral decisions—what people prefer to do in order to regulate their moods—and how much people are willing to invest in tasks that promise affect regulation. Referring to motivational intensity theory, this should influence potential motivation—the level of maximally justified effort—in that more effort is justified for actions that are highly instrumental for hedonic mood regulation.

A series of studies examined this directive mood impact on effort examining if positive hedonic associations or consequences of tasks result in higher success importance and an increased willingness to invest effort in difficult tasks. Experiments by Silvestrini and Gendolla (2007, 2011b) revealed that people in a negative mood showed stronger SBP and PEP responses in order to repair their moods, because a negative mood resulted in high subjective task demand and the performance-related facilities for hedonic mood regulation justified the high subjectively necessary effort. Additional studies tested the idea that pleasant performance-contingent performance concomitants and consequences can even eliminate the effort mobilization deficit of people facing an objectively difficult task in a negative mood.

The first experiments testing this idea were run by Gendolla and Krüsken (2002c). After being induced into positive versus negative moods with video excerpts, participants worked on an easy or difficult memory task in the first study. Before the task, half of the participants learned that a pleasant relaxation period would follow the memory task irrespective of their achievement. The other half learned that the pleasant relaxation period would follow the performance period *only* if they attained a fixed performance standard—correctly memorizing all items. The latter condition was intended to justify high effort. The results were as expected. When hedonic reward was noncontingent upon success, SBP responses showed the same crossover interaction pattern predicted by the informational mood impact on effort mobilization discussed above (eg, Gendolla & Krüsken, 2001b, 2002a). Negative mood participants tried harder than positive mood participants in the easy condition, but withheld effort in the difficult condition. When the hedonic incentive was contingent upon success, the same pattern emerged in three of the four mood x difficulty conditions. The exception was the negative mood—difficult condition, in which participants now mobilized the highest effort instead of low effort. Apparently, the very high subjectively necessary effort in this condition was mobilized when it was justified by performance-contingent reward. A follow-up experiment that promised exposure to elating materials after success or exposure to depressing materials after failure replicated these findings.

Two later experiments further tested this effect with manipulations that were more clearly focused on the affect regulation facilities of task performance. In one study (Silvestrini & Gendolla, 2009a), participants were either promised the presentation of a comedy video or a distressing video after success on an easy or difficult memory task. Obviously, the positive incentive of a hedonically pleasant video should justify much higher effort for success than the negative hedonic incentive of a distressing video. Another experiment manipulated the hedonic associations of a task itself (Silvestrini & Gendolla, 2009b): participants completed scenario sentences in a positive, pleasant versus negative, unpleasant way. Task difficulty was manipulated by the number of scenarios to complete. Both experiments replicated the basic findings by Gendolla and Krüsken (2002c): Fig. 7 shows the effects of the combined impact of mood, hedonic incentive, and task difficulty on SBP responses during performance in the Silvestrini and Gendolla (2009a) study: when success provided low hedonic incentive or if performance was unpleasant, SBP reactivity revealed the crossover interaction pattern anticipated for the joint effect of mood and objective task difficulty. However, when the hedonic incentive of success was high or if performance was pleasant, SBP reactivity of participants in the negative-mood/difficult-task condition increased significantly, because the very high effort that was

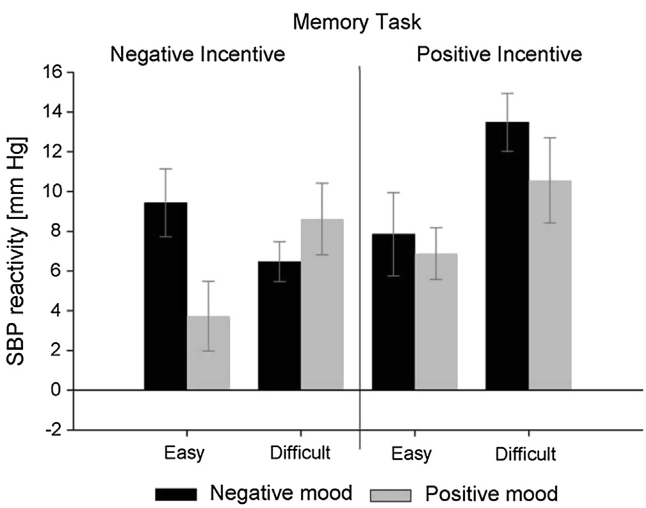

Figure 7 Responses of systolic blood pressure (SBP) during performance on an easy versus difficult memory task in a positive versus a negative mood under conditions of hedonically positive versus negative incentive in the experiment by Silvestrini and Gendolla. *Reprinted from Silvestrini, N., & Gendolla, G.H.E. (2009a). Mood-regulative hedonic incentive interacts with mood and task difficulty to determine effort-related cardiovascular response and facial EMG.* Biological Psychology, 82, *54–63. http://dx.doi.org/10.1016/j.biopsycho.2009.05.005. Copyright by Elsevier. Reproduced with permission.*

perceived as necessary was now justified. Importantly, these findings show that it is not success per se that justifies the mobilization of high effort. Rather, positive hedonic aspects of succeeding are necessary for this.

3.2.3 Extensions and Applications That Conflict With Motivational Intensity Theory's Basic Predictions

Motivational intensity theory has inspired research that resulted in predictions or findings that are difficult to reconcile with motivational intensity theory. In their work on the mood–behavior model, Gendolla and colleagues (eg, Gendolla, Abele, & Krüsken, 2001; Gendolla & Krüsken, 2001a, 2002a) examined the impact of mood on effort mobilization under conditions of unfixed task difficulty. They observed that mood had a mood-congruent impact on subjective task difficulty and that individuals in a negative mood showed stronger SBP reactivity during task performance than individuals in a positive mood. Brinkmann and Gendolla (2007) replicated this result comparing dysphoric and non-dysphoric students. Performing either a memory task or an attention task, students with high scores (dysphoric) on a depression scale showed stronger SBP reactivity than students with low scores (non-dysphoric). The work by Gendolla and colleagues also revealed two boundaries of this effect. First, the effect only occurred when a task was presented as a cognitive challenge but not when it was presented as a filler event that did not necessitate task demand evaluations and effort mobilization (De Burgo & Gendolla, 2009). Second, the effects on task demand and effort were neutralized when the diagnostic value of mood for demand appraisals was called into question by the experimental context (Brinkmann, Grept, & Gendolla, 2012; Gendolla & Krüsken, 2002b).

Even if these findings for the impact of mood and dysphoria under conditions of unfixed task difficulty are in line with the mood–behavior model and the findings for the impact of mood and dysphoria under conditions of known and fixed difficulty, they do not fit well with motivational intensity theory's basic predictions. As outlined in the preceding sections, motivational intensity theory predicts that success importance is the crucial determinant of effort in the task where task difficulty is not fixed. Any effort differences in unfixed difficulty tasks are—according to the theory—due to differences in success importance. This is clearly in conflict with the work by Gendolla and colleagues, who suggested that the effort differences that they observed in unfixed tasks can be explained by differences in subjective task difficulty. It is noteworthy that the findings by Gendolla and colleagues not only conflict with motivational intensity theory's predictions but also conflict with a study by Silvia, Nusbaum, Eddington, Beaty, and Kwapil (2014) who found a negative association between effort-related cardiovascular response and anhedonic depressive symptoms under conditions of unfixed task difficulty. They observed that effort decreased with increasing depressive symptoms and interpreted their result as evidence that success importance is reduced in depression. So far, no empirical or theoretical paper has addressed the mismatch between the findings by Gendolla and colleagues and motivational intensity theory's basic assumptions about effort mobilization when task difficulty is unfixed.

A second line of research that is difficult to reconcile with motivational intensity theory is Gendolla and Silvestrini's work on direct effort priming. Drawing on the ideomotor principle (Hommel, Müsseler, Aschersleben, & Prinz, 2001), Gendolla and Silvestrini (2010) exposed participants to general action and inaction primes during a short-term memory task. They found that the implicit activation of the action concept led to a stronger effort-related PEP response (and faster response times) than the activation of the inaction concept. This effect was replicated by Blanchfield et al. (2014, Study 2) for an effortful physical endurance task.

Silvestrini and Gendolla (2013) identified two boundary conditions, which refer to the resource conservation principle. In one study, action primes led to a stronger PEP response than inaction primes only as long as a cognitive task was feasible, but not if task difficulty was impossible. In another study, action primes resulted in stronger cardiac PEP reactivity and better performance in an arithmetic task when monetary success incentive was relatively high, but not when incentive was low and justified only low effort.

Drawing on these findings, Gendolla and Silvestrini (2015) integrated the ideomotor principle underlying direct effort priming and the resource conservation principle in a bounded automatic effort approach. Accordingly, the resource conservation principle sets limits to the automaticity effect on effort mobilization: automatic effort should only occur as long as success is possible and justified. The implicit activation of the action should increase effort mobilization "automatically," but only as long as success is possible and the necessary effort is justified.

Even if motivational intensity theory and the bounded automatic effort approach both draw on the resource conservation principle, there are substantial differences. Motivational intensity theory builds on the idea of the primacy of resource conservation: individuals aim at avoiding the waste of resources by investing the required effort and not more. The observation that action primes can lead to increased resource investment is in conflict with this basic assumption of motivational intensity theory. Assuming that action primes do not increase the amount of resources required for task success, the increase in effort caused by action primes constitutes an unnecessary waste of resources.

4. SUMMARY AND OPEN QUESTIONS

In the preceding sections we reviewed the main extensions and developments of motivational intensity theory in recent years. The theory's basic predictions have been extensively tested and the theory has been successfully applied to study the impact of various factors in effort mobilization. In most cases, the empirical research has corroborated the predictions derived from motivational intensity theory and its extensions. However two points warrant further elaboration. First, some studies provided unexpected, contradicting results that challenge motivational intensity theory. Second, some research raised new questions that warrant further examination.

As discussed in the section on hand grip studies, two hand grip findings were unexpected and conflicted with motivational intensity theory's predictions. First, the observation that individuals exerted a higher force than required—and consequently wasted energy—conflicts with motivational intensity theory's basic postulate that individuals invest only the energy that is required to successfully perform a task to avoid wasting energy. There are several ways to address this finding. One might speculate that the finding constitutes a methodological artifact. Participants might have had problems to estimate correctly both the force that they were exerting and the force that they had to exert. For this reason, they might have failed to exert the required force. However, if this was true, participants should not have consistently exerted a higher force. One would have expected participants to show some variation: some participants would exert a higher force than required, others would exert less than required. Alternatively, one might propose post hoc explanations for the finding. For instance, one might suggest that the difference in resources required to exert a low or a high force was so low that participants did not care about adapting their force level. However, this explanation conflicts with the observation that participants adapted their force as a function of task difficulty. If energy conservation concerns did not play a role in the hand grip task, participants' exerted force should not have differed between task difficulty levels. An alternative post-hoc explanation is that participants exerted a higher force than required to assure success. This explanation is sound but it does not help to bring the findings in line with motivational intensity theory, given that the theory does not include a factor that refers to the motive to assure task success.

The second finding coming from the hand grip studies that was unexpected is the observation that task difficulty and success importance had an additive effect on effort mobilization and not the predicted interactive effect. This result not only conflicts with motivational intensity theory, it also conflicts with the cardiovascular studies that consistently provided evidence for the interaction. In particular, the cardiovascular studies frequently observed a reduction in effort investment—sometimes even full disengagement—in the highest difficulty condition compared to lower difficulty levels. The hand grip studies failed to provide evidence for this. Even if participants were asked to perform an impossible task, they invested a considerable amount of effort to perform it. Again, one might speculate that methodological aspects caused the finding. Participants might not have dared to completely disengage from the task because they assumed that the experimenter expected them to perform the task.

Instead of speculating about the reasons for the failure to provide evidence for the primacy of resource conservation and disengagement, it seems more promising to focus on two options in future research. One may conduct studies that aim at providing evidence for the hypothesis that individuals invest exactly the required effort using alternative measures and designs. Alternatively, one may develop a new theoretical framework that can account for the findings of the hand grip tasks as well as all the preceding cardiovascular findings that could be successfully explained by motivational intensity theory.

As pointed out, the cardiovascular studies also resulted in two lines of research that are difficult to reconcile with motivational intensity theory. First, the work by Gendolla, Brinkmann, and colleagues on mood and dysphoria impact in tasks with unfixed difficulty led to results that do not fit well. They found mood/dysphoria effects on effort that were mediated by task difficulty, whereas motivational intensity theory would have predicted effects mediated by success importance. Second, the work by Gendolla and Silvestrini on the influence of action primes on effort also challenges motivational intensity theory. According to the theory, task difficulty should be the sole determinant of effort in tasks with fixed and known difficulty. Other factors should be either irrelevant or set the upper limit of the difficulty—effort relationship. Gendolla and Silvestrini's observation that action primes have a direct impact on effort (without being mediated by task difficulty appraisals) thus conflicts with one of motivational intensity theory's basic predictions. We do not have a clear explanation for the divergence between these findings and motivational intensity theory, so far. Further research needs to address this issue by developing new integrative models and conducting additional research that addresses the conditions under which task difficulty determines effort in conditions of unfixed task difficulty.

One of the questions raised by the described empirical research concerns the theory's distinction between different task types. Motivational intensity theory offers predictions for three types of tasks: tasks with fixed and known difficulty, tasks with fixed but unknown difficulty (unclear difficulty), and tasks with unfixed difficulty. The theory thereby suggests that one can either be completely unsure or completely sure about the demand of a task—there is nothing in between. It is an unresolved empirical question if individuals' certainty regarding task demands indeed oscillates between these two extremes. If this is not the case and individuals can be more or less sure about task demands, motivational intensity theory might be extended by adding predictions for the transition from unclear task difficulty to clear task difficulty.

The almost exclusive focus of motivational intensity theory research on sympathetic nervous system activity poses another interesting question. Drawing on Wright's (1996) influential paper, researchers have assessed effort as myocardial sympathetic impact on the heart. For this reason their focus on myocardial sympathetic activity was reasonable (see also Kelsey, 2012). But this does not suit an exercise physiology view on effort. Increases in effort during physical exercise are not always associated with increased sympathetic activity. At low-intensity exercise, increases in cardiac activity are mainly due to parasympathetic withdrawal (eg, Fagraeus & Linnarsson, 1976; Maciel, Gallo, Marin Neto, Lima Filho, & Martins, 1986; Victor, Seals, Mark, & Kempf, 1987). If one walks on a treadmill at a very low speed, HR increases compared to rest due to a decrease of inhibiting parasympathetic activity. Slowly walking without doubt requires more energy and effort than sitting still, but this increase in effort is not accompanied by an increase in sympathetic activity. The sympathetic nervous system only contributes to increases in cardiac activity at higher exercise intensity levels.

From an exercise physiology perspective, researchers on motivational intensity theory missed the opportunity to assess the full range of autonomic responses that are associated with effort mobilization. Their focus on sympathetic-driven cardiovascular measures impeded results regarding the link between mental effort and parasympathetic functioning. Given that the parasympathetic system dominates at low-intensity physical exercise, one might wonder if the sympathetic-driven cardiovascular measures used in the research on motivational intensity theory were only capable of capturing differences in effort mobilization at high effort levels. They might not have been sensitive enough to detect effort differences at low effort levels.

Future research on motivational intensity theory might draw on the exercise physiology literature to conceptualize effort as both a reduction in parasympathetic activity and an increase in sympathetic activity. This line of research would enable a more comprehensive understanding of the autonomic changes associated with mental effort. It is of note that researchers in other domains have simultaneously assessed sympathetic and parasympathetic activity, while varying the amount of required effort. For instance, researchers interested in listening effort have started to address sympathetic and parasympathetic responses to effortful listening (eg, Mackersie, MacPhee, & Heldt, 2015; Seeman & Sims, 2015; see Mackersie & Calderon-Moultrie, 2016; for a review). However, most of the research that has simultaneously assessed sympathetic and parasympathetic activity has drawn on the assumption that changes in task difficulty always lead to differences in effort. It thus has neglected the limiting impact of success importance and has not provided much information on whether motivational intensity theory can predict changes in parasympathetic and sympathetic activity.

In the preceding sections we elaborated on motivational intensity theory, its extensions and applications, and the associated empirical research. We have shown that the theory has been a fruitful framework for various studies over the last three decades and that a large portion of the empirical evidence supports the predictions of the theory and its extensions. However, we have also highlighted research that challenges the theory. Recent research has questioned the primacy of the energy conservation principle, suggested that impossible tasks do not always result in disengagement, and demonstrated that task difficulty can be a determinant of effort in tasks with unfixed task difficulty and can be irrelevant in tasks with fixed and known difficulty. These conflicting results together with questions about the physiological processes underlying effort mobilization and the task type classification will constitute the agenda of researchers working on motivational intensity theory for the years to come.

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