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"Rest or cash: the interactional influence of fatigue and success importance on behavioral restrain"

verfasst von / submitted by

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Abstract (English)

The limited resource model (LRM) was intensively debated in recent decades. The LRM argues that self-control is a limited resource, meaning that one can only use it if it is not depleted. Since the LRM gained a lot of empirical support we did not want to reject the model in total but to expand it, even though there is also research arguing against its validity and stability. We integrated motivational processes (motivational intensity theory) and fatigue into the LRM for a more valid prediction of performance. Furthermore, there is no research yet that integrated success importance and task difficulty into the model. We manipulated task difficulty (Stroop task increased in difficulty) and success importance (different amount of incentives for each group). Fatigue was measured by a questionnaire before and after the self-control task. Our sample consists of $N = 151$ (43.7% female) with an average age of 41.20 ($SD = 11.00$). As expected, participants with a high success importance performed better for a longer time than participants with a low success importance ($p = .02$, $\beta = 0.05$). Surprisingly, non-fatigued participants did not perform better than fatigued participants ($p = .28$, $\beta = -0.03$). Our study shows that it is reasonable to integrate motivational processes to extend the LRM. Since we only measured the self-reported fatigue level, we suggest to manipulate fatigue in the labor. Furthermore, we suggest measuring effort with cardiovascular methods for a better understanding of our extended model.

Keywords: Self-control, fatigue, success importance, task difficulty, limited resources, motivational intensity

Abstract (German)

Das limitierte Ressourcen Modell (LRM) wurde in den letzten Jahrzehnten intensiv debattiert. Das LRM beschreibt Selbstkontrolle als eine limitierte Ressource, das heißt man kann sie nur ausüben, wenn sie nicht erschöpft ist. Da das LRM viel empirische Unterstützung bekommen hat wollten wir dieses nicht komplett verwerfen, sondern erweitern, obwohl es auch Forschung gegen die Validität und Stabilität dieses Modells gibt. Wir haben motivationale Prozesse (Theorie der Motivationsintensität) und Erschöpfung in das LRM integriert, um eine validere Vorhersage über Leistung treffen zu können. Weiters gibt es bis jetzt keine Studien, die Erfolgswichtigkeit und Aufgabenschwierigkeit in das LRM integrieren. Wir haben die Aufgabenschwierigkeit (Stroop-Aufgabe wird laufend schwieriger) und die Erfolgswichtigkeit (unterschiedlich hohe Belohnungen für Gruppen) manipuliert. Die Erschöpfung wurde mittels Fragebogen, vor und nach der Selbstkontrollaufgabe, erhoben. Unsere Stichprobe besteht aus N = 151 Personen (43,7% weiblich), mit einem Durchschnittsalter von 41,20 (SD = 11.00). Wie erwartet, haben Teilnehmer*innen mit hoher Belohnung längere Zeit eine gute Leistung erbracht als Teilnehmer*innen mit niedriger Belohnung (p = .02, β = 0.05). Überraschenderweise haben erschöpfte Teilnehmer*innen keine bessere Leistung erbracht als nicht erschöpfte Teilnehmer*innen (p = .28, β = -0.03). Unsere Studie zeigt, dass es sinnvoll ist motivationale Prozesse in das LRM zu integrieren, um dieses zu erweitern. Da wir die Erschöpfung nur mittels Selbstbericht gemessen haben, empfehlen wir für zukünftige Forschung eine Manipulation dieser. Des Weiteren empfehlen wir die Anstrengung mittels kardiovaskulärer Methoden zu messen, um ein besseres Verständnis für unser erweitertes Modell zu bekommen.

Schlüsselwörter: Selbstkontrolle, Erschöpfung, Erfolgswichtigkeit, Aufgabenschwierigkeit, limitierte Ressourcen, Motivationsintensität

Introduction

The limited resource model (LRM; Baumeister & Vohs, 2016) argues that there is a limited resource that is in charge for inhibiting automatic behaviors in order to perform self-control. Self-control is the inhibition of automatic, habitual or innate behaviors, urges, emotions or desires that would otherwise interfere with goal directed behavior. Self-control performance was hypothesized to consume this limited resource, making one less able to perform self-control on a subsequent task (Baumeister & Vohs, 2016; Kanfer & Karoly, 1972). This depleted state is called ego-depletion, a temporary reduction in the ability to engage in volitional action, caused by prior self-control (Baumeister et al., 1998; Inzlicht & Schmeichel, 2012; Muraven et al., 1998).

In recent decades the LRM was intensively debated in scientific research. It gained a lot of empirical support (e.g. Fischer et al., 2008; Schmeichel et al., 2003), but was nevertheless, recently questioned in its stability and validity due to failed replication attempts (Carter et al., 2015; Friese et al., 2019; Moller et al., 2006; Tice et al., 2007). Further, research has shown that the effect only works if people believe that there is a limited resource, in this study willpower (Job et al., 2010). It has also been suggest that motivation moderates the effect (Muraven & Slessareva, 2003). For this reason, we wanted to integrate motivational processes into the LRM to get a better understanding of self-control in performance settings. The motivational intensity theory (MIT) explains the mobilization of effort in goal pursuit to succeed in a worthwhile task (Richter et al., 2016). Furthermore, fatigue plays an important role in self-control performance (Mlynski et al., 2021).

We wanted to integrate motivational processes and fatigue into the model to improve it. There is no research yet that considers the importance level of task success or the urge magnitude level (task difficulty) regarding the LRM. Considering previous research, if one does not control these variables, one is just guessing if the LRM is going to be replicated or

not. Therefore, we manipulated the urge magnitude level continuously and the success importance level for each group, to see if these variables have an impact on the performance. The two experimental groups got a different amount of incentives if they performed accurate (success importance), whereas the Stroop task got more difficult per block (urge magnitude level). Furthermore, we analyzed if pre-experimental fatigue has an impact on performance. For this purpose we conducted an online study including a fatigue questionnaire, the Mood-Checklist, the Stroop task (Stroop, 1935), the willpower questionnaire (Job et al., 2010) and the trait self-control questionnaire (Tangney et al., 2004). First, differences in performance between the experimental groups were tested. Second, group and prior fatigue were used to predict performance, using multi-level modeling. Since we worked in a group on this topic, there will also be a second master thesis regarding this research.

Theoretical Background

The limited resource model (LRM)

In the literature, arguing in favor of the LRM, it is hypothesized that self-control is a limited resource (e.g., Baumeister et al., 1998; Inzlicht & Schmeichel, 2012; Muraven et al., 1998). Self-control is the inhibition of automatic, habitual or innate behaviors, urges, emotions or desires that would otherwise interfere with goal directed behavior (Baumeister & Vohs, 2016; Kanfer & Karoly, 1972). The LRM suggests that self-control performance consumes an inner limited resource (self-control strength), leaving people in a state of depletion and in consequence making them less able to perform self-control on a subsequent task (Baumeister & Vohs, 2016; Muraven & Baumeister, 2000). Self-control strength is a domain-general capacity, which means that depleting it in one domain also leads to a lack of self-control in another domain (Baumeister & Vohs, 2016). This depletion of self-control is also known as the ego depletion effect (Baumeister et al., 1998; Inzlicht & Schmeichel, 2012; Muraven et al., 1998).

The ego depletion effect is only a short-term effect. Baumeister and Vohs (2016) also describe a long-term effect in the limited resource model. They compare self-control with a muscle, that can be strengthened. In this analogy they argue that through repeated exercise in self-control it becomes stronger which leads to an improvement in self-control capacity over time. Research (e.g., Muraven et al., 1999; Oaten & Cheng, 2006a, 2006b) supported this assumption of the training effect. Yet, a recent meta-analysis estimates a rather weak effect (Friese et al., 2017).

The backside of the limited resource model

Even though the LRM has received certain evidentiality, more recent research questions its stability and validity (Moller et al., 2006; Tice et al., 2007). Also meta analyses showed that the short-term effect of ego depletion is weak (Carter et al., 2015) or are skeptical if the effect even exists (Friese et al., 2019). Two studies specifically questioned the effect of resource depletion in its core mechanisms.

One finding is that the depletion on an inner resource only works on people that believe in the effect (Job et al., 2010). The study has shown that people who believe that willpower is a limited resource show ego depletion, whereas people who believe that willpower is unlimited do not show ego depletion. Also motivation moderates the effect of ego depletion (Muraven & Slessareva, 2003). Depleted participants persist longer on a frustrating self-control task if they believe that it could help others, or they self could benefit from doing the task. The LRM argues that there is a specific limited resource that is required for behavioral restraint, which one must use in order to perform self-control. If that is the case, there is no reason that one's believes or one's perception should affect if one has the resources available or not. It seems that there is an undermining motivational process: It is not about the resources one has available, but more about motivational processes regarding if one wants (or does not want) to do the subsequent task.

The motivational intensity theory (MIT)

Considering the inconsistent findings, it seems important to understand why the LRM is replicable in some cases and is not in others. In our study, this was tried by using motivational frameworks on the paradigm. Specifically, we applied the motivational intensity theory (MIT; Richter et al., 2016). MIT explains the mobilization of effort in goal pursuit. Effort is an investment of resources that enables individuals to execute behavior. But resources are valuable, so individuals are motivated to avoid wasting these resources. Therefore, effort is only mobilized in the needed amount for successful task performance. Individuals that want to safe resources need an indicator of the amount of resources that are required for successful task performance. Task difficulty provides this information, according to MIT. This means that the higher the difficulty, the more resources are needed. But individuals also must estimate if the task success is even possible, otherwise resources would be wasted too. The same applies to success importance, if one invests resources in a task where the costs are higher than the possible outcome (Richter et al., 2016). This interaction is illustrated in Fig. 1.

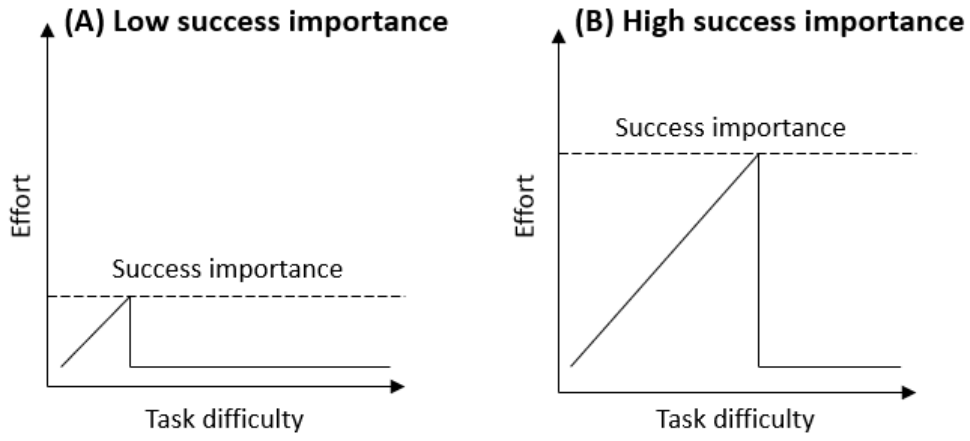


Figure 1. The prediction of inserted effort for tasks with known and fixed difficulty based on the motivational intensity theory.

Effort mobilizes the resources to perform on a task if an individuum can control the task outcome by performing well. Therefore, one can measure effort by the amount of myocardial sympathetic reactivity. The gold standard is the measurement of the myocardial contractility. The best method is the measurement of the pre-ejection period, which is the time interval between the electrical stimulation of the ventricles and the cardiac ejection (Richter et al., 2016).

Behavioral restraint extension

Pure MIT is not the only explanation of the inconsistent findings regarding the LRM. Whereas the behavioral restraint argues that one must resist against a behavioral urge or impulse to perform on a task, the extension of behavioral restraint assumes that restraint contains the expanding of oneself to meet a performance challenge which can be in different severities (Wright et al., 2018). One can more or less intensively apply themselves to accomplish the task of resisting an urge (Higgins, 2006). This can also be shown by looking into biophysiological measures. One important finding is that effort varies with the beta-adrenergic influence on the cardiovascular system (Agtarap et al., 2016; Obrist, 1976; Richter et al., 2012). Another one is that effort does not vary monotonically with the difficulty of performing a task: first it rises and then it suddenly falls when the success importance does not justify the task requirements anymore or the success seems impossible (Brehm & Self, 1989). Research has shown that there is a difficulty by importance interaction for systolic blood pressure (Agtarap et al., 2016; Murray et al., 1993; Richter et al., 2008).

Mlynsiki et al. (2021) showed how fatigue can be integrated in this extension. In their study they manipulated urge magnitude (task difficulty) and fatigue to see the impacts on performance, the cardiovascular system and effort. Figure 2 shows effort implications, considering fatigue. When one is in a state of fatigue (either mental or physical) it seems there are some resources lacking that are needed for whatever task they are trying to do. If one

perceives that this resource is missing, every task seems more difficult (Section A). Therefore, if one is fatigued and chooses to engage in a task, because it is still perceived as worthwhile, he or she must put in more effort to accomplish the same task (compensation) as the rested counterpart because it seems more difficult. If one is sustaining the behavior, the performance is about one's ability to do the task. Because fatigued people see the task as more difficult, they more rapidly disengage because the effort gets too high in comparison to the success importance. Therefore, rested people keep trying longer to succeed while fatigued people stop trying (Section B). This disengagement should be seen in performance differences. After a while, everybody should disengage (Section C). This model explains why the LRM could be replicated sometimes but could not be replicated other times: the LRM only works in the sweet spot (Section B) and does not work when fatigued people put in more effort (Section A) to compensate their fatigue (Mlynski et al., 2021).

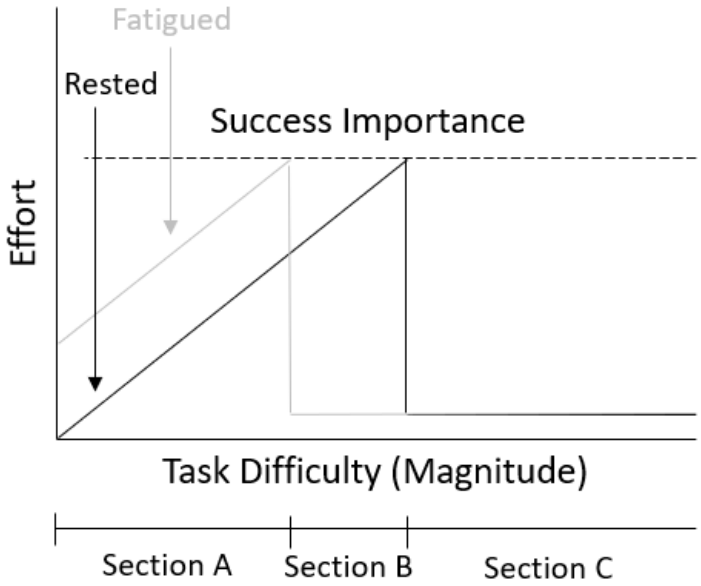


Figure 2. Fatigued participants disengage sooner than rested participants. The part of failure (sweet spot) is where performance differences occur (Section B).

Current study

As already mentioned, there is some research that does not support the LRM, but it also gained a lot of important understandings and was replicated a lot of times. Therefore, we want to take all the findings and integrate them into motivational models to show why the ego depletion effect can sometimes be replicated and why sometimes not. There are no studies yet that manipulate the importance level or the urge magnitude level regarding the LRM. If one does not control these variables, you are just able to guess if the LRM is going to be replicated or not. Therefore, in our experiment we manipulated these variables.

The participants were randomly assigned to one out of two experimental groups. Each group got promised a different amount of incentives for performing accurate (different success importance). The high incentive group got promised four euros for accurate performance, whereas the low incentive group got promised 50 cents for performing accordingly. For both groups the difficulty of the Stroop task was raised equally from block to block (rising magnitude level) by giving the participants less time to respond. The difficulty was the same for each participant per block. To look at the influence of fatigue, we measured the pre-experimental fatigue level using the fatigue questionnaire. Our Hypotheses were: fatigued participants perform worse sooner than non-fatigued participants (H1) and participants of the low incentive group perform worse sooner than participants of the high incentive group (H2). For testing our hypotheses, we fitted a linear mixed model, in which the interaction of group, a quadratic term for difficulty and prior fatigue were used to predict performance. Additionally, random effects for participants were included across blocks.

Method

Experimental design and procedure

We conducted an online study to look on the effect of success importance on performance on a more continuous level than previous research. For this purpose, we manipulated urge magnitude by making the Stroop task continuously more difficult while success importance was held constant. We did not manipulate the fatigue level but measured it before the experiment to predict its influence on task performance. Since the independent variable success importance could take one out of two values, it was a one factor between-subject design. Whereas the independent variable urge magnitude was a one factor within-subject design because it was raised during the experiment continuously for all participants equally. The dependent variable is the performance on the Stroop task, which we measured by the point of falling under the performance standard (80 percent correct answers per block) for the second time.

The participants were randomly assigned to one out of two groups. One group got the information that they would get an incentive of four euros if they perform good enough (minimum 80 percent correct answers) on 14 out of 15 Stroop task blocks. The other group got the information that they would get an incentive of 50 cents if they perform accordingly. This accounts for congruent and incongruent trials. The difficulty for both groups was equal. It continuously raised for each block, meaning that they had 0.1s less time to respond per trial. The first block had no time limit, block two started with 1500ms maximum reaction time, the last block had 200ms maximum reaction time. At some point all participants were expected to disengage because the magnitude was too high.

At the beginning, both groups received a welcome text and an explanation of what they had to do to get the incentive. Afterwards they had to fill out the fatigue questionnaire so we could see how fatigued each participant was at the beginning of the survey. Additionally,

the participants had to fill out the Mood-Checklist. Then they got an explanation of how the Stroop task works and also got the chance to get some practice in the task. After the trial phase the main Stroop task started. Every participant did the 15 blocks of Stroop task taking about two or three minutes each. After the 15 Stroop task blocks, they again had to fill out the fatigue questionnaire and the Mood-Checklist. Additionally, they had to fill out the willpower questionnaire (Job et al., 2010) and the short version of the self-control questionnaire (Tangney et al., 2004). At the end we also asked them about their gender, age and language skills.

Sample

For the calculation of the sample size we used G*Power (Faul et al., 2009). For a small to medium effect size (Cohen, 2013) of Cohens d = 0.4, α = .05 and β = .80 we got a minimum sample size of N = 156, for a t-test for independent samples. Due to the novel design, we planned to sample up to N = 170 for our study. There were no specific sociodemographic data restrictions, except the minimum age of 18. We acquired the sample, using MTurk (Amazon.com, Inc.). The survey was online from October 5th, 2022, to October 6th, 2022, and was started 221 times during that time period. 151 participants finished the survey accordingly. The total sample size of the analyzed participants was N = 151, whereas n = 68 were in the low incentive group and n = 83 were in the high incentive group.

The average age of the participants was 41.29 (SD = 11.00) ranging from 22 to 84. 43.7% described themselves as female and 56.3% as male. English is the mother tongue of 94% of the participants and 6% stated that they are fluent in English. At the time of the study, 7.9% said that they were currently studying at the university, whereas 92.1% were not studying at that moment. Furthermore, 51% stated that at least one of their parents has finished a university degree, 48.3% that none of their parents has finished a university degree and 0.7% did not know if one of their parents had finished a university degree.

Stroop task

The Stroop task goes back to studies of the Stroop effect (Stroop, 1935), which argues that there is an automatic reading process that makes it easier for people to read a colour word in any colour than naming the colour of the print of a colour word. The Stroop task is used as a measure for self-control. The Stroop task shows different colour words (blue, red, yellow) written in different colour prints (blue, red, yellow). The colours of the letters can be congruent (e.g. if the word blue is written in the colour blue) or incongruent (e.g. if the word blue is written in the colour red). The participants have to react on the colour of the print, independent of the meaning. They indicate their answers through pressing the respective buttons on their keyboard. If the word 'yellow' is displayed the participants have to react to the button for yellow, independent of the colour of the letters. The response time for each item and the accuracy of the answers can be measured.

Questionnaires

Fatigue questionnaire. The Fatigue questionnaire is our own scale and already tested. It is a 7-point rating scale (1 = does not apply at all, 7 = fully applies) with 5 items. An example of the questionnaire is "I feel mentally exhausted.".

Mood-Checklist. The Mood checklist is a 11-point rating scale (0 = not at all, 10 = extremely) with 20 items of which we used two subscales. The reliability of the questionnaire is $\alpha = .88$. Example items of the questionnaire are "active" or "sleepy".

Willpower questionnaire. The Willpower questionnaire is a 6-point rating scale (1 = strongly agree, 6 = strongly disagree) with 12 items. The reliability of this questionnaire is $\alpha = .89$. An example item of the questionnaire is "After a strenuous mental activity, you feel energized for further challenging activities." (Job et al., 2010).

Self-control questionnaire. The short version Self-control questionnaire is a 6-point rating scale (1 = strongly agree, 6 = strongly disagree) with 13 items. The reliability of this questionnaire is α = .89. An example item of the questionnaire is "I am good at resisting temptation." (Tangney et al., 2004).

Ethical aspects

People of the different groups got paid a different amount of money, depending on their group. Furthermore, they had to do a task that is mentally exhausting and in the end impossible to solve. But these are no serious limitations for the participants, concluding that we see the experiment as acceptable belonging to ethical aspects. Furthermore, the study was approved by the departmental review board of the faculty of Psychology and the Institute for economic Psychology at the University of Vienna, Austria.

Results

Descriptive Data

For the purpose of data preparation, we computed the means of each questionnaire. The results for the fatigue questionnaire are shown in table 1. The reliability of the fatigue questionnaire was Cronbach´s α = .90 for the pre-Stroop task questionnaire and Cronbach´s α = .87 for the post-Stroop task questionnaire and for the pre- and post-Stroop task questionnaires combined too.

We also measured the Mood-Checklist before and after the Stroop task. For our research the subscales Energy and Tiredness were interesting. The results are shown in table 2 and table 3. The reliability of the checklist for Energy was Cronbach´s α = .94 and for Tiredness Cronbach´s α = .92 for both measurement time points (pre- and post-Stroop task questionnaires) and for pre- and post-Stroop task questionnaires combined too.

Table 1

Means, standard deviations, medians, minimum and maximum of fatigue levels before (Fatigue 1) and after (Fatigue 2) the Stroop task. BG = both groups, LI = low incentive group, HI = high incentive group.

	Fatigue 1 (BG)	Fatigue 1 (LI)	Fatigue 1 (HI)	Fatigue 2 (BG)	Fatigue 2 (LI)	Fatigue 2 (HI)
M	2.11	2.12	2.10	3.74	3.56	3.87
SD	1.27	1.40	1.20	1.61	1.62	1.61
Median	1.60	1.50	1.60	3.80	3.50	4.00
Min.	1.00	1.00	1.00	1.00	1.00	1.00
Max.	6.20	6.20	5.40	7.00	7.00	7.00

Table 2

Means, standard deviations, medians, minimum and maximum of Energy levels before (Energy 1) and after (Energy 2) the Stroop task. BG = both groups, LI = low incentive group, HI = high incentive group.

	Energy 1 (BG)	Energy 1 (LI)	Energy 1 (HI)	Energy 2 (BG)	Energy 2 (LI)	Energy 2 (HI)
M	6.43	6.24	6.60	5.34	5.40	5.30
SD	2.35	2.63	2.09	2.76	2.81	2.73
Median	6.80	6.40	7.00	5.60	5.90	5.40
Min.	0.20	0.20	1.00	0.00	0.00	0.00
Max.	10.00	10.00	10.00	10.00	10.00	10.00

Table 3

Means, standard deviations, medians, minimum and maximum of Tiredness levels before (Tiredness 1) and after (Tiredness 2) the Stroop task. BG = both groups, LI = low incentive group, HI = high incentive group.

	Tiredness 1 (BG)	Tiredness 1 (LI)	Tiredness 1 (HI)	Tiredness 2 (BG)	Tiredness 2 (LI)	Tiredness 2 (HI)
M	2.09	2.09	2.10	3.26	3.08	3.40
SD	2.28	2.46	2.14	2.83	2.97	2.73
Median	1.20	1.00	1.20	2.80	2.10	3.00
Min.	0.00	0.00	0.00	0.00	0.00	0.00
Max.	10.00	10.00	9.40	10.00	10.00	9.60

The participants had to fill out the Self-control questionnaire and the Willpower questionnaire after the Stroop task. The results for the Self-control questionnaire are shown in table 4 and for the Willpower questionnaire in table 5. The reliability for the Self-control questionnaire was Cronbach´s α = .88 and for the Willpower questionnaire Cronbach´s α = .82.

Table 4

Means, standard deviations, medians, minimum and maximum of the trait self-control (TSC). BG = both groups, LI = low incentive group, HI = high incentive group.

	TSC (BG)	TSC (LI)	TSC (HI)
M	3.71	3.80	3.64
SD	0.91	0.95	0.88
Median	3.69	3.88	3.50
Min.	1.27	1.27	1.83
Max.	6.00	6.00	5.31

Table 5

Means, standard deviations, medians, minimum and maximum of the Willpower. BG = both groups, LI = low incentive group, HI = high incentive group.

	Willpower (BG)	Willpower (LI)	Willpower (HI)
M	3.41	3.38	3.43
SD	0.71	0.71	0.71
Median	3.42	3.29	3.42
Min.	1.42	1.42	1.83
Max.	5.58	5.17	5.58

Data preparation

To analyze if the randomization was successful, we conducted a t-test for the variables age, language proficiency and academic parents. For the variables gender and currently studying (Yes/No) we conducted a χ^2-test. The randomization was successful for age (t = .40, p = .68), language proficiency (t = -72, p = .47), academic parents (t = -.88, p = .38), gender ($\chi^2(1)$ = 0.56, p = .45) and currently studying ($\chi^2(2)$ = 0.13, p = .72), because of the non-significant results.

Explorative Analysis

For explorational reasons we wanted to check if there was a group difference in the total amount of correct (incongruent and congruent) trials in the Stroop task for all 15 blocks. The results are shown in table 6 and a visualization is shown in figure 3. For this purpose, we conducted an independent sample t-test. There was statistically no significant difference between the total amount of correctly solved trials between the low incentive group and the high incentive group, t(149) = -0.882, p = .38. A visualization of the performance decline over the blocks are in figure 4 and figure 5.

Table 6

Means, standard deviations, median, minimum and maximum of correct trials in percentage for all 15 blocks combined, separated in low and high incentive group.

Group	Low incentive	High incentive
M	54.81%	56.39%
SD	11.32	10.77
Median	57.48%	57.28%
Min.	29%	32%
Max.	73%	78%

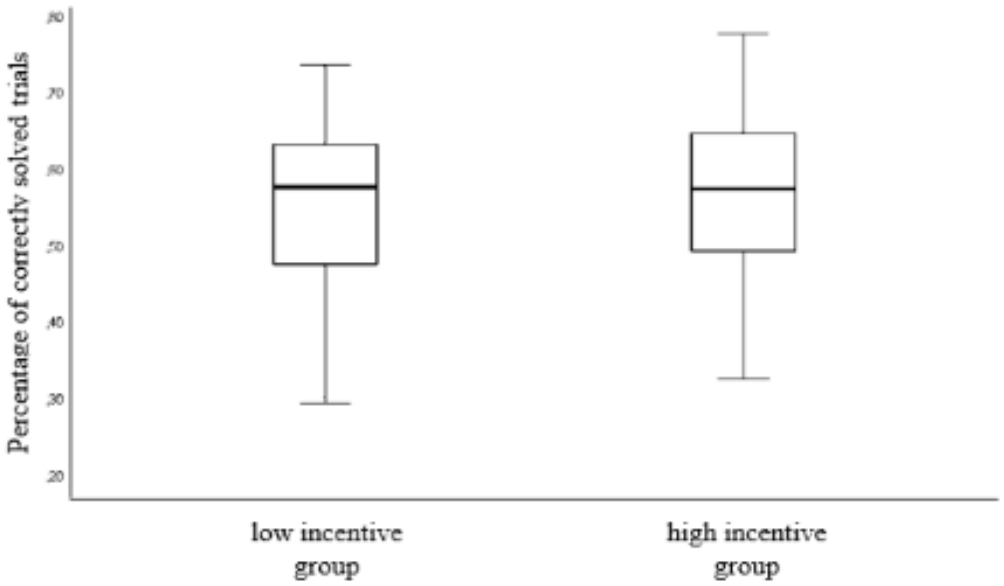


Figure 3. Visualization of the performance differences between the low incentive group and the high incentive group.

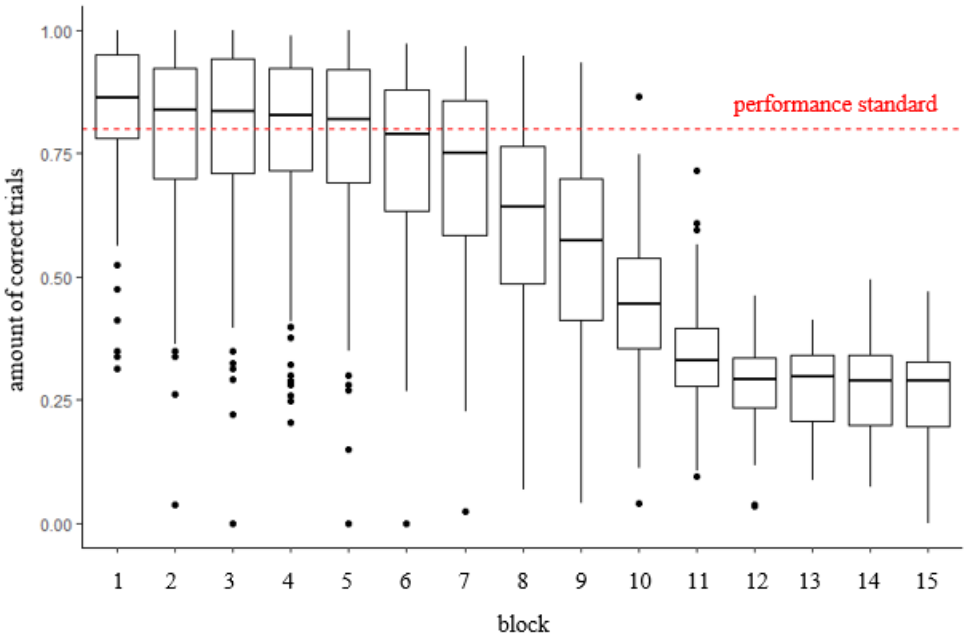


Figure 4. Visualization of the decline of the performance over the blocks for all participants.

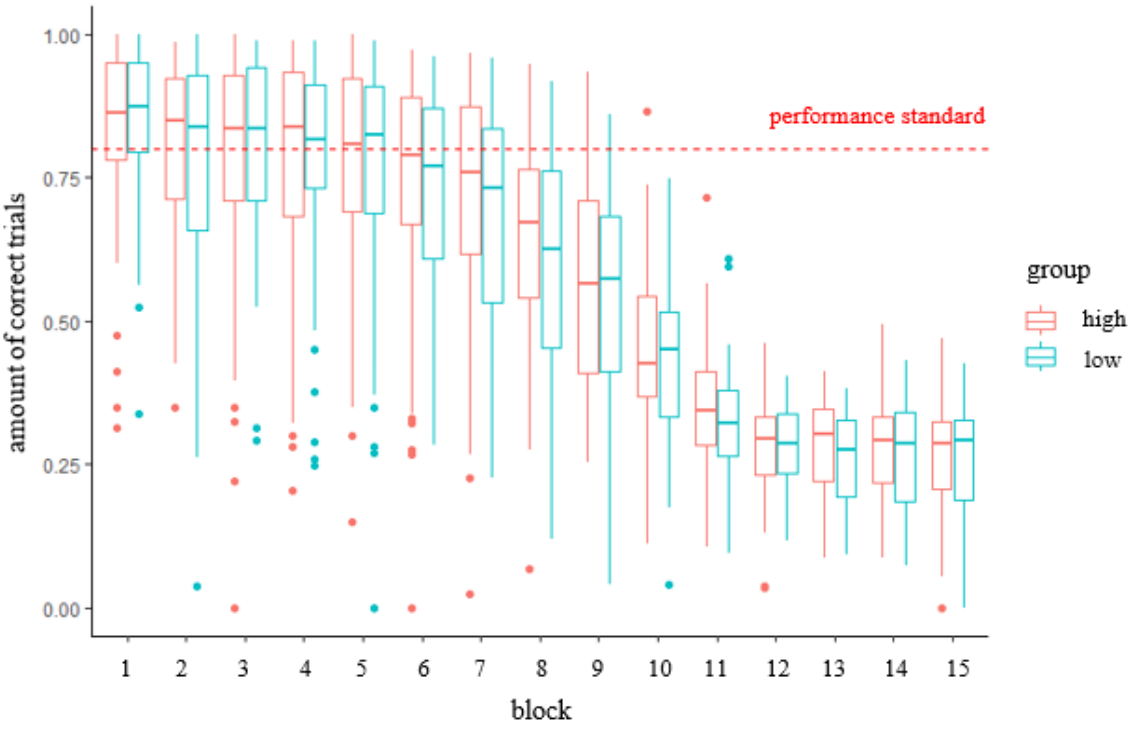


Figure 5. Visualization of the decline of the performance over the blocks, separated by group.

We also conducted three mixed ANOVA´s, regarding fatigue, tiredness and energy. These mixed ANOVA´s only showed time-effects. The significant main effect of time for fatigue shows that the participants are more fatigued after the Stroop task than before, Greenhouse-Geisser F(1, 149) = 147.08, p = <.001, partial η^2 = .50. However, there was no significant main effect for group, meaning that the high incentive group is not significantly more fatigued after the Stroop task than the low incentive group, F(1, 149) = 0.45, p = .51, partial η^2 = .01. For tiredness there was also a significant main effect for time, meaning that the participants are more tired after the Stroop task than before, Greenhouse-Geisser F(1, 149) = 32.87, p = <.001, partial η^2 = .18. For group there was also no significant main effect, meaning that the high incentive group is not significantly more tired after the Stroop task than the low incentive group, F(1, 149) = 0.21, p = .65, partial η^2 = .00. For energy there was again a significant main effect for time, meaning that the participants have less energy after the Stroop task than before, Greenhouse-Geisser F(1, 149) = 31.50, p = <.001, partial η^2 = .18.

For group there was again no significant main effect, meaning that the low incentive group has not significantly more energy after the Stroop task than the low incentive group, F(1, 149) = 0.11, p = .74, partial η^2 = .00.

Testing hypotheses

For testing our hypotheses, standardized parameters were obtained by fitting the model on a standardized version of the dataset, using only the incongruent trials. 95% confidence intervals and p-values were computed using a Wald t-distribution approximation. We fitted a linear mixed model, in which the interaction of group, a quadratic term for difficulty and prior fatigue were used to predict performance. We included random effects for participants across blocks. The model's total explanatory power is substantial (conditional R^2 = .87), and the part related to the fixed effects alone (marginal R^2) explains 26.9% of the variance. For this model the adjusted (only random effects) *ICC* was .82 and the unadjusted (fixed and random effects) *ICC* was .60. This means that the model is a good fit because the measurements in the groups resemble each other. Within this model the effect of prior fatigue is statistically non-significant and negative (t(2254) = -1.07, p = .28, std. β = -0.03, *CI* = [-0.09, 0.03]). Therefore, our first hypothesis has to be rejected based on our findings. The interaction between group and the quadratic term for difficulty is statistically significant and positive (t(2254) = 2.26, p = .02, std. β = 0.05, *CI* = [0.01, 0.09]). This shows that participants of the high incentive group perform better for a longer time than participants of the low incentive group. Therefore, hypotheses H2 is validated. The results of the multilevel analysis are shown in Table 7.

Furthermore, we were able to find the previously mentioned sweet spot (see figure 6). Before this sweet spot, the task is too easy to measure performance differences underlying motivational differences, and after the sweet spot, the task is too difficult to solve for both

groups, independent of the motivation of the participants. But within this sweet spot performance differences occur between the high incentive group and the low incentive group.

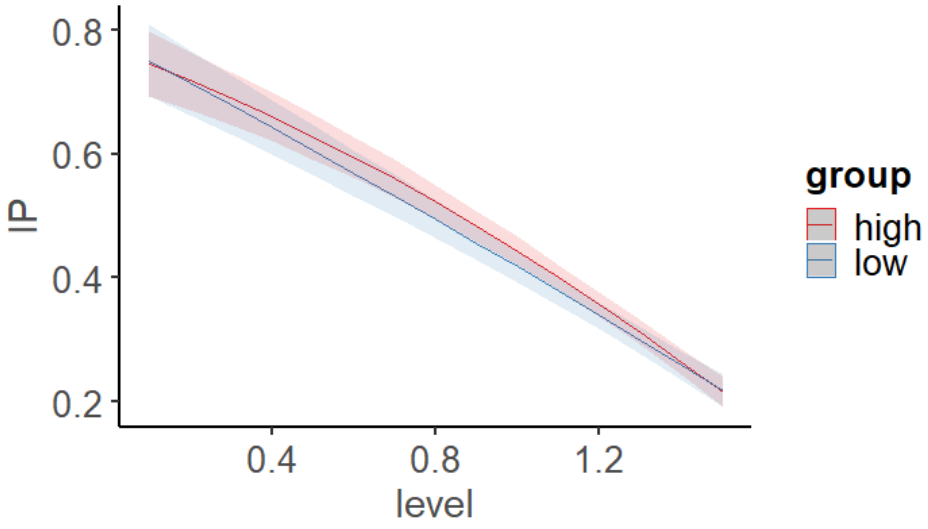


Figure 6. Visualization of the point of falling under the performance standard of the participants, separated by high incentive group and low incentive group.

Table 7

Results of the multilevel analysis.

Predictor	Intercept	Prior fatigue	Group	Level 1	Level 2	Group x level 1	Group x level 2
t(2254)	1.65	-1.07	-1.34	-18.19	-4.40	-0.06	2.26
β	0.09	-0.03	-0.11	-0.67	-0.07	0.00	0.05
CI	-0.02 – 0.21	-0.09 – 0.03	-0.28 – 0.05	-0.74 – -0.59	-0.09 – -0.04	-0.11 – 0.10	0.01 – 0.09
p	.10	.28	.18	< .001	< .001	0.95	0.02

Discussion

We first measured the fatigue level of the participants and then let them perform the Stroop task. The difficulty of the Stroop task was continuously raised for each participant equally (rising urge magnitude). Since one group got a higher amount of incentives for performing well, the success importance for this group was higher than for the low incentive group. As expected, the high incentive group performed for a longer time well than the low incentive group. Regarding fatigue the results were surprising. Our data did not show an influence of fatigue on the performance, although previous research led us to this assumption.

As already mentioned in the introduction, in recent decades the LRM was questioned in its stability and validity (Carter et al., 2015; Friese et al., 2019; Moller et al., 2006; Tice et al., 2007). But because there is also a lot of empirical support for the LRM (e.g. Fischer et al., 2008; Schmeichel et al., 2003), we wanted to extend the model with motivational processes to get a better understanding of self-control in performance settings. Specifically, we integrated the MIT and fatigue into the LRM. Furthermore, there are no studies yet that manipulate success importance or the urge magnitude level researching the LRM. We think that its mandatory to integrate these variables to replicate the LRM. Our predictions for this research were twofold. First, the fatigue level prior to the Stroop task should influence the performance. More specific, fatigued participants should perform worse sooner than non-fatigued participants (H1). Second, success importance should interact with the difficulty level of the Stroop task and therefore influence the performance. Meaning that participants of the low incentive group perform worse sooner than participants of the high incentive group (H2). As shown in the results, analysis of the data did not support the thesis that fatigue has an influence on the performance. But there was a significant effect for the interaction between group and the quadratic term for difficulty. This result shows that participants of the low

incentive group perform worse significantly sooner than participants of the high incentive group.

These findings implicate that integrating motivational processes into the LRM can explain why the model could be replicated in some studies and could not be replicated in others. Self-control seems to be not just a limited resource as assumed by previous research (e.g., Baumeister et al., 1998; Inzlicht & Schmeichel, 2012; Muraven et al., 1998) but is also dependent on the success importance and therefore the motivation. This is in line with the findings of Muraven & Slessareva (2003). According to MIT, success importance provides the information for individuals to decide if it is worth to put effort in a task or if it is better to safe these resources (Richter et al., 2016). In our study, participants of the high incentive group performed better so they seemed to put in more effort in the Stroop task than participants of the low incentive group. This implicates that the success importance was higher due to the higher value of the incentives.

The fact that fatigue had no effect on performance is interesting in light of earlier research (Mlynski et al., 2021). According to that study, individuals that are in a state of fatigue seem to lack of resources that are needed for performing well in a task. If one perceives that this resource is missing, the task seems more difficult. Fatigued individuals should therefore perform worse sooner than non-fatigued participants because the effort gets too high in comparison to the success importance. This finding might occurred because we only asked the participants about their fatigue level and did not measure it objectively or manipulate it. It is possible that participants were not honest with their self-reported answers on the questionnaire or that they were not able to interpret their fatigue level well, so they were not able to answer according to their real fatigue level.

Limitations

We have only found a time effect regarding fatigue (also for tiredness and energy) but no group effect. This means that the Stroop task is exhausting and so all participants are significantly more fatigued after the task than before. However, as there is no significant difference between the two experimental groups, we cannot be sure that the participants of the high incentive group really have put in more effort than the participants of the low incentive group. Considering that there were performance differences that are in line with the MIT (Richter et al., 2016) and that more fatigued participants should put in more effort to succeed in the task (Mlynski et al., 2021), there should have been a difference between the two experimental groups. Due to the online study design, we were not able to measure biophysiological data. We had to rely on the self-report answers of the participants regarding fatigue and did not have any measurement for effort. Because it was an online study, we could neither control certain circumstances like the concentration, the environment, and the seriousness. For a novel study to get a first understanding of this idea this is a sufficient method but for further research it is important to control these variables in the laboratory.

The participants of the high incentive group were able to get incentives of four euros and participants of the low incentive group 50 cents. Since this is percental a huge difference we decided that it is acceptable for our research. But we cannot be sure if the possibility of earning four euros for this study is high enough to put in more effort. Further research should offer the high incentive group higher incentives to overcome this possible limitation.

According to G*Power (Faul et al., 2009) we needed a minimum sample size of N = 156. Because of the novel study design, we wanted to sample up to N = 170. Even though 221 people started our survey, only 151 finished it accordingly. Therefore, we did not reach our planned sample size and neither the computed sample size. Since we found a significant interaction effect anyway and we only have five participants lacking to our computed sample

size this is not really a limitation, but we wanted to mention it for a completeness of this research.

Implications for further research

Because our study already showed significant effects for success importance it is worth it for further research to look into our extended LRM in the labor, measuring additionally biophysiological data. That is necessary to get a better understanding of how individuals differ in the amount of effort that is put into accomplishing a task successfully. It would be interesting to measure effort with myocardial contractility to see if individuals with a high success importance level really put in more effort in a task than individuals with a low success importance level.

It would also be interesting, if fatigued participants have to put in more effort from the beginning than non-fatigued participants as proposed by Mlynski et al. (2021). Because we did not manipulate the fatigue level, we could not control this variable. Therefore, it is recommended for further research to manipulate the level of fatigue before doing a self-control task to get a better understanding of the influence of fatigue on performance in general but also on the LRM. Since we cannot be sure if individuals are honest in answering a questionnaire, this is the best method to control this variable and to see if it has an influence on performance.

Conclusion

In our research we could find that success importance has a significant effect on performance which supports our extended model of LRM. Since we did not manipulate pre-experimental fatigue but only measure it with a questionnaire, the results do not totally falsify our model. Therefore, for further research we have two important suggestions. First, it is mandatory to manipulate fatigue before doing a self-control task. We cannot be sure if people answer honestly on the questionnaire but have to take the values as they are. If one

manipulates fatigue, the questionnaire can be left out or is just needed as a manipulation check and one can be sure that the participants really are fatigued (depending on their experimental group). Second, it is necessary to measure cardiovascular data. Effort is an important variable in performance, so it is also important to measure it when you are researching performance. It is also an important to see if participants of the high incentive group put more effort in the task than participants of the low incentive group. Overall, we could show that it is worth to look into the integration of motivational processes into the LRM to make it more valid and stable.

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Appendix

Appendix 1: Abstract (English)

The limited resource model (LRM) was intensively debated in recent decades. The LRM argues that self-control is a limited resource, meaning that one can only use it if it is not depleted. Since the LRM gained a lot of empirical support we did not want to reject the model in total but to expand it, even though there is also research arguing against its validity and stability. We integrated motivational processes (motivational intensity theory) and fatigue into the LRM for a more valid prediction of performance. Furthermore, there is no research yet that integrated success importance and task difficulty into the model. We manipulated task difficulty (Stroop task increased in difficulty) and success importance (different amount of incentives for each group). Fatigue was measured by a questionnaire before and after the self-control task. Our sample consists of $N = 151$ (43.7% female) with an average age of 41.20 ($SD = 11.00$). As expected, participants with a high success importance performed better for a longer time than participants with a low success importance ($p = .02$, $\beta = 0.05$). Surprisingly, non-fatigued participants did not perform better than fatigued participants ($p = .28$, $\beta = -0.03$). Our study shows that it is reasonable to integrate motivational processes to extend the LRM. Since we only measured the self-reported fatigue level, we suggest to manipulate fatigue in the labor. Furthermore, we suggest measuring effort with cardiovascular methods for a better understanding of our extended model.

Keywords: Self-control, fatigue, success importance, task difficulty, limited resources, motivational intensity

Appendix 2: Abstract (German)

Das limitierte Ressourcen Modell (LRM) wurde in den letzten Jahrzehnten intensiv debattiert. Das LRM beschreibt Selbstkontrolle als eine limitierte Ressource, das heißt man kann sie nur ausüben, wenn sie nicht erschöpft ist. Da das LRM viel empirische Unterstützung bekommen hat wollten wir dieses nicht komplett verwerfen, sondern erweitern, obwohl es auch Forschung gegen die Validität und Stabilität dieses Modells gibt. Wir haben motivationale Prozesse (Theorie der Motivationsintensität) und Erschöpfung in das LRM integriert, um eine validere Vorhersage über Leistung treffen zu können. Weiters gibt es bis jetzt keine Studien, die Erfolgswichtigkeit und Aufgabenschwierigkeit in das LRM integrieren. Wir haben die Aufgabenschwierigkeit (Stroop-Aufgabe wird laufend schwieriger) und die Erfolgswichtigkeit (unterschiedlich hohe Belohnungen für Gruppen) manipuliert. Die Erschöpfung wurde mittels Fragebogen, vor und nach der Selbstkontrollaufgabe, erhoben. Unsere Stichprobe besteht aus N = 151 Personen (43,7% weiblich), mit einem Durchschnittsalter von 41,20 (SD = 11.00). Wie erwartet, haben Teilnehmer*innen mit hoher Belohnung längere Zeit eine gute Leistung erbracht als Teilnehmer*innen mit niedriger Belohnung (p = .02, β = 0.05). Überraschenderweise haben erschöpfte Teilnehmer*innen keine bessere Leistung erbracht als nicht erschöpfte Teilnehmer*innen (p = .28, β = -0.03). Unsere Studie zeigt, dass es sinnvoll ist motivationale Prozesse in das LRM zu integrieren, um dieses zu erweitern. Da wir die Erschöpfung nur mittels Selbstbericht gemessen haben, empfehlen wir für zukünftige Forschung eine Manipulation dieser. Des Weiteren empfehlen wir die Anstrengung mittels kardiovaskulärer Methoden zu messen, um ein besseres Verständnis für unser erweitertes Modell zu bekommen.

Schlüsselwörter: Selbstkontrolle, Erschöpfung, Erfolgswichtigkeit, Aufgabenschwierigkeit, limitierte Ressourcen, Motivationsintensität