Measuring How You Feel: Monitoring Grit And Self-Efficacy On A Daily Basis

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Abstract

Background: Grit and self-efficacy have been regarded as important predictors of success, particularly in the academic setting. Previous studies have explored their relation as character traits and have found positive correlation between the two constructs. Even though these studies' results are at the between-person level, the conclusions and recommendations are drawn at within-person level. The same association between grit and self-efficacy at trait level, cannot be inferred at the state level. There is a lack of research on how these two constructs are associated on a moment to moment basis. **Objective:** The current study's goal was to explore how a student's state-level grit and self-efficacy are associated and how this association is comparable to the positive relation found at the trait-level. It was also explored whether state grit's relation with self-efficacy is mostly on a state-level (within-person) or on a trait-level (between-person). **Method**: A repeated measure, online experience sampling study with 30 university students was conducted. To measure the trait-level grit and self-efficacy, the Grit Scale for Children and Adults (GSCA) and New General Self-Efficacy Scale (NGSE) were used respectively. For the state measures, a questionnaire composed of two items per construct were utilized and administered three times per day over period of eight days on the participants' personal mobile device. **Results**: State grit and self-efficacy were significantly positively correlated similar to their trait counterparts. Moderate positive correlation between trait and state grit and weak positive correlation between trait and state self-efficacy was found. The result of LMM analysis suggest state grit has a significantly stronger between- than within-person association with self-efficacy. **Conclusion:** Initial hypothesis of reverse relation between state grit and self-efficacy was rejected. Following previous research, it is advised that teachers try to increase a student's average (trait) self-efficacy rather than enhancing their state grit.

Keywords: ecological momentary assessment, experience sampling method, ESM, grit, self-efficacy, state measure, trait measure

Measuring how you feel: monitoring grit and self-efficacy on a daily basis – an experience sampling study

Over the past two decades, positive characteristics such as grit and self-efficacy have been regarded among the most important predictors of success in individuals. A student's grit – defined as perseverance and passion for long term goals – has been connected to a number of positive academic and health-related results (Datu et al., 2017; Guerrero et al., 2016). An individual's self-efficacy (the person's appraisal of their capabilities) has been reported to directly predict grade point average and other academic achievements (Chemers et al., 2001; Feldman & Kubota, 2015). In recent years, the relation between these two constructs as character traits has gained attraction (Sturman & Zappala-Piemme, 2017; Wolters & Hussain, 2015) as they have demonstrated joint predictive power of individual's behavior in academic and mental health settings (Guerrero et al., 2016).

Almost all previous studies have focused on average association between the two construct using between-person measures and they have been demonstrated to have a positive correlation as *traits*. However, since grit and self-efficacy are emotional experiences, they can be considered affective *states*; therefore, on an individual (within-person) level, subject to fluctuations over time. Furthermore, the relation between day to day grit and self-efficacy has rarely been examined. An observed relation between two constructs at between-person level cannot be assumed to hold true on a within-person level (Curran & Bauer, 2011). Therefore, it is possible that momentary lapses of grit display a negative correlation with momentary self-efficacy than the positive association found on the trait level. Hence, the present study's objective is to investigate how a person's state-level grit and self-efficacy are associated with the means of an ecological momentary assessment and whether this association is reflected at the trait-level.

Grit

Grit as psychological construct has been claimed to be a tool for achieving success in variety of fields (Duckworth, 2016) and thus has gained increasing attention among researchers**.** Originally conceived as *Perseverance* – one of the many character strength proposed by Seligman (2002) – it has been further elaborated and popularized as *Grit* by works of Angela Duckworth and her colleagues (Duckworth et al., 2007). Grit has been defined as the ability "To sustain a focused effort to achieve success in a task, regardless of the challenges that present themselves, and the ability to overcome setbacks."(Sturman & Zappala-Piemme, 2017, p. 2). The previous mentioned studies, have defined grit as a *trait-like* personality variable; i.e. a stable characteristic of the individual independent of domain or given context.

Over the years, subsequent research has connected trait-level grit to a number of positive academic and work-related results (Datu et al., 2017) from association with higher academic achievement (Bowman et al., 2015; Strayhorn, 2014; Wolters & Hussain, 2015), to predicting performance on standardised tests (Sturman & Zappala-Piemme, 2017). Moreover, studies on grit from a mental health standpoint have shown that individual's high grit level can indirectly reduce risk of suicidal ideation among college students by increasing meaning in life (Kleiman et al., 2013). This has led researchers to view grit as a promising positive psychological trait to target in psychological interventions.

Despite these findings, a recent meta-analysis proposes trait-level grit as more or less a measure of other personality constructs such as conscientiousness (Credé et al., 2017). Furthermore, another study was unable to explain any significant amount of variance in high school and college students' academic performance using trait-level grit (Muenks et al., 2017). These inconsistent results have prompted a number of researchers to investigate grit as a *state-like* motivation variable; i.e. a situated, context sensitive experience that can fluctuate on a day to day basis. However, exact definitions of what constitutes 'state' grit varies across these limited studies. As an example, a recent research in a German high school has defined

state grit as different but stable levels for different school subject domains such as math or biology. They have demonstrated that subject sensitive grit is a more valuable predictor of GPA than trait-level grit (Schmidt et al., 2019). In another case, a newly created context sensitive model of grit appears to be a better predictor of academic success in a study conducted among students of a Filipino (traditionally context sensitive) population (Datu et al., 2017). However, studies investigating grit as a state are still limited and there are calls for further investigation using state-level methods of analysis (Ericsson, 2016) and conceptualization of grit as day to day, fluctuating construct in academic settings (Janzen et al., 2019). Timing of measuring grit as well as its possible fluctuation throughout time can be the missing factor in explaining inconsistent results of trait grit in predicting standardised test scores and by extension academic success. Therefore, conceptualizing grit as a state could provide more accurate picture of what is happening to a student in a given moment when conducting tests. Furthermore, this time sensitivity has potential to improve interventions by boosting grit at the right time when the individuals need it the most. Thus, this study aims to capture an individual's state-level grit over a fixed period of time and compare it to their trait-level grit and to see to what extent they are associated with each other. For the purposes of this study, we have opted for a definition of state grit as an experience that can fluctuate on a day to day, momentary basis, regardless of the context, domain or setting. Trait grit is seen as a character attribute that is stable over time as described by Sturman and Zappala-Piemme (2017) . It is hypothesized that this state-level grit will showcase a positive correlation with its trait-level counterpart.

Self-efficacy

Self-efficacy is a well-established psychological construct from social cognitive theory developed by Bandura (2001) and his colleagues. Self-efficacy has been proposed to guide behavior and motivation both directly or indirectly by influencing a person's effort and persistence. The definition of self-efficacy given by Bandura (2001) as being situationally

oriented has led researchers to predominantly conceptualize this construct as a task specific or state-like variable (Gist & Mitchell, 1992). As an example, college students with high academic self-efficacy have been found to possess better academic performance as well as being capable of coping with stress and other challenges than their low academic self-efficacy classmates (Chemers et al., 2001; Feldman & Kubota, 2015).

Yet a few researchers have shown interest in defining self-efficacy of a given person as a general, trait-like variable and to see if it retains its power in predicting performance regardless of a given subject or context. Chen et al. (2001) defines trait-level general self-efficacy as "individuals' perception of their ability to perform across a variety of different situations" (p. 63). Comparing different people, it captures differences in each person's tendency to view themselves as capable of meeting demands and challenges regardless of the context. Furthermore, Chen et al., (2001) argues that general self-efficacy (GSE) positively influences specific self-efficacy (SSE). In their study, Chen et al., (2001) tried to develop and validate the new general self-efficacy scale (NGSE) as a new tool for measuring GSE in individuals. As an additional goal, they set out to test whether their new scale for GSE would positively correlate with SSE for performing different tasks. While they reported moderate correlation between trait and state level self-efficacy, they have called for further empirical investigation to support their findings (Chen et al., 2001).

Hence, to further investigate this idea, the present study will examine an individual's state-level self-efficacy and compare it to their trait-level self-efficacy and to see to what extent they are associated with each other. In line with Chen et al., (2001) findings, it is hypothesised that state self-efficacy will be positively associated with trait self-efficacy. We adopt Chen et al., (2001) definition of trait self-efficacy as well. Similar to state grit, state self-efficacy is conceptualized as a fluctuating day to day experience, regardless of the context, domain or setting.

Grit and self-efficacy

In recent years, the relation between grit and self-efficacy has risen in appeal among researchers. Chen et al., (2001) has proposed that general self-efficacy is positively related to other trait-like personality constructs such as conscientiousness. This has spawned interest in examining self-efficacy with grit together in relation to academic success in a number of subsequent studies (Sturman & Zappala-Piemme, 2017; Usher et al., 2019; Wolters & Hussain, 2015). As an example, in a study of high school and college students, Muenks et al. (2017) observed that academic (state-level) self-efficacy and trait-level grit predict grades; suggesting that both jointly explain the performance of students in different academic context. In another study, Wolters & Hussain (2015) found a positive correlation between trait grit and trait self-efficacy; meaning the higher student's grit, the more self-efficacy they possess or vice versa. Lastly, a recent study examining these two trait-level constructs and their predictive relationship with achievement in U.S. elementary and middle school students has proposed self-efficacy to be at least a partial mediating factor between an individual's grit and school performance (Usher et al., 2019).

Outside of the academic setting, as previously mentioned, some studies have demonstrated predictive possibilities of grit in stressful mental health situations (Burkhart et al., 2014; Kleiman et al., 2013). Guerrero et al. (2016) has suggested high grit as a protective factor against substance abuse and other risky behaviours among adolescents and reported that higher self-efficacy scores were associated with higher grit scores. Therefore, acquiring deeper insight into relation between these two constructs could help in tailoring interventions to the needs of the individual.

However, almost all previous studies exploring grit and self-efficacy together have focused on the trait-level conceptualization. Even though the results of these studies are from single-time point (cross-sectional) measures at the between-person level, the conclusions and recommendations are drawn at the individual level (within-person). Since it has been known

that data at this level of analysis is neither necessary nor sufficient to imply an effect at another level (Curran & Bauer, 2011); the same association between grit and self-efficacy at trait level, cannot be inferred at the state level. Not recognizing the important distinction between these level can lead to consequential errors of inference, particularly the ecological fallacy (Curran & Bauer, 2011). In this case it would imply while these two constructs have a positive correlation as traits, the same relation could be counterintuitively different on a state-level. We argue that when people find a given task difficult in the moment, only those individuals who are focused persistently will be able to overcome the challenge. In other words, a person might actually show high levels of state grit when their state self-efficacy is low. Additionally, it is not well known whether the person's day to day grit and self-efficacy demonstrates a stable pattern over time or fluctuates drastically; and whether these fluctuations are mostly associated with the person's average level of self-efficacy or day to day fluctuations over a period of time.

To the best of the author's knowledge, no study as of yet has examined the association between grit and self-efficacy on a state-level. Thus, the current study aims to explore these ideas and examine the relation between grit and self-efficacy on a state-level and their relation with their trait level counterparts to help fill this knowledge gap as well as to re-assess the trait-level association between these two constructs.

Current study

The current study's goal is to explore how a student's state-level grit and self-efficacy are associated and whether this association is reflected at the trait-level. We explore independently how state grit and self-efficacy are experienced on day to day basis using an experience sampling method (ESM). Firstly, it is hypothesized that those with high levels of trait grit will naturally demonstrate high levels of average state grit. The same positive association is assumed for trait and state self-efficacy. Secondly, on a trait-level comparison between grit and self-efficacy, a positive correlation is expected as previous studies have

proposed. However, on the state level, a negative association between the two is hypothesized. Thirdly, it is investigated whether state grit's relation with self-efficacy is mostly on a state-level (within-person) or a trait-level (between-person).

Method

Design

For this study, a structured, repeated-measure questionnaire was utilized. To measure the trait-level grit and self-efficacy, the Grit Scale for Children and Adults (GSCA) (Sturman & Zappala-Piemme, 2017) and New General Self-efficacy Scale (NGSE) (Chen et al., 2001) were used respectively. To measure the state-level, day to day experiences of grit and self-efficacy an experience sampling method (ESM) was utilized. ESM is an organized, self-report diary procedure designed to evaluate symptoms, moods, appraisals and context of an individual as they take place throughout daily life (Myin-Germeys et al., 2018). This method lessens the burden on participants' memory to recall events or experiences. Furthermore, data collection can be targeted to the immediate, particular context or emotional state that the researcher is interested in (Berkel et al., 2017).

In our study, we adopted a time-contingent design in form of daily state questionnaire for grit and self-efficacy administrated three times a day for period of eight days. A recent literature review on use of ESM on mobile devices advocates at least one week as the study duration in order to obtain a representative varied sample of experience a person goes through on a daily basis (Van Berkel et al., 2017). Additionally, the three to five time per day sampling frequency was recommended as a good balance between minimizing participant burden and risk of retention while providing the researchers with enough varied data points (Berkel et al., 2017). Since most participants were university students, three times per day would lend itself to capturing a snapshot of individual's grit and self-efficacy while they perform varying tasks throughout the day. In this case, 24 data points in total per participants

per question in case of a 100% response rate. Additionally, the eight days study duration provide the chance to obtain data from varying working activities throughout the week.

Data was collected throughout April 2020. Participants accessed the state and trait questionnaires using an online survey environment created in the application *Ethica* (described below) by downloading it on their personal smartphone. This study was approved by the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences (BMS) of the University of Twente (request no. 200382).

Participants

The study contained a sample of 30 students mainly from university of Twente's BMS faculty. Participants were between 18 to 35 years old (M_{age} = 22.6, SD_{age}=3.82, women 50%, men 50%,). Out of all the participants, 43.3% identified as Dutch, 30% as German, and 26.7% as other nationalities. The participants joined the study by means of convenient sampling; through university of Twente's BMS faculty SONA (subject pool software) system and the researchers' own personal contacts. The participants from BMS faculty were compensated with study credits for completing the study.

As inclusion criteria, participants from SONA system were asked to be a registered student and above the age of 18, be proficient in the English language and able to download the app Ethica on their mobile device to be able to participate in the survey.

Materials and measures

The online survey was created using the application *Ethica*. The test battery consisted of four daily state questions and two trait questionnaires.

Ethica

Ethica is a smartphone software environment designed for researchers to create, maintain and deploy surveys and other forms of studies. It functions as a platform for participants to join the study using their smartphones and complete the questionnaires; while providing web

desktop environment (ethicadata.com) for the researcher to obtain and view participant data (Ethica, 2020). The mobile app can be installed on most recent smart phones using Android and iOS operating systems. In this study, version 153 of the smartphone app was utilized. On the researcher web app, questions can be grouped into survey modules called ‘activities’, which once created can be made available to participants on their smartphone using a variety of trigging logics such as a fixed time of day publication. Pop up notifications can be scheduled as reminders to participants when a particular activity (i.e. survey) needs to be completed.

Trait Questionnaire

Grit Scale for Children and Adults (GSCA): The GSCA defines trait grit as sustained effort to achieve tasks despite facing challenges (Sturman & Zappala-Piemme, 2017). The scale is made up of 12 items (appendix A) which can be answered on a 5-point Likert-Scale from one (strongly disagree) to five (strongly agree). Example items are ‘I always finish what I start’ and ‘Challenges in my life sometimes make me want to stop trying’. Scores range from minimum 12 (lowest trait grit) to maximum 60 (highest trait grit). It has demonstrated adequate internal consistency (Cronbach's alpha of 0.84) as well as high construct and criterion validity and high correlation with self-efficacy in comparison with other existing grit measures (Sturman & Zappala-Piemme, 2017).

New General Self-efficacy Scale (NGSE): The NGSE assess self-efficacy using 8 items (appendix A) on a 5-point Likert-Scale from one (strongly disagree) to five (strongly agree) (Chen et al., 2001). Items include ‘I will be able to achieve most of the goals that I have set for myself’ and ‘Compared to other people, I can do most tasks very well’. Scores range from minimum 8 (lowest trait self-efficacy) to maximum 40 (highest trait self-efficacy) It has showcased robust psychometric properties, having adequate internal consistency (α =

0.86) and test-retest reliability (r = 0.90) as well as relatively high content validity in comparison to other contemporary self-efficacy scales (Chen et al., 2001).

Daily Questionnaire

As previously mentioned in the introduction, as far as the authors are aware, there are very few studies at this time which have operationalized grit as a state. Thus, in order to measure state grit, two trait questions from the GSCA scale were selected and modified. Similar to state grit, state self-efficacy was assessed by two statements adapted from modifying two questions from the NGSE scale. These questions were chosen based on their high factor loading and how well they could be adjusted to fit the state conceptualization of grit and self-efficacy. For both constructs, participants answered to what extent they agree with the statements on a 5-point Likert-Scale, ranging from one (strongly disagree) to five (strongly agree). Table 1 provides a full list of the state statements and their details.

Table 1

List of statements used for state questionnaire.

Scale	Trait question:	Factor loading	Modified state question	Correlation
GSCA	4. I always stick to the task I am working on until it is complete.	0.70	At the moment, I feel determined to stick to my current task until it's complete.	Positively correlated with Grit
GSCA	10. Sometimes I don't care about my work as much as I should.	0.74	At the moment, I don't feel committed to my current task as much as I should.	Negatively correlated with Grit

NGSE	4. I believe I can succeed at most any endeavor to which I set my mind.	0.69	Right now, I believe I can succeed in my current task, if I set my mind to it.	Positively correlated with self-efficacy
NGSE	6. I am confident that I can perform effectively on many different tasks.	0.75	Right now, I don't feel confident in my ability to effectively accomplish my current task.	Negatively correlated with self-efficacy

Note. Included from left to right column a) the corresponding scale the statements are adapted from, b) the original question they are based on, c) the original question factor loading d) new statement used in state questionnaire and e) the intended correlation of the new statement with its corresponding construct.

Procedure

This study took place over a period of nine days in total. The first day was reserved for participants to join the study and make sure they were ready for the upcoming days. After signing up either via SONA or directly through the researchers, participants were asked to download the Ethica application on their smartphone. They were then provided the Ethica study code and had to enter it alongside their email address to register for the study on the Ethica app. Afterwards, the first page they were provided on the Ethica was a general overview about the study and what is expected of them throughout the week (appendix B-1). All participated voluntarily joined the study and accepted an informed consent at the beginning when registering on Ethica for the first time and before starting any of the surveys (Appendix B-2)

For the first day, they were tasked to fill in the demographic survey and to make sure the notification setting on their phone allows for pop-up notification from Ethica. The importance of this functionality was clarified to the participants with brief information on how to adjust this setting on their phone based on their smartphone type (Android or iOS).

Afterwards, participants were provided with the two grit and self-efficacy *trait* questionnaires. Since these two surveys measure the 'average' trait level of these concepts, administering the daily questions first could impact their overall score. Therefore, it was important to administer these questionnaires *before* the participants accessed the daily state survey. After completing the two trait questionnaires, participants were then informed that this was everything to do for the first day and then more information would be provided on the following day and they should keep an eye out for notifications from Ethica. Participants were also encouraged to report any problems with setting up the app to the researchers.

On the next day (day 2) for the next eight days (day 2-9) they were given the four state questions. For the state questionnaire, the present study grouped the four questions (two for grit and two for self-efficacy) into one survey called 'daily state survey' (appendix B-3). To answer these ESM questions, we used three timeframes per day called morning, afternoon and evening *sessions* over a period of eight days. These sessions were randomly generated between the time frame of a) 9 to 10:30, b) 14 to 16:30, and c) 20 and 21:30 daily. This random starting time was utilized in order to prevent the habituation of the participants. In order to guaranty the sequential order of the data points, the state survey would expire after the 90-minute session time window.

As an example, if a morning session was triggered at 9:30 am, participants would have until 11 am to answer the survey. This prevented the participants from filling the survey at end of the day if they had forgotten to do so at the appropriate time frame thus preserving the sequential ordering of responses. Lastly, once a session started three pop-up notifications were generated automatically every 30 minutes to announce to participants that a new survey is available and remind them a survey is waiting for completion in case they have not seen it yet (appendix B-4). A recent literature review on use of ESM on mobile devices suggest these signal contingent reminders can drastically reduce participant burden (Berkel et al., 2017).

While creating the study's environment in *Ethica*, each survey was repeatedly tested and adjusted on the researchers own phone to make sure the user interface is readable and to avoid unclear elements or designs. A two-day pilot study was conducted with two participants testing the functionality of the surveys, the pop-up reminder, response functions and the user interfaces. An answer had to be given to each question before going to the next one. Appreciative messages were given to participants at the end of each survey session to encourage their continual response rate and maintain participant retention. Throughout the duration of study, participant response rate was monitored. Researchers contacted those with no response for multiple consecutive days to potentially increase their participation effort and provide encouragement. On day nine, the participants were thanked for their contribution.

Data analysis

Since data has been collected at multiple points in time from a number of individuals, there is a need to disaggregate the between-person and within-person effects in one model to avoid errors of inference (Curran & Bauer, 2011). Therefore, for both self-efficacy and grit, the average person mean (PM) score per participant over the course of eight days, was calculated to allow for between-person analysis and compare the data from trait and state questionnaires. Furthermore, the state scores for self-efficacy and grit were subtracted from their respective PM score to calculate the person mean-centered score (PM-centered) for each participant; allowing for within-person analysis.

To evaluate the reliability of NGSE and GSCA trait questionnaires, Cronbach's alpha was calculated. In interpreting the alpha, as Field (2013) recommends, an alpha with value as low as .5 is deemed acceptable, with $\alpha > .6$ being considered good, and $\alpha > .7$ being excellent. This is due to the fact that these were short questionnaires with relatively few items and some items negatively phrased. For the state items, test-retest reliability analysis was used to assess the stability of responses. Additionally, to examine the validity of the state questionnaires items for self-efficacy and grit, Pearson correlation analysis was used between

a) state self-efficacy (PM) and the NGSE, b) state grit (PM) and GSCA with interpretation of correlation coefficient (r) as follows; $r > 0.50$ suggesting a strong relation, $r > 0.30$ a moderate relation, and $r > 0.10$ a weak relation.

Pearson correlation was utilized to see the relationship between a) trait self-efficacy and trait grit, b) trait self-efficacy and state self-efficacy (PM) and c) trait grit and state grit (PM) and d) state grit (PM) and state self-efficacy (PM). Furthermore, linear mixed modeling (LMM) was utilized to explore the relation between state grit and state self-efficacy. To account for missing measurement points and data dependency, the LMM used an autoregressive structure with time points as covariate. Lastly, LMM was incorporated to understand whether the relation between self-efficacy and grit is a state-like (within-person) or a trait-like (between-person) association. In this analysis, state grit was set as the dependent variable while state self-efficacy PM (between-person relation) and state self-efficacy PM-centered (within-person relation) as fixed independent variables. To assist in interpreting the between and within person estimates, the variables were standardized.

IBM SPSS Statistics (version 26) was utilized to analysis the participant data exported from Ethica. Only those participants with above 50% response rate of the daily state questionnaire were included in the final analysis as this is common cut-off point among ESM studies (Conner & Lehman, 2012). Descriptive statistics were calculated for their overall demographic data (age, gender and nationality) and the mean grit and self-efficacy scores from the trait questionnaires. Microsoft Excel 2016 was used for the visual analysis.

Results

Descriptive

In total, 43 individuals signed up for the study. Out of those, 13 were excluded due to insufficient data points in the state questionnaire (below 50% response rate). Table 1 showcases the mean, minimum and maximum scores of trait self-efficacy and grit results for total of 30 participants. The average response rate was 76.94%. The Pearson correlation between the state self-efficacy (PM) and NGSE questionnaire (trait self-efficacy) results demonstrates significant yet weak positive correlation ($r = .144$, $p < .001$) while the state grit (PM) and GSCA (trait grit) show significant, moderate positive correlation ($r = .405$, $p < .001$). When assessing the reliability of the trait questionnaires, NGSE shows good reliability ($\alpha = .689$) and the GSCA shows excellent reliability ($\alpha = .764$). Lastly, the state grit items showed excellent reliability ($\alpha = .838$, $p < .001$) while state self-efficacy items showed good reliability ($\alpha = .688$ $p < .001$)

Table 1
Means (M), Minimum, Maximum Scores and Standard Deviations (SD) of Trait Self-efficacy and Trait grit.

Variables	Minimum (scale minimum)	Maximum (scale maximum)	M	SD
GSCA (trait grit)	21 (12)	51 (60)	37.57	6.37
NGSE (trait self-efficacy)	20 (8)	36 (40)	30.73	3.38

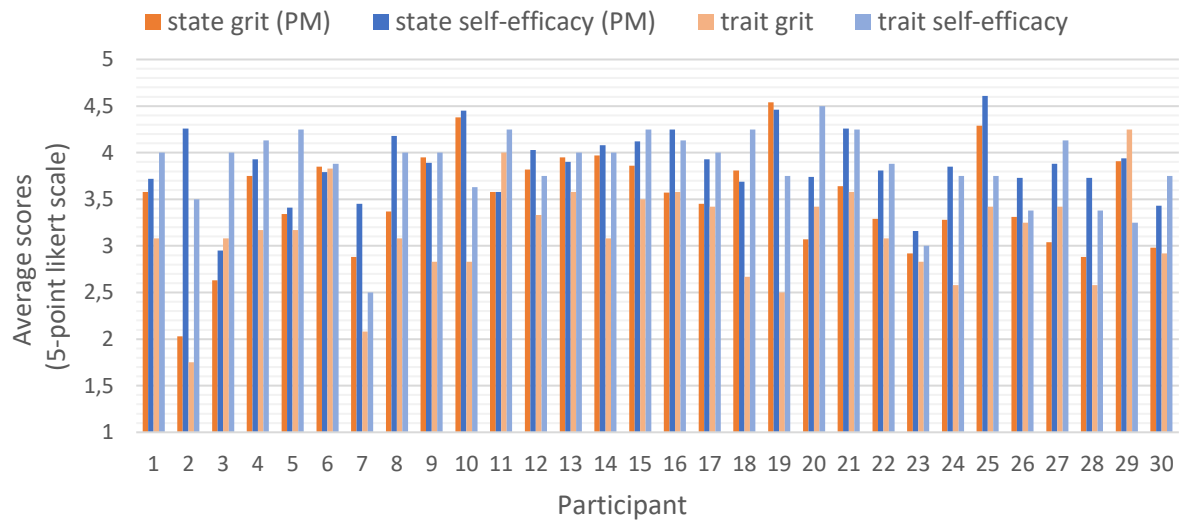
N=30

Associations between self-efficacy and grit

As expected, Pearson correlation analysis indicates a significant, moderate to strong positive correlation between trait self-efficacy and trait grit (r= .499, p< .001). Meaning those who score high on trait self-efficacy tend to score high on trait grit. These results seem to hold true for state self-efficacy (PM) and state grit (PM) as well (r= .536, p< .001). Figure 1 provides a visual comparison between participants for each of their trait and state measures. As can be seen in the figure, within the participants the difference between the four measures tends to be very minimal, with scores being relatively stable and consistent as can be seen in participant 6, 12, 13, 23 and 26. The difference between the participants were relatively minor as well, with most demonstrating average to high scores on all four measures. A notable exception is participant 2 who shows low state and trait grit relative to their high state and trait self-efficacy.

Figure 1

Visual representation of mean scores for trait grit (light orange), state grit PM (dark orange), trait self-efficacy (light blue) and state self-efficacy PM (dark blue) for each participant.



Furthermore, the result of LMM analysis indicate that state grit depends more on trait self-efficacy (i.e. between-person PM) (β_{pm} =0.77, SE=0.13, p<0.001) and less on state self-efficacy (within-person PM-centred) (β_{pmc} =0.48, SE=0.05, p<0.001). Since the estimate of

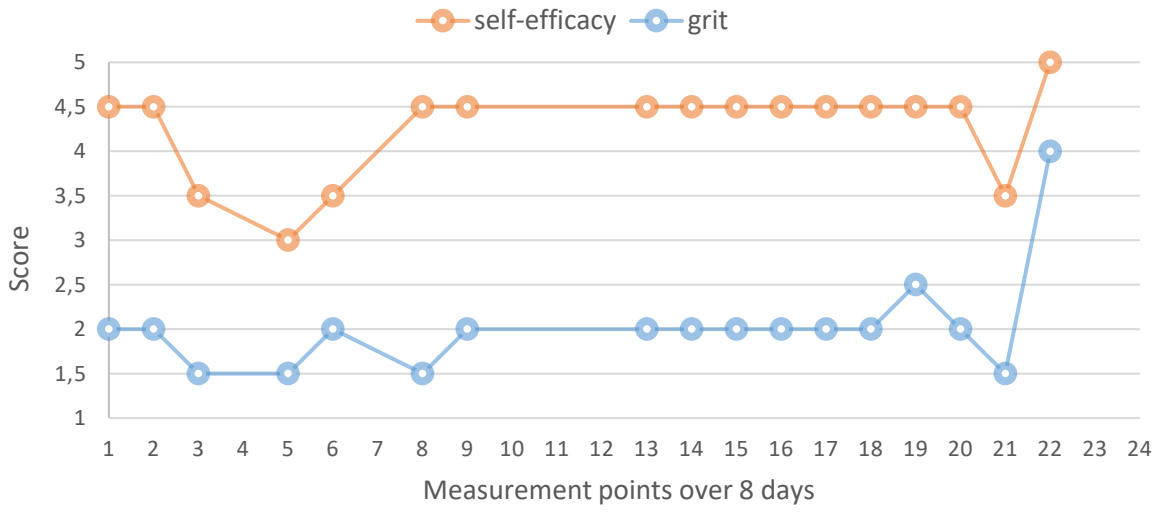
PMC is outside the 95% confidence interval (± 1.96 SE) of the PM estimate, the between-person association is significantly stronger.

Individual case analysis

In order to obtain a more precise picture of participants' daily state grit and self-efficacy over time, a number of participants with representative scores were selected as examples for a further examination on the individual level. First example, participant 2, has the lowest trait grit (1.75) and state grit (2.0) among all the participants. In contrast, their average state self-efficacy (4.26) is one of the highest among all participants and their trait self-efficacy (3.5) is above average as well (Figure 1). The pattern of the participant's state self-efficacy and grit scores over time can be seen in Figure 2. The two lines show some variations at beginning and end of the study yet seem stable over the course of the week. The changing patterns of self-efficacy and grit seem similar over time as most of the curves shift in parallel in the same direction. The magnitude of change appears to be somewhat more pronounced in self-efficacy than in grit. Even though their grit and self-efficacy levels are quite different, the two constructs show a clear pattern of positive relation with each other.

Figure 2

Participant 2 daily scores for state self-efficacy (orange) and state grit (blue) per measurement point.

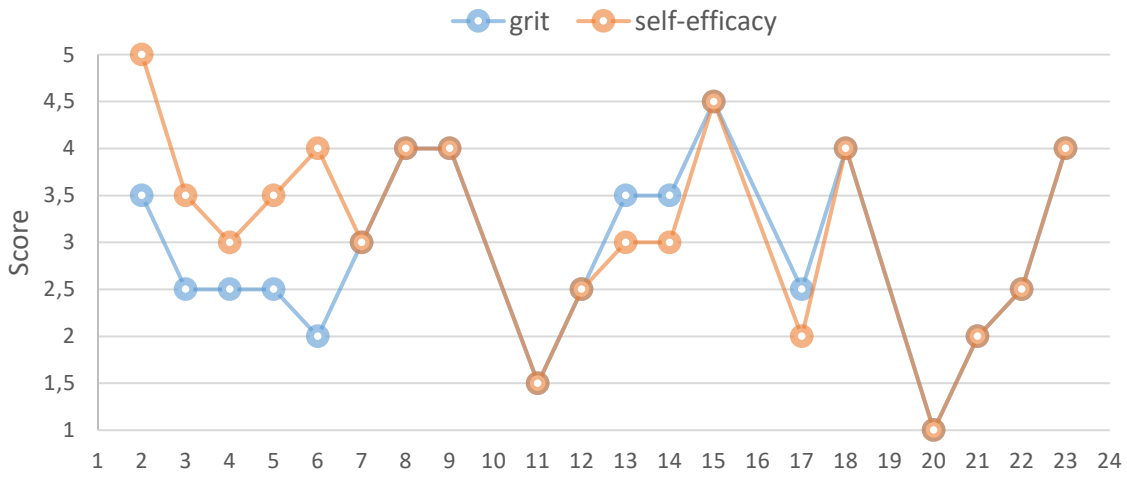


Note. The measurement numbers without points (circles) such as number 10, 11 and 12 showcases sessions with missing data. The participant did not fill the survey during those sessions.

The second example, participant 23, has very similar values for all four variables and sits at average levels for all of them; with a trait grit score of 2.83, average state grit of 2.92, trait self-efficacy of 3, and average state self-efficacy of 3.16 (figure 1). Their daily state patterns can be seen in Figure 3. Similar to the previous participant, the fluctuations of self-efficacy and grit have quite a bit of overlap and they shift over time parallel to each other in the same direction. For this participant, the magnitude of change is more pronounced particularly for self-efficacy as it starts the week quite high then drops very low midway at point 11 and continues to have large fluctuations for the rest of the week. Despite this more fluctuating pattern of change, both constructs appear to have clear positive association with each other similar to the previous participant.

Figure 3

Participant 23 daily scores for state self-efficacy (orange) and state grit (blue) per measurement point.



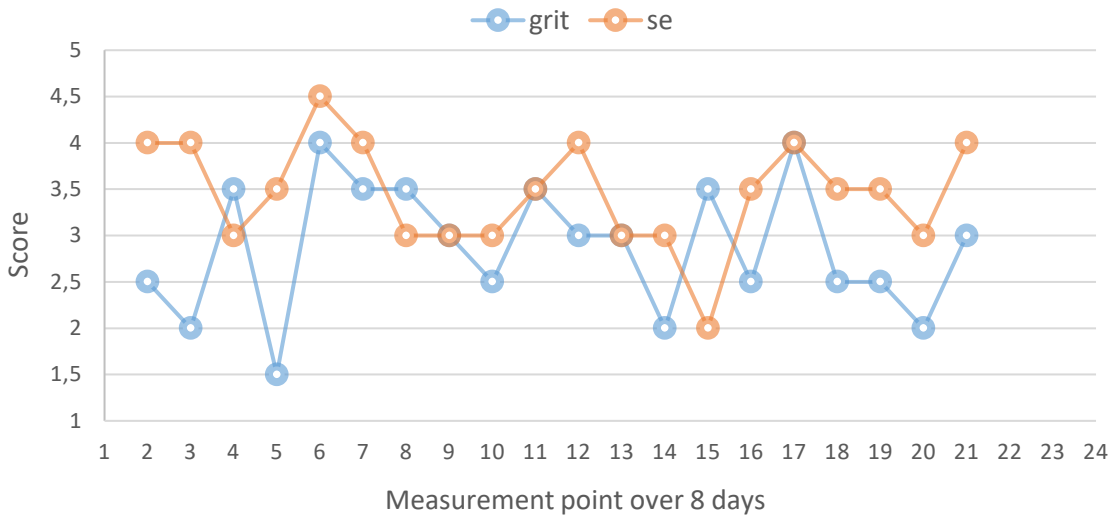
Note. The measurement numbers without points (circles) such as number 1, 22, 23, and 24 showcases sessions with missing data. The participant did not fill the survey during those sessions.

Lastly, participant 7, showcases patterns unlike the previous two examples. They possess low trait grit (2.08), average level state grit (2.88), below average trait self-efficacy (2.5), and above average state self-efficacy (3.45) (figure 1). Their daily state patterns are shown in Figure 4. Both grit and self-efficacy fluctuate throughout the week and seem to not

possess a stable, consistent pattern. Additionally, at particular points (3 to 5 and 12 to 16) they seem to possess a negative relation, with self-efficacy going up as grit goes down and vice versa. However, for the rest of the time points they demonstrate more or less the same parallel shifts as per previous examples.

Figure 4

Participant 7 daily scores for state self-efficacy (orange) and state grit (blue) per measurement point.



Note. The measurement numbers without points (circles) such as number 1, 9, 10, 16, and 19 showcases sessions with missing data. The participant did not fill the survey during those sessions.

Overall, the three individual examples suggest that there is a discernible positive relationship pattern between state grit and self-efficacy despite varying levels of each construct or the magnitude of their fluctuations throughout the week.

Discussion

The purpose of this study was to gain a better understanding of the association between an individual's grit and self-efficacy on a momentary basis (state-level) and to see whether this relation is reflected at a person's general characteristic (trait-level). Overall, the current study's results are consistent with previous research on trait grit and self-efficacy and support the hypothesis that these two constructs are strongly positively associated on a trait level. In line with our expectations, the results indicate that trait grit is positively related to its state counterpart as well; meaning that those having high levels of trait grit will naturally showcase high levels of average state grit. For trait and state self-efficacy a similar yet weaker connection was found. On a state level, results show strong positive relation between grit and self-efficacy, rejecting our hypothesis of being negatively associated on the state level. Furthermore, our findings suggest state grit has a significantly stronger between-person association with self-efficacy than within-person; meaning state grit depends on trait-level self-efficacy more so than on state-level self-efficacy.

Interpretation and similarity of result with previous studies

In regards to relation between trait and state self-efficacy, our findings are consistent with Chen et al., (2001) theoretical formulation of general self-efficacy; providing a weak yet significant empirical support for their idea of trait self-efficacy's positive relation to the motivational (state) self-efficacy traditionally defined by most researchers (Gist & Mitchell, 1992).

On a trait level, the results of the current study are in line with previous research on grit and self-efficacy's association suggesting people who on average, perceive themselves as capable in performing any given task (i.e. high general self-efficacy) tend to demonstrate persistence effort to achieve their task (i.e. high trait grit) as well. These findings have potential implications for interventions. For example, by enhancing the general level of one's

self-efficacy using well established self-efficacy exercises, one's level of trait grit can possibly increase as well, which as Guerrero et al. (2016) has suggested in his study could potentially help reduce risky behavior such as substance abuse among adolescents.

On a state level, our results hint to a comparable, significant positive association between these two constructs on a momentary basis. In other words, a person actually shows high levels of state grit in real-time experience when their in moment self-efficacy is also high. These results were not in line with our hypothesis. Since it seems the relation between these two constructs on trait level is closely reflected on the state level, previous research implications that explored how these two constructs as traits jointly predict academic success (Wolters & Hussain, 2015) could hold true as states.

Lastly, when we investigated whether in moment grit is more closely associated with state-like (within-person) or a trait-like (between-person) self-efficacy, the LMM analysis suggested the between-person association is significantly stronger. This is somewhat still in line with our initial assumptions of association between state grit and self-efficacy. Instead of the correlation being negative, it is positive yet less strong than the association with trait self-efficacy. Furthermore, An interpretation of this finding is that if a person generally perceives themselves competent (high trait self-efficacy), they would be more persistent in facing a challenging situation at a given time point (state grit) despite not feeling up to the task at that particular point in time (state self-efficacy). This lends support to Usher (2019) claim that a person's self-efficacy is a mediating factor between grit and school performance. Since it can be argued that a student possessing an overall high self-efficacy will be able to persevere in difficult daily school challenges.

Strengths, limitations and future direction

One of the main strengths of this study, is its analysis of the same construct on a state and trait level. To the best of author's knowledge, this is one of the first studies that looks at

grit from a state perspective and compares its relation with its trait counterpart. Our results indicated a moderate positive association between these two levels of grit. Since trait grit has been suggested as a performance predicting factor for tests in academic settings (Sturman & Zappala-Piemme, 2017), it would be interesting to explore if the same holds true for state-level grit. This is particularly relevant as some studies have questioned the validity of trait level grit as a construct (Credé et al., 2017) and some like Muenks et al., (2017) were not able to predict academic test scores for individual students using trait-level grit. As our individual visual analysis of grit over time suggest, a student's grit can change drastically between the time the measurement test is taken and the time which the student will conduct their academic test. Our findings suggest that the inconsistent reports of previous studies could be addressed by measuring grit on a state level since on this level, the variance of this construct throughout time is taken into account. Future studies could for example test a student's in moment grit before conducting an academic test and see if it could predict the results more accurately. Additionally, since the items used to measure state grit were adopted from GSCA scale demonstrated good reliability, the rest of the items in this scale could be utilized in creating a new state grit questionnaire.

Secondly, another major consideration for future investigation is inclusion of situational context. As mentioned in the introduction, Schmidt et al., (2019) highlighted the importance of conceptualizing grit at a domain specific level and how it has a higher predictive power than general trait grit. As Datu et al., (2017) have argued, these different contexts could have varying effects on both general and moment to moment levels of grit of an individual. Perhaps students demonstrate different in moment self-efficacy or grit when faced with a particular type of situation such as a stressful study environment or being in an academic test than moments where they do not particularly feel challenged. That is why for

future studies it is recommended to include additional categorical context variables such as the presence or absence of social, study or personal stressors.

Thirdly, a major strength of this study was the usage of experience sampling method (ESM) as a way to measure momentary self-efficacy and grit, providing high ecological validity to our results (Van Berkel et al., 2017). However, a few technical problems with the ESM survey platform Ethica that arose during the study could have affected this validity. Some participants reported issues with receiving notifications for daily questionnaire and some received fewer (or sometimes more) than three sessions per day to fill in. A few participants also had less than eight days of study duration due to mismanagement of setting the duration of study properly by the researchers. These technical hurdles could be the reason for 13 individuals having insufficient data points (below 50% response rate) out of the total 43 participants who signed up for the study. Unfortunately, due to untimely deletion of these participant data and inability to recover these excluded data points, we could not investigate whether the above assumptions were the reason for this missing entry rate or some other systematic pattern was the underlying cause.

In addition, a major limitation of this study deals with generalizability. Almost all of the participants were students within a limited age range and by extension socio-economic statues (SES). Usher et al., (2019) found significantly different grit and self-efficacy results when comparing the scores of students from contrasting SES backgrounds. Therefore, future research should include a more diverse range of participants and take into account their particular cultural and economic background in the analysis of relations between the different constructs. Lastly, it would be useful for further research to consider a longer time frame for the daily questionnaire. A duration of 2 to 3 weeks is most commonly advised as a balance between participant retention and capturing sufficient measurement points for detailed

analysis of relation between variables; particularly if a specific context that occurs regularly is taken into account as well (Van Berkel et al., 2017).

In conclusion, the current study can be considered a preliminary step to fill the knowledge gap in investigated the association between grit and self-efficacy on a state-level. We observed that relation between these two constructs on state and trait level is quite similar and at a given point in time, the grit score is more dependent on an individual's average self-efficacy. Following with Usher (2019) advice, it is recommended that teachers target students' self-efficacy conception and try to bring its average level up to enhance performance as opposed to motivating them on a momentary basis (i.e. enhancing their state grit).

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Appendices

Appendix A: Trait questionnaires

New General Self-efficacy Scale (NGSE) items

1. I will be able to achieve most of the goals that I have set for myself.
2. When facing difficult tasks, I am certain that I will accomplish them.
3. In general, I think that I can obtain outcomes that are important to me.
4. I believe I can succeed at most any endeavor to which I set my mind.
5. I will be able to successfully overcome many challenges.
6. I am confident that I can perform effectively on many different tasks.
7. Compared to other people, I can do most tasks very well.
8. Even when things are tough, I can perform quite well.

To calculate the total score for each participant, take the average rating of the items by adding respondents' answers to each item and dividing this sum by the total number of items (8).

Grit Scale for Children and Adults (GSCA) items

** Items with reverse scoring*

*1. I don't always work as hard as I can.
2. I always finish what I start.
*3. I am not always motivated to do my best.
4. I always stick to the task I am working on until it is complete.
5. I always keep working for what I want even when I don't do as well as I would like to.
*6. Sometimes I am not as focused on my work as I would like to be.
*7. Challenges in my life sometimes make me want to stop trying.

8. No matter what happens to me I will be okay.

9. I always pay attention to what I am working on to make sure I do it well.

*10. Sometimes I don't care about my work as much as I should.

11. I never give up even when things get tough.

12. I am able to get through tough times without any difficulty.

Appendix B: Ethica

B-1 sign up information provided to the participants upon registering

Thank you very much for signing up for our study! Before you start, a short introduction will follow.

The purpose of this study is to measure how you feel throughout the day. By using monitoring tools that help us to identify the daily fluctuations of constructs from mental health, we can obtain an insight into their dynamic interactions. This can then be applied to develop more personalized psychological interventions and therapies.

This study will run for about a week. On the first day we will start with a couple of questionnaires. These initial questionnaires need to be filled in only once and it shouldn't take more than 30 minutes. From the next day onward, you will receive notifications via ethica when you can answer a couple of questions throughout the day. That will happen three times per day - morning, afternoon and evening and it won't take more than 15 minutes per day. That will continue for 7 days until the end of the study. Please keep in mind you can opt-out of the study at any moment by simply not answering any questions or deleting ethica without needing to provide any reason.

We know people are quite occupied nowadays but we will ask you to fill in these daily questions as much as possible. For this purpose, we are giving you the possibility to fill it in for an hour after receiving a notification instead of immediately, afterwards it will expire and you won't be able to do it. Please, check occasionally if you have some activities to be done.

Additionally, we want to ask you to turn on the notification option for the Ethica app and to adjust the battery optimization settings which sometimes might intervene with the pop-up and sound notifications. We will provide you with some guidelines on how to do it if you don't know, they can be found in the overview of the study.

And that is it for today! ***further information will be provided to you tomorrow in the app. Make sure to check your phone for details. We will send a notification via ethica as well to remind you.***

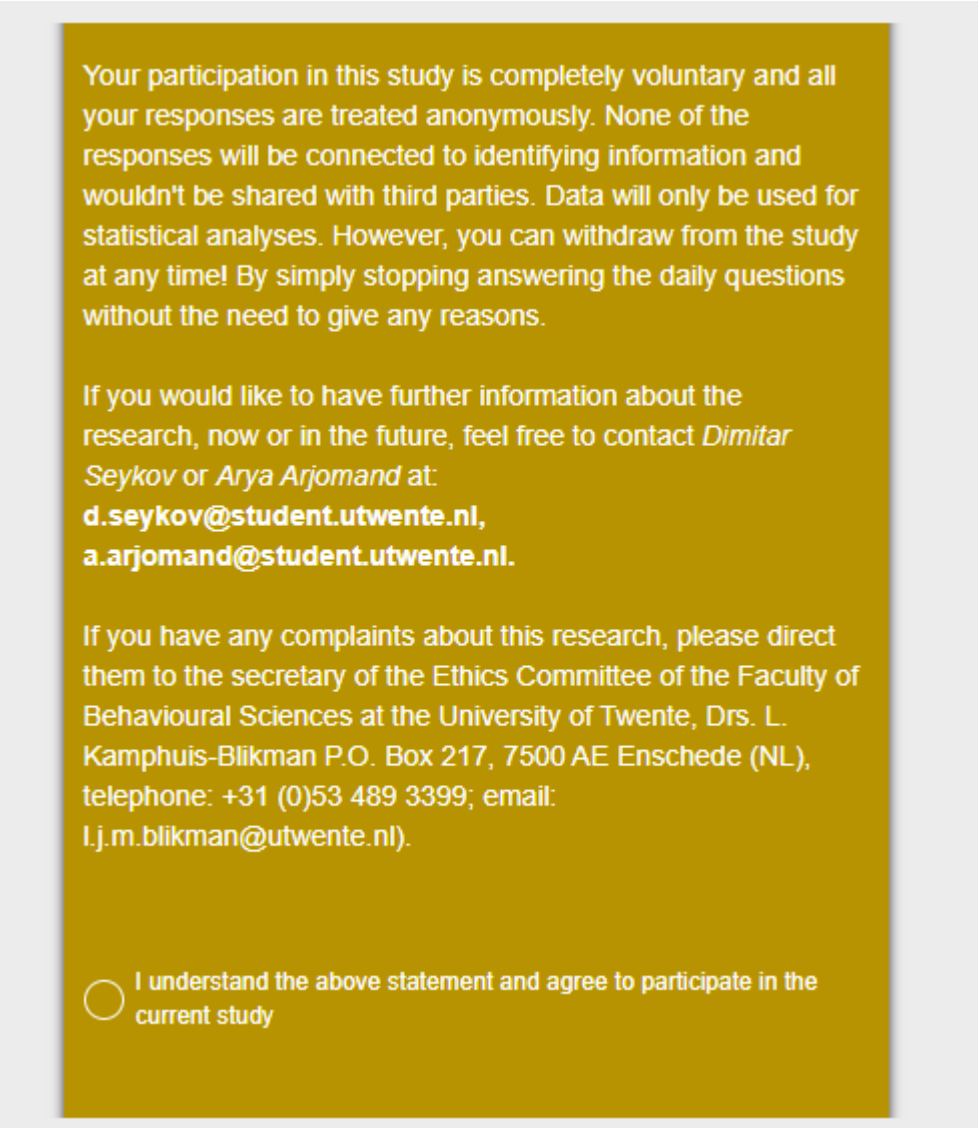
Thank you again for joining. If you have any trouble setting up the app or have questions about the study at any point feel free to contact

Dimitar Seykov or *Arya Arjomand* at:

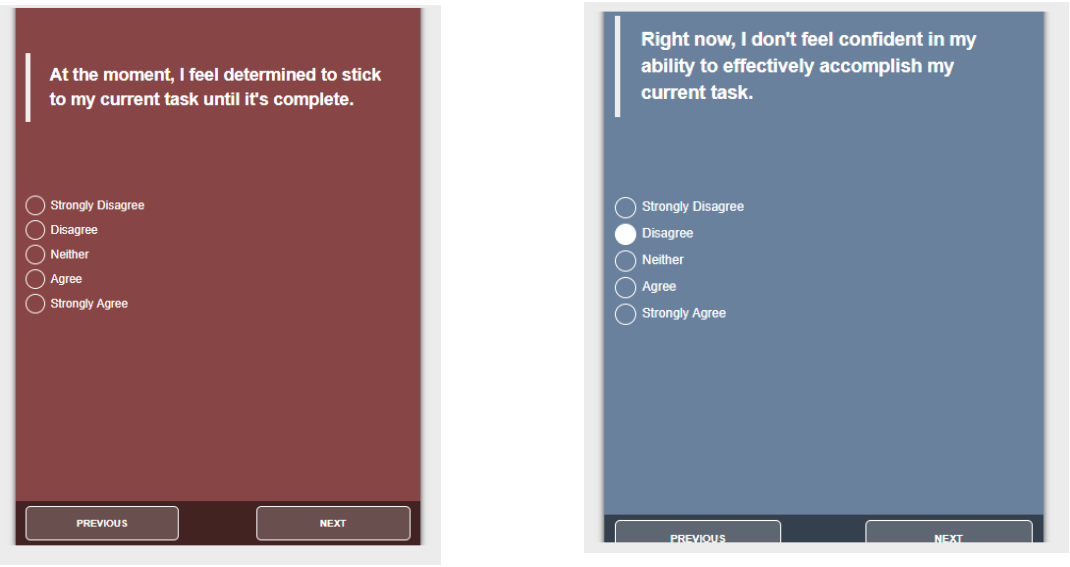
d.seykov@student.utwente.nl

a.arjomand@student.utwente.nl

B-2 Consent form



B-3 example daily state survey provided to the participants on the smartphone app



B-4 daily reminder notification settings on Ethica web app for researchers