Relationships Between Cortisol, Optimism, and Perseverance Measured in Two Military Settings

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Optimism and perseverance are 2 important assets for soldiers to be able to perform competitively in high-risk environments and to complete complex and stressful tasks. Traditionally, optimism is measured using questionnaires and most frequently in a retrospective manner, for example, after a mission is completed. As such, ability to persevere in challenging environments is generally taken into account when it is too late, that is, when the soldier is showing severe signs of deficiency or failing to persevere. Therefore, there is a need for more objective measurements with which to predict perseverance. We conducted and present 2 studies in which the hormone cortisol seems to play a key role, relating with optimism, and possibly predicting perseverance. In the first study, we measured cortisol levels during a computer-simulated military training mission. A significant correlation between cortisol levels and optimism measured by the revised Life Orientation Test (LOT-R) Scale was found. In the second study, we followed 29 recruits through a demanding military training course required for joining the Dutch Air Mobile Brigade. The recruits who persevered and completed the course had a higher cortisol response to a stressful training event compared with those who leave the course. A regression model showed that a combination of the soldiers’ optimism and cortisol response best predicted perseverance. This study shows that a combination of attitudinal instruments and a biomarker has potential for predicting military training course attrition.

Military and other personnel employed in high-risk professions are exposed to a range of severe stressors during their professional career. For example, during deployment, soldiers sometimes operate on a 24-hr schedule while they are exposed to physical and mental demands caused by diverse combat or patrol missions, complex and critical tasks, harsh climates, sleep deprivation, time pressures, ambiguous information, threats to safety, and doubts about their physical and mental capabilities. In such situations, soldiers and other personnel are prone to negative consequences of stress, which can lead to decreased professional performance (Carlier, Lamberts, & Gersons, 1997) and/or mental and/or physical health problems (Kolkow, Spira, Morse, & Griege, 2007), and contribute to failure in completing tasks in complex or hostile environments. Decreased performance and health issues not only occur during deployed operations, but may be problems earlier in the military career. In recent studies of failure rates in basic training and predeployment preparations, up to 68% of
recruits dropped out from basic training in their efforts to join infantry forces (i.e., mechanized infantry, marines, air mobile; Binsch, Banko, Veenstra, & Valk, 2015; Binsch, Jetten, Veenstra, & Valk, 2014; Binsch, Valk, & Veenstra, 2014), and up to 25% left predeployment training where the dropouts lacked mental and physical operational readiness as indicated by lower levels of motivation measured by questionnaires and interviews, and by low physical performance measured by physical fitness tests (Engelhardt et al., 2007). Dropout rate is the ultimate indicator of failing to persevere in training or with a task. To make better use of training resources, it would be useful to be able to identify those individuals who are most likely to complete rigorous training. One’s sense of optimism is a potential indicator as it appears to be related to perseverance in stressful tasks, training, and/or deployments to hostile environments (Cuvelier & Van den Berg, 2005). The trait construct optimism has been an element of retrospective studies of deployment investigating troop morale (Boermans, 2015; Cuvelier & Van den Berg, 2005; Kamphuis et al., 2012), coping styles, and levels of resiliency (Boermans, Kamphuis, Delahaij, Korteling, & Euwema, 2013), and for gaining insight into motivation to persevere in military tasks and training that might be related to failure of personnel (Binsch et al., 2014). In these applications, however, the ability to persevere in challenging environments was studied after the fact, that is, when indications of deficiency or failing to persevere were already evident.

The Psychological Construct of Optimism

Optimism is, according to Carver, Scheier, and Segerstrom (2010), “an individual difference variable, measured by a multi-point scale, that reflects the extent to which people hold generalized favorable expectancies for their future.” It is related to better subjective well-being in times of adversity or difficulty (Scheier, Carver, & Bridges, 2001). Optimism is associated with taking proactive steps to protect one’s health (Schou, Ekeberg, & Ruland, 2005), whereas pessimism is associated with health-damaging behaviors (Carver, Lehman, & Antoni, 2003; Carver et al., 2010). Consistent with these findings, the construct of optimism has positive relationships to engagement and/or more perseverance, and negative relationships to avoidance, or disengagement (Aspinwall & Taylor, 1997; Scheier et al., 2001; Schou et al., 2005; Solberg Nes & Segerstrom, 2006). According to self-regulation theory (Carver & Scheier, 1998), people who face difficulties in moving toward their goals have two options. They may further engage and persevere to overcome those difficulties or disengage and drop out to avoid those difficulties. Optimism is an important determinant of viewing goals as attainable and of engagement/disengagement decisions (Solberg Nes & Segerstrom, 2006). An increase in effort results when desired outcomes are seen as attainable, and a decrease in effort is shown when desired outcomes appear unattainable. Conflicts and difficult or stressful situations therefore lead to perseverance among those more optimistic and to drop out among the less optimistic (Aspinwall & Richter, 1999; Carver, Peterson, Follansbee, & Scheier, 1983; Carver & Scheier, 1998; Solberg Nes, Segerstrom, & Sephton, 2005).

A measure of optimism has potential as a predictor for perseverance in different settings (Binsch, Valk, & Veenstra, 2014; Boermans, Delahaij, Euwema, Kamphuis, & Korteling, 2012, Boermans et al. 2013; Carbone, Cigrang, Todd, & Fiedler, 1999), but modeling approaches predicting perseverance might be improved if this subjectively measured psychological construct were combined with an objective psychophysiological measurement, for example, a biomarker, indicative of some characteristic related to perseverance.

The Hormone Cortisol

Cortisol has an established history in stress research (Hellhammer, Wüst, & Kudielka, 2009), and its collection via saliva makes it a practical measurement in field conditions. Cortisol is a cholesterol-based, steroid hormone released by the adrenal cortex following activation of the hypothalamic-pituitary sequence by limbic, cortical, and brainstem signals reacting to psychological and physical stress. Among its multiple functions in acute response situations, including an anti-inflammatory role (Guyton & Hall, 2000), is the stimulation of breakdown of lipids and labile proteins, and subsequent glucose synthesis in liver cells, believed to be primarily protecting cerebral glucose-dependent
metabolism (Peters et al., 2004). Stressful conditions such as military training for resistance to captivity provoke significant cortisol levels (Taylor et al., 2007).

Many factors determine the salivary cortisol response to challenges in humans (Kudielka, Hellhammer, & Wüst, 2009). Dickerson and Kemeny (2004) concluded from reviewing 208 laboratory stress studies that cortisol and adrenocorticotropin hormone (triggers cortisol release) reliably respond to motivated performance tasks (tasks requiring a cognitive response) only if those tasks featured uncontrollable conditions or the probability of social evaluation (e.g., performing mental arithmetic under time constraint or in front of a judging audience). The Trier Social Stress Test (TSST) contains such elements and is a common tool in stress research (Kirschbaum, Pirke, & Hellhammer, 1993). In a boot camp training setting, socially dominant army recruits showed higher salivary cortisol responses on exposure to TSST and to an exercise test compared with socially subordinate recruits (Hellhammer, Buchtal, Gutberlet, & Kirschbaum, 1997). Other psychosocial factors are related to more modest salivary cortisol responses. For example, higher intensities of personal growth and purpose in life of elderly persons are associated with flatter slopes of the diurnal change in salivary cortisol levels (Ryff, Singer, & Dienberg Love, 2004).

In the clinical domain, greater optimism is related to lower cortisol awakening responses when controlled for depression and mood (Lai et al., 2005). This is supported by the finding that salivary cortisol levels are inversely correlated with happiness or positive affect (Steptoe, Wardle, & Marmot, 2005), even when affect is measured using momentary assessment techniques (Steptoe, Dockray, & Wardle, 2009).

The Purpose of the Study

Research suggests that salivary cortisol should respond to a physical or psychological challenge and could be directly or indirectly related to optimism and purpose. Therefore, we view the salivary cortisol measurement as a candidate marker for optimism and perseverance. However, it is difficult to predict the level of cortisol responding to a challenge in a military setting. Although low cortisol levels are related to avoiding chronic stress diseases, higher cortisol responses could reflect an increased engagement necessary for completing demanding tasks. Therefore, the purpose of the current study was to examine the relationships among optimism, cortisol, and perseverance in a military context and to find what levels of cortisol and optimism are associated with soldiers’ perseverance.

We analyzed different aspects of data from two experiments. The aim of the first experiment was to establish cortisol as an objective measure of optimism in a simulated, stressful military scenario. In the second experiment, we used a different military setting to further investigate the relationship between cortisol and optimism, and then to determine their association to perseverance, that is, to attrition in a military basic training setting. In the discussion, we reflect on the significance of this work in the military context.

Experiment 1

Military personnel performing predeployment training participated in a video game scenario in which mission-deployed peace support soldiers encounter stressful situations in the course of investigating a violent attack on a police car in a strife-filled, third-world country.

Method

Subjects. Thirty-five service members (2 female and 33 male) with an average age of 23.1 years ($SD = 2.6$) participated in this study. Their rank varied between private and corporal. Thirty-two of the participants were deployed between one to three times for at least six months on the North Atlantic Treaty Organization (NATO) security mission in Afghanistan. The participants had experience as infantry personnel in several patrols on foot or in armored vehicles, but no one had experience in a commander role. Six participants indicated experience with playing recreational (combat) video games. The study’s protocol was approved by the Ethics Committee (TCPE) of the Dutch Research Institute for Applied Sciences (TNO).

Data collection procedures. The study was conducted in the briefing room of an infantry unit in the south of the Netherlands. The participant was seated next to his or her military training partner, acted by a sergeant. Every par-
participant worked with this same partner. The partner was responsible for introducing the training software and acted as a subordinate within the played scenario. The data were collected over the period from 09:00 to 16:00 hrs.

The participant was instructed to act as a team commander in a two-man patrol performing one virtual peace mission scenario. In the commander role, the participant was to lead the different phases in gathering of information at different phases from residents concerning recent incidents in the neighborhood. After the study goals and procedures were explained, the informed consent form was signed, and the first saliva sample was collected. Then instructions on controlling the avatar in the Virtual Battlespace software (VBS2, Bohemia Interactive Simulations) were given, after which the second saliva sample was collected. Then a prerecorded issue of orders was presented to the participant via headphones. Subsequently, the participant and partner started the simulated military patrol task by virtually leaving the command post. During the simulation, contact with higher command was maintained that delivered basic instructions to each participant such as “try again” or “move on.” After completing each phase of the single patrol scenario, the third saliva sample was collected. Two more saliva samples were collected 5 and 10 min later. The experiment (see Figure 1) required approximately 60 min.

The virtual battlespace scenario consisted of the following phases. The issued order was to walk the avatar to the nearest houses outside the compound to learn what villagers knew about last week’s attack on a police vehicle and about other cases of violence involving injury and death. The participant first encounters children seeking candy and gifts, then they meet and interview a farmer. The command post orders the participant to mediate a quarrel between two farmers that escalates resulting in a beating. The quarrel turns toward the participant, which is then aggravated by other villagers throwing rocks from 50 yards. Gunfire creates further disruption after which the participant is ordered to return to the compound. Children approach them again.

Salivary samples were obtained using a Salivette (Sarsted, Germany), a roll-shaped swab chewed for 30 s, then collected in a labeled plastic tube and stored in a freezer. Cortisol concentrations in the saliva samples were analyzed using a radioimmunoassay method (Walker, Riad-Fahmy, & Read, 1978) by U-Diagnostics, test center of the University Hospital of Utrecht, the Netherlands.

Optimism was measured after the simulation with participants completing the Dutch version of the Life Orientation Test (LOT; Scheier & Carver, 1985). It was originally designed to measure dispositional optimism, the general expectation that good things will happen. The revised Life Orientation Test (LOT-R) consists of 10 items—3 items assessing optimism, 3 pessimism items, and 4 filler items (Scheier, Carver, & Bridges, 1994). Participants scored each item against a 5-point Likert scale, ranging from 1 strongly disagree to 5 strongly agree. Glaesmer et al. (2012) validated LOT-R in a sample of 3,372 subjects across all age groups. The LOT-R has also been applied in different military settings, for example to study buffering effects of dispositional optimism on warzone stress in 2,439 soldiers following deployment to Iraq (Thomas, Britt, Odle-Dusseau, & Bliese, 2011).

Statistical analysis. The focus of this first study was on the relationships between the mea-

![Figure 1. Procedures for Study 1.](Image)
sure of optimism and changes in cortisol levels in response to the simulated scenario. Each subject’s LOT-R optimism score was calculated as the sum of the 3 optimism and 3 pessimism (reverse scored) items (4 filler items excluded). The subjects were ranked according to their LOT-R optimism score and then divided at the median optimism score resulting in two groups with low and high optimism, respectively.

In reaction to time-limited challenges, cortisol is secreted within minutes, reaches a peak level in tens of minutes, then wanes (Kirschbaum & Hellhammer, 1989), therefore 5 saliva samples were collected to capture the cortisol response for each subject. These measurements were analyzed with the area under the curve (AUC) summary procedure (Hellhammer, Wüst, & Kudielka, 2009; Matthews, Altman, Campbell, & Royston, 1990). This procedure is applicable for serial data where: (a) successive measurements from a participant are correlated, (b) the maximum (or minimum) response and/or (c) the time to the maximum (or minimum) may be different among individuals and groups, and/or (d) when the overall value of the outcome variable may be the same in different groups but required different time spans to be produced (Matthews et al., 1990). The AUC for two consecutive cortisol measurements y1 and y2 at times t1 and t2 is the product of the time difference and the average of the two measurements. Thus, we computed \((t2 - t1) (y1 + y2)/2\) for AUC between t1 and t2. AUC was calculated for each segment between t2 and t3, t3 and t4, and t4 and t5, and for the four AUC segments combined.

Nonparametric statistics were used for 3 reasons: (a) LOT-R optimism was measured with an ordinal Likert scale (rather than interval scale) in which the 5 points were associated with descriptors, for example, strongly agree, for each participant to apply; (b) after splitting the original participant sample into low and high optimism groups at the median optimism score, we made no assumption about the homogeneity of the data variance in these groups; and (c) the time segments between cortisol samples were not equal. The Mann–Whitney U (MWU) test was conducted with cortisol (AUC) and LOT-R optimism as factors. The MWU was conducted for the whole AUCcortisol and for the 4 single AUCs cortisol segments between the 5 saliva collection times. Spearman’s rank correlations (Spearman, 1904) were calculated between the LOT-R optimism scores and the cortisol measurements at the different time points for the participants as one group.

**Results**

**Cortisol and optimism group, descriptives.** Cortisol and LOT-R optimism scores were available for 31 of the 35 participants. The LOT-R median optimism separation of the participants resulted in a low optimism group of 14 subjects and a high optimism group of 17 subjects. The LOT-R optimism scores ranged from 2.7 to 4.4.; the group split occurred at the score of 3.6. As cortisol has a diurnal cycle, we checked the potential confound associated with the timing of salivary collection and the participants grouping by LOT-R optimism score. The distribution of the participants with high versus low optimism scores was comparable as 8 participants of the low optimism group and 7 of the high optimism group were tested between 09:00 and 12:00 hrs; and 6 of the low optimism group and 10 of the high optimism group were tested between 13:00 and 16:00 hrs.

**Cortisol and optimism group, Mann–Whitney U.** The MWU test comparing the whole AUCcortisol of the two groups (high \([n = 17]\) and low optimism \([n = 14]\)), showed no significant difference \((U = 104.0, p = .57)\). The high versus low optimism groups differed significantly at the AUCcortisol segment between time points 4 and 5 \((U = 59.5, p = .02 \text{ [two-tailed]})\). The high optimism group had a higher (by 15.9 nmol-min/L higher) cortisol concentration during the last stage of the measurement compared with the low optimism group (see Figure 2 and Table 1).

**Cortisol and optimism, correlation.** The Spearman’s rank correlations were significant between the LOT-R optimism scores and the cortisol time point t5, \(r = .501, p = .004\) and between the AUCcortisol segment between time points 4 and 5, \(r = .346, p = .028\). Correlations at the other time points and segments were not significant (see Table 2).

**Discussion**

The aim of this first study was to discover if cortisol was related to optimism in a simulated, human-in-the-loop, military patrol scenario using virtual battlespace. AUCcortisol post scenario...
was significantly greater for the soldiers scoring higher in optimism compared with the low optimism group. Optimism scores and cortisol levels at the final time segment of the experiment were also significantly correlated. For infantry units of the Dutch Ministry of Defense, high attrition rates (varying from 32% to 68%) during initial training are a persistent problem (Binsch et al., 2014). The reasons for this attrition are varied and not yet conclusive (Binsch et al., 2015). With a relationship between cortisol and optimism in a scenario with no outcomes for the soldiers, that is, no attrition would be expected; the question raised is whether a similar association relates to soldier success/failure in a more complex military setting. Therefore, the aim of the second study was to investigate the relationship among cortisol, optimism, and perseverance in demanding actual military training.

### Experiment 2

#### Method

**Participants.** Twenty-nine recruits from a Dutch Armed Forces Air Mobile Brigade (AMB) School platoon (mean age = 19.2 years, SD = 0.6, age range = 18–21) participated voluntarily. The recruits had varied back-
grounds (e.g., student, craftsman, military trainee). They were all considered highly physically fit as they had passed the selection and AMB fitness test.

Experimental set-up and procedure. Weeks 6 and 7 of the AMB training program were used as the experimental setting for the second study that was conducted during a monitoring research program requested by the Dutch Ministry of Defense. Graduates of the 24-week AMB training program will have mastered shooting with standard rifle and machine gun, day/night orienteering, surviving in the field, and executing group and section-level attack and defensive tactics. In the past five years, course attrition rates ranged from 32% to 68% (Binsch et al., 2014). As the recruits qualified for AMB training based on their physical fitness, the main causes of the high attrition rates are described by military trainers as a “lack of motivation,” and/or that the recruits were “insufficiently resilient” (Binsch et al., 2015). Approximately 16% of the recruits attrit for medical reasons (e.g., injury or disease).

The protocol was approved by the TNO ethics committee prior to data collection. In the first week of the AMB training, the recruits were informed that several noninvasive tests, such as saliva collection, and the completion of different questionnaires would be requested throughout the course. The recruits agreed and informed consent was given.

Daily during the course, the trainees completed an 8-item load questionnaire (LQ—generally perceived physical and mental demands), but only the two LQ items addressing motivation and optimism to persevere in the training course will be described here. As in Study 1, these two questions originate from the LOT-R (Scheier & Carver, 1985) and were adapted. The motivational item translates as: “I’m really looking forward to this course.” The optimism item was further adapted from the version used in Study 1 and translates as: “I’m optimistic that I’ll be able to persevere in this training course.” Each statement was rated with a 5-point Likert scale ranging from 1 strongly disagree to 5 strongly agree. Because the recruits followed an extremely full training schedule (06:00–22:00 hrs daily), we were required to use only uncomplicated procedures and abbreviated questionnaires (i.e., not full LOT-R). Our single optimism item was adapted from Item #4 of LOT-R. In a two-factor (optimism, pessimism) model (Glaesmer et al., 2012), Item #4 had the highest standardized regression coefficient (0.796) with the LOT-R 3-item optimism subscale. Analysis of data from our first study indicate that the equivalent of this single optimism item correlated significantly ($r = .68$, $p = .001$, two-tailed) with the LOT-R optimism subscale values from those trainees. Other single-item optimism measures have also correlated significantly ($r = .63$) with the LOT-R optimism subscale (Kemper, Kovaleva, Bierlein, & Rammstedt, 2011). From our first study, that single optimism item correlated moderately with cortisol concentration at Time 5 ($r = .31$, $p < .046$, one-tailed) and with AUC$_{corticis}$ time segment 4 to 5, $r = .32$, $p = 0.40$, one-tailed.

The current study was designed to measure salivary cortisol in both unloaded (i.e., low-stress training during week 6) and loaded (i.e., high-stress training during week 7) training settings.

Week 6 was characterized by daily marksman training at a shooting range. Pressure to perform was low (i.e., not challenging, unloaded), and the pace was generally relaxed (e.g., periods of waiting in open shelters before entering the shooting range). Week 7 comprised the field exercise (i.e., challenging, loaded). The activities included surviving in the field, building trenches, and executing tactical maneuvers such as defending positions, withdraws, and attacks. So that evening rest would be similar in both weeks, on Tuesday and Wednesday eve-

<table>
<thead>
<tr>
<th>Correlation coefficient $R$</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortisol (nmol/l) 1</td>
<td>.242</td>
</tr>
<tr>
<td>Cortisol (nmol/l) 2</td>
<td>.045</td>
</tr>
<tr>
<td>Cortisol (nmol/l) 3</td>
<td>.011</td>
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<tr>
<td>Cortisol (nmol/l) 4</td>
<td>.238</td>
</tr>
<tr>
<td>Cortisol (nmol/l) 5</td>
<td>.501</td>
</tr>
<tr>
<td>Cortisol (AUC, nmol-min/l) t1 – t2</td>
<td>.045</td>
</tr>
<tr>
<td>Cortisol (AUC, nmol-min/l) t2 – t3</td>
<td>.033</td>
</tr>
<tr>
<td>Cortisol (AUC, nmol-min/l) t3 – t4</td>
<td>.149</td>
</tr>
<tr>
<td>Cortisol (AUC, nmol-min/l) t4 – t5</td>
<td>.346</td>
</tr>
<tr>
<td>Total Cortisol (AUC, nmol-min/l) t1 – t5</td>
<td>.147</td>
</tr>
</tbody>
</table>
nings the platoon was excluded from patrolling the shooting range and field camp. Then, after consultation with the commandant and the directly involved drill sergeants, the Wednesday and Thursday mornings of both weeks were used to implement the study procedures.

On these mornings of Week 6, the platoon’s waiting time at the shooting range was used to administer the LQ and collect saliva. Specifically, on Wednesday the LQ survey was completed followed by saliva sampling at 07:00 hours. This procedure was repeated on Thursday with the addition of saliva collection at 07:10, 07:20, and 07:30 hours. In Week 7, again on Wednesday morning before 07:00 hours, the LQ was administered followed by the recruit providing one saliva sample under no pressure conditions. On Thursday morning of that week at 06:40 hours, the recruits were instructed by the drill sergeant to move into foxholes and to maintain their personal equipment. The LQ survey was completed at 06:55 hrs, and saliva was sampled at 07:00 hrs within this no-pressure situation. Just 3 min later, four simulated grenades were released by the drill sergeant, exploding in the proximity of the foxholes, followed by the command “defend positions!” After the recruits responded with several rounds of blanks fired in the direction of training targets placed some meters in front of them, the scenario was concluded, and saliva collected immediately afterward at 07:10, 07:20, and 07:30 hrs. The recruits were then debriefed by the experimenters and subsequently continued with field training.

**Design.** All 29 recruits participated during the shooting training week, that is, the control (unloaded) condition, and during the field exercise week, that is, the experimental (loaded) condition. In both conditions, five saliva samples were collected from each recruit (see Figure 3). Wednesday’s salivary cortisol sampling in both the control and experimental weeks was made to establish a routine, that is, that its collection was not necessarily a prelude for significant events. This first sample is displayed in the Results figures, but the actual analyses was limited to 232 salivary cortisol samples (29 recruits × 2 conditions (control, experimental) × 4 salivary cortisol times (2, 3, 4, 5). The LQ was administered four times. The same week, Wednesday and Thursday optimism item scores were averaged producing a control and an experimental optimism value for each recruit. The motivation item was treated identically. Because these optimism and motivation values were highly correlated ($R = .86, p < .001$), only the optimism data set (i.e., 58 averaged optimism scores; 29 scores from week 6 and 29 from week 7) was used for further analyses.

**Statistical analysis.** Of the 290 cortisol measurements obtained from the saliva samples, 15 measurements evenly distributed over the samples were missing. To avoid the loss of data from seven subjects, we used a Fully Conditional Specification (FCS) method provided by the Statistical Package for the Social Sciences (SPSS) statistics program to impute the missing values (Field, 2013).

The $AUC_{cortisol}$ values (nmol-min/L) were calculated from the 4 cortisol samples (i.e., $t_2$, $t_3$, $t_4$, $t_5$) per participant for each time frame between the measurements (i.e., Thursday’s $t_2$ –
t3, t3 – t4, and t4 – t5), and per condition (i.e., control, experimental). Then, the MWU test was conducted on AUCCortisol with optimism scores and group (perseverance, dropout) as factors. The optimism scores gathered in Weeks 6 and 7 were analyzed in relationship with the corresponding cortisol data from the same week.

To further explore the relationship between optimism and training perseverance, and whether it was moderated by the cortisol value of the recruits, several regression analyses and an interaction (moderation) analysis (cf. Baron & Kenny, 1986) were conducted. Because the data included repeated observations within participants (5 salivary cortisol measurements during the experimental condition), the effects of cortisol and optimism on training perseverance were assessed using generalized estimating equations (GEE; Liang & Zeger, 1993). This extension of generalized linear models allows misspecification of the covariance structure, that is, correlated data (IBM SPSS software).

Following the approach of Baron and Kenny (1986), we used the GEE regression analyses to examine the role of cortisol as moderator of the relationship between optimism and training perseverance. Prior to the moderator analysis, four regression analyses were conducted using cortisol as a predictor for training perseverance or optimism, and using optimism as a predictor for training perseverance on the data from all subjects combined. In the first regression analysis, the relationship between cortisol and training perseverance was tested according to:

\[
TP = \text{constant} + B_1 \cdot C
\]

in which TP is training perseverance (training perseverance = 1; training dropout = 0), C is cortisol concentration (nmol/L), and B1 is the regression coefficient.

In the second regression analysis, the cortisol values were related to optimism according to:

\[
O = \text{constant} + B_1 \cdot C
\]

in which O is optimism rating, C is cortisol concentration, and B1 is the regression coefficient.

In the third regression analysis, the optimism variable was related to training perseverance according to:

\[
TP = \text{constant} + B_2 \cdot O
\]

in which TP is training perseverance (training perseverance = 1; training dropout = 0), O is optimism, and B2 is the regression coefficient.

In the fourth regression analysis, the cortisol and optimism variables were related to training perseverance according to:

\[
TP = \text{constant} + B_1 \cdot C + B_2 \cdot O
\]

in which TP is training perseverance (training perseverance = 1; training dropout = 0), C is cortisol concentration, O is optimism, and B1 and B2 are the regression coefficients, respectively.

Finally, the regression analysis described by Baron and Kenny (1986) was conducted to examine whether the previously tested relationship between optimism and training perseverance would be moderated by cortisol according to:

\[
TP = \text{constant} + B_1 \cdot C + B_2 \cdot O + B_3 \cdot (O \cdot C)
\]

in which TP is training perseverance (training perseverance = 1; training dropout = 0), C is cortisol, O is optimism, and B1 and B2 are the regression coefficients, respectively. Moderation is identified by the interaction term, that is, O \cdot C.

For each regression model, the explained variance (R^2) was computed, that is, the correlation coefficient between the real outcome and the predicted outcome.

**Results**

Eight recruits left the course of their own volition leading to a group design of training perseverance \([n = 21]\) versus training dropout \([n = 8]\). The withdrawals occurred after data collection and in the period Weeks 11–13 (representative activities—bivouacking, river crossing exercises, speed marching events, obstacle course runs). According to exit interviews, these trainees were no longer motivated to continue or had different expectations of military service/training.

**Cortisol and perseverance.** For the control condition, the MWU test conducted on total AUCCortisol for the two groups showed no significant effect of group \((U = 96.0, p = .53; \ldots)\)
The group effect was significant for total AUC_{cortisol} from the experimental condition ($U = 36.0, p = .03$ [two-tailed]). Specifically, the group that persevered in the training had a higher (by 55.0 nmol-min/L) total AUC_{cortisol} compared with the dropout group (see Figure 4B and Table 3).

**Optimism and perseverance.** For the control condition, the MWU test conducted on the optimism scores for the two groups showed no significant effect of group ($U = 66.5, p = .29$). The group effect was significant ($U = 43.0, p = .02$ [two-tailed]) for the optimism scores from the experimental condition. Specifically, the group persevering in the training had a greater (by 0.75) optimism score compared with the dropout group (see Table 3).

**Relationships among cortisol, perseverance, and optimism.** Consistent with the MWU results on AUC_{cortisol} from the experimental condition, the first regression analysis on the dataset of the experimental (loaded) week (two averaged optimism scores and 5 cortisol samples) showed a significant relationship between cortisol and training perseverance (see Table 4, Regression 1) for the repeated measures dataset. The regression equation was:

$$TP = 0.36 + 0.26 \cdot C$$

![Graph showing cortisol concentration (nmol/l) for training perseverance and training dropout groups during Week 6 (A: control condition) and Week 7 (B: experimental condition, field exercise).]
The constant in this regression comprises the estimated average value of training perseverance at a cortisol value of zero. Since physiological cortisol concentration can never be at this level, the constant has no purpose, other than possible statistical comparison of regressions, and will not be considered further.

The relationship between cortisol and optimism was not significant ($p = .17$; Table 4, Regression 2). The relationship between optimism and training perseverance was significant (Table 4, Regression 3). The regression equation for this analysis was:

\[ TP = -0.60 \pm 0.14 \cdot C + 0.30 \cdot O \]

The final equation using the cortisol and optimism variables includes the interaction term. Cortisol had a significant moderating effect on optimism (Table 4, Regression 5). Regression equation 5 was:

\[ TP = -1.88 + 0.11 \cdot C + 0.55 \cdot O - 0.21 \cdot (O \cdot C) \]

The explained variance for Regressions 4 and 5 were 0.26 and 0.27, respectively (see Table 4).

**General Discussion**

Because of the resource cost to produce qualified armed forces personnel, attrition from military training courses is problematic (Binsch et al., 2014, 2015). Better methods to screen out those likely to fail and recruit those likely to...
succeed are expected by policy decision makers (General Accounting Office, 1997). Psychological factors account for much of the training course outcomes for candidates once medical and physical fitness factors are removed (Larsson, Broman, & Harms-Ringdahl, 2009; Strickland, 2005), a key feature being optimism (Carbone et al., 1999; Cigrang, Carbone, Todd, & Fiedler, 1998). To better understand human behavior, biomarkers from blood-based (e.g., Kirschbaum et al., 1993) and noninvasive physiological (e.g., Binsch et al., 2015) sources are being integrated with the insight provided by attitudinal instruments. We measured optimism and salivary cortisol concentration in two scenarios to investigate a possible relationship with perseverance in military training courses.

In Study 1 following a simulated military patrol scenario, the group of soldiers scoring higher in optimism showed a significantly larger area under the cortisol curve at the end of the training. The optimism scores and cortisol concentrations were also significantly correlated. This suggested that cortisol might be an objective marker for optimism in this setting. In the training challenge phase of the second study, the perseverance group compared with the dropout group had higher optimism scores and showed higher cortisol concentration. Cortisol and optimism across the high and low optimism groups were not correlated in this case, but each was significantly and positively associated with perseverance in the demanding training course. When optimism and cortisol were combined, approximately one quarter of the variance in training perseverance was explained. The Optimism × Cortisol interaction term was significant, consistent with our reason-

<table>
<thead>
<tr>
<th>Table 4: Results of Regression Analyses Concerning Relationships Among Training Perseverance, Cortisol Concentration, and Optimism Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression 1: Training perseverance</td>
</tr>
<tr>
<td>Constant: 1 Cortisol concentration (nmol/l) ( B_1 )</td>
</tr>
<tr>
<td>Coefficient: .36</td>
</tr>
<tr>
<td>( SE ): .18</td>
</tr>
<tr>
<td>( p ) value: .48</td>
</tr>
<tr>
<td>Regression 2: Optimism</td>
</tr>
<tr>
<td>Coefficient: 3.98</td>
</tr>
<tr>
<td>( SE ): .21</td>
</tr>
<tr>
<td>( p ) value: .00</td>
</tr>
<tr>
<td>Regression 3: Training perseverance</td>
</tr>
<tr>
<td>Coefficient: -.57</td>
</tr>
<tr>
<td>( SE ): .32</td>
</tr>
<tr>
<td>( p ) value: .08</td>
</tr>
<tr>
<td>Regression 4: Training perseverance</td>
</tr>
<tr>
<td>Coefficient: -.60</td>
</tr>
<tr>
<td>( SE ): .32</td>
</tr>
<tr>
<td>( p ) value: .06</td>
</tr>
<tr>
<td>Regression 5: Training perseverance</td>
</tr>
<tr>
<td>Coefficient: 1.88</td>
</tr>
<tr>
<td>( SE ): .90</td>
</tr>
<tr>
<td>( p ) value: .04</td>
</tr>
</tbody>
</table>

Note. The actual values, standard errors (SE), and corresponding p values are presented for the constants and the regression coefficients \( B_1 \)–\( B_3 \). The values of (nonadjusted) \( R^2 \) represent the proportion of the explained variance in comparing predictions by the GEE model and actual measured values.
ing that cortisol concentration might moderate the relationship between optimism and training perseverance. While Regression 5 coefficients are positive for both cortisol and optimism, the negative coefficient of the interaction term shows that, for a portion of the total TP variance, the effect of optimism on training perseverance decreases as the effect of cortisol increases.

What could explain the discrepant results in the optimism-cortisol correlations in the two studies? Possibilities concern validity of the optimism measure, cortisol validity, the scenarios in the two studies, and the interaction/independence of the two variables.

That we found a linear relationship between cortisol and optimism in the first study but not in the second study was perhaps because the full, 6-item LOT-R scale (Scheier, Carver, & Bridges, 1994) was used in the former study but only one LOT-R item was used in the latter. Also, the single LOT-R item was modified with a context specific ending (i.e., “to persevere the training course”), which could have altered construct validity. The LOT-R measures dispositional optimism whereas our single item more addresses specific optimism (Schmitt, Gielnik, Zacher, & Klemann, 2013). The modified and reduced optimism scale was employed as a time-conserving strategy in this operational setting.

Studies reviewing earlier research investigating psycho-endocrine relationships have noted the frequency of inconsistent results (Dickerson & Kemeny, 2004; Hellhammer et al., 2009; Kudielka et al., 2009). Among the explanations, including potential confounders which were accounted for here, are that cortisol is not a perfect biomarker for psychological states, and that measures quantifying such states, as well as traits, are themselves not perfect (Dickerson & Kemeny, 2004; Hellhammer et al., 2009; Kudielka et al., 2009). In consideration of clinical diagnoses, Aronson (2005) discusses features of an ideal biomarker that can be applied to the current work: (a) biomarker is specific for the psychologic state; (b) the psychologic state occurs through the biomarker; (c) the psychologic state and biomarker operate in parallel but connected pathways; (d) the psychologic state and biomarker covary in time, and with consistency and strength of association; and (e) the association between the psychologic state and biomarker are biologically or conceptually plausible. It is unlikely that features (a) and (b) apply to cortisol as used in the current work. Evidence in support of feature (d) above are the finding of cortisol’s correlation with optimism in Study 1, and the cortisol differences between the optimism groups in both Studies. With respect to biomarker features (c) and (e), which overlap in application to the current work, other research demonstrates that the optimism-cortisol association is plausible.

1. Cortisol increases as a result of emotional activation, heightened arousal which could reflect intensely positive or negative moods and an anticipation of imminent activity (Brown, Sirota, Niura, & Engebretson, 1993; Mason, 1968).
2. Cortisol increases from the extra engagement and effort optimists expend toward accomplishing difficult goals that they see as reachable. Further, individuals combining high optimism and high self-consciousness demonstrated the best task perseverance (Solberg Nes et al., 2005).
3. In anticipation of competition, skilled judoists showed increased cortisol concentration, and winners had greater cortisol levels before and after the competition compared with losers. Both groups had similar motivation to win, but on ability to win, winners had higher self-ratings (Suay et al., 1999).

The cortisol concentrations themselves are reliable. The baseline cortisol concentrations in both studies are consistent with the morning values reported by others (Kirschbaum & Hellhammer, 1989). Further, the cortisol concentration responses lie within the range observed for psychological stressors and are expectedly less than those seen in heavy exercise (Kirschbaum & Hellhammer, 1994) and in military survival training (Taverniers et al., 2010; Taylor et al., 2007). It was important to collect several serial samples of cortisol because it has a consistent response pattern of rising within minutes (Kirschbaum & Hellhammer, 1989; Kirschbaum & Hellhammer, 1994) and reaching a peak value in tens of minutes (Dickerson & Kemeny, 2004; Kirschbaum & Hellhammer, 1989; Kirschbaum & Hellhammer, 1994) after an acute stress exposure. Only serial sampling will reliably capture the peak value.

A possible limitation relevant to the postchallenge cortisol levels in Study 2 is their elevation in concentration just before the experimental challenge. Between cortisol collections at prechallenge 1 and prechallenge 2, all trainees were instructed to move to foxholes with their equipment. With already moderate intensity ex-
ercise a known stimulator of this hormone (Hill et al., 2008), this physical exertion likely caused the parallel increase in cortisol concentration at prechallenge 2 for both groups (Figure 4B). This elevated cortisol could have influenced the subsequent cortisol response to the challenge, that is, the simulated grenade attack.

Other possible reasons for the dissimilar correlation results between the studies are differences in participant population and setting. The high optimism group had the greater cortisol concentration each time, but the trainees in the first study were more experienced soldiers compared with the recently joined recruits in the second study. In addition, the first study used a simulated setting with the stressor being the assigned command of a virtual military patrol, whereas the participants of the second study were active members undertaking real-life, special forces training. The superior fitness of Study 2 participants likely means that the relationship among training perseverance, optimism, and cortisol is not generalizable to training courses unless they require high fitness entry standards. The timing of the collection of the optimism scores in the studies may also have affected the correlation between optimism and cortisol. In the first study, the optimism questionnaire was administered after the training event, but in the second study, it was conducted prior to experiencing the cortisol-stimulating event. Study 1 participants’ experience with the just-performed virtual patrol scenario could have influenced their self-report of optimism, thus creating a potential follow-up effect.

Perhaps it is possible that the optimism-cortisol correlation of Study 1 is a coincidental finding. We showed earlier that this association is plausible (i.e., Aronson’s features (c) and (e)), but with the evidence being only indirect, the association is not strong. Study 2 showed no optimism-cortisol correlation, but each was significantly related with training perseverance. When they were combined, the explained variance increased considerably. This suggests that each variable is contributing something different to the measurement of training perseverance.

The indirect evidence highlighted in reference to Aronson’s features (c) and (e) suggests that individuals with high optimism and high concentrations of stimulated cortisol associated with completing the training course are recruits with high expectations and confidence in their abilities, who were motivated and engaged in the training activities, were emotionally charged by the simulated grenades event, and were the ones most prepared to exert full effort and perseverance toward attaining a valued goal.

Even though the regression with the interaction term (moderation) accounted for slightly more of the training perseverance variance than the regression without it, of more importance is that any regression with optimism and cortisol better explained training perseverance variance than optimism or cortisol alone. We are aware of only two other studies that have combined measurements of psychological factors and biomarkers in efforts to explain military training course attrition. In one study (Moran et al., 2012), bone quality, hemoglobin, and minerals, vitamins and proteins in blood were measured on the first day of training while self-confidence, motivation, and stress coping were measured at the beginning, and at 2 and 4 months. Perceived commander’s appreciation and self-confidence were found to contributed most to the attrition prediction model (Moran et al., 2012). In the second study (Kalns et al., 2011), the Emotional Quotient Inventory test was part of a pretraining battery of assessments that included physical fitness, aptitude, and two salivary proteins generating a biomarker fatigue index. Two indicators of fitness and the proteins best explained training success (Kalns et al., 2011). In our work, different variables were measured, and our biomarker was collected in response to the training activity rather than before training.

Low scores on the single optimism-perseverance item predicted those recruits who would eventually quit the training course over the following four weeks. This item is now permanently part of the load questionnaire and monitored weekly. This and other interventions based on the outcome of the results of the load questionnaire have significantly reduced the attrition rate of the recruits’ training course in the Dutch Armed Forces.

As salivary cortisol and the optimism item are potentially able to predict specific perseverance, or rather lack thereof, it would be of interest to know the duration of this mental state before dropout occurs. For the eight participants of Study 2, the dropouts occurred in the middle
of the training course. Given that attrition is a feature of demanding military courses, it would be useful to discover dropout likelihood as early as possible. Our second study observed no relationship between salivary cortisol and optimism scores in the unchallenging phase but these were relevant in the challenging segment. This suggests that a challenging environment permits the optimism-cortisol-perseverance relationship to materialize because it exposes the recruit’s most vulnerable condition.

Finally, while training perseverance was significantly associated with increased optimism scores and cortisol concentration, three-quarters of the variance in training perseverance remains to be explained. This calls for continued efforts to improve measurement methods and investigate other potential factors affecting dropout from rigorous, specialized, military training. As our optimism scale is still in the developmental stage, future research studying cortisol and optimism should make efforts toward establishing validity. Variations in psychoneuroendocrinological response profiles to challenging situations within a military context should be explored further. A broader set of markers would also reveal a more detailed picture of the differences among service members. The power of optimism and cortisol to predict perseverance should be explored in military settings with a broader range of challenging conditions in longitudinal studies. Similar work could be extended to entire units and possibly explain why some individuals perform better than others.

References


## Relationships Between Cortisol, Optimism, and Perseverance Measured in Two Military Settings

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Optimism and perseverance are 2 important assets for soldiers to be able to perform competently in high-risk environments and to complete complex and stressful tasks. Traditionally, optimism is measured using questionnaires and most frequently in a retrospective manner, for example, after a mission is completed. As such, ability to persevere in challenging environments is generally taken into account when it is too late, that is, when the soldier is showing severe signs of deficiency or failing to persevere. Therefore, there is a need for more objective measurements with which to predict perseverance. We conducted and present 2 studies in which the hormone cortisol seems to play a key role, relating with optimism, and possibly predicting perseverance. In the first study, we measured cortisol levels during a computersimulated military training mission. A significant correlation between cortisol levels and optimism measured by the revised Life Orientation Test (LOT-R) Scale was found. In the second study, we followed 29 recruits through a demanding military training course required for joining the Dutch Air Mobile Brigade. The recruits who persevered and completed the course had a higher cortisol response to a stressful training event compared with those who leave the course. A regression model showed that a combination of the soldiers’ optimism and cortisol response best predicted perseverance. This study shows that a combination of attitudinal instruments and a biomarker has potential for predicting military training course attrition.

attrition, bio marker, hormones, military training, infantry