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Emotional intelligence and emotion regulation in self-induced emotional states: Physiological evidence

Leehu Zysberg[a,*], Sivan Raz[b]

[a] The Graduate School, Gordon College of Education, 73 Tchernichowski Street, Haifa, Israel
[b] Dept. of Psychology, Tel Hai College and Yzrael Valley College, Israel

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ABSTRACT

Emotional intelligence (EI) is associated, both theoretically and empirically, with the ability to manage and regulate one's own emotions. Most evidence in this venue, however, comes from self-report measures. We tested the hypothesis that EI will associate with effective performance in an emotional regulation task in which participants were asked to self-induce emotional arousal and then to relax (modulation). One hundred twenty-seven young adults performed the task while we monitored their heart rate as an indicator of emotional responsiveness, and blood pressure as an indicator of long-term emotion regulation. They took tests of trait EI, ability EI, and trait anxiety. Structural equation modeling path analysis showed that ability EI, trait anxiety, and gender were associated with a factorial score of heart-rate variability, representing emotional regulation (arousal and modulation) indicators. The associations suggested that people with higher ability-EI scores more effectively regulated their emotional responses when asked to do so. The results also showed negative associations between ability EI and baseline blood pressure indicators. Results are discussed in light of theory and existing evidence on the link between EI and emotional regulation.

1. Introduction

The concept of Emotion regulation (ER) describes a group of psychological processes and behavioral tactics that people use to manage their own emotional responses in an adaptive manner (Gross & Thompson, 2007). The concept is perceived by many to be the basis of our emotional and social adaptation (Appelhans & Luecken, 2006; McRae et al., 2012).

The ability to voluntarily understand, manipulate, regulate, and modulate emotional responses to fit situational demands has been defined as one of the basic manifestations of emotional intelligence (EI; Barrett & Gross, 2001; Mayer & Salovey, 1995; MacCann, Joseph, Newman, & Roberts, 2014) since the introduction of the concept. While some theories define ER as an integral component of EI, others see EI as the general potential for ER – thus viewing it as a manifestation or outcome of EI (Mayer & Salovey, 1995).

Theorists suggest that people construct their own rules of ER and emotional display based on their experience, culture and personal needs (e.g., personality traits, motivations; Mayer & Salovey, 1995(. Behavioral evidence supports these suggestions, proposing that EI is a major resource enabling the development of ER related skills. In other words, individuals with high EI can manipulate and manage their emotions more effectively across a wide range of conditions and settings (Laborde, Lautenbach, Allen, Herbert, & Achtzehn, 2014). Studies show how ER tactics help protect individuals from dysfunctional emotional coping patterns (Mikolajczak, Petrides, & Hurry, 2009).

Most explanations for the above findings rely on physiological processes that are assumed to underlie ER and, indirectly, EI: Bar-On, Tranel, Denburg, and Bechara (2003) and Krueger et al. (2009) associated emotion regulation with activity in the prefrontal lobe. Other accounts applied a social/interpersonal approach to ER and related skills (Morris, Silk, Steinberg, Myers, & Robinson, 2007) and discussed how ER is learned and honed through social interaction. Petrides and Furnham (2003), showed that people who are high in EI react more effectively than their low-EI counterparts to emotionally laden stimuli. Other studies showed that ER helps people recover from trauma (Tugade & Fredrickson, 2004), adapt more effectively in stressful work settings (Schutte, Malouff, Simunek, McKenley, & Hollander, 2002), or perform better in demanding academic settings (Libbrecht, Lievens, Carette, & Côté, 2014).

Most of the evidence looks at ER at the response level, examining how it moderates people's responses to external objective emotional stimuli. ER, however, does not have to be passive. It may allow people to induce emotion at will. Few studies demonstrated the potential role

* Corresponding author.
E-mail address: leehuzysberg@yahoo.com (L. Zysberg).

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of ER as a function allowing both self-induced emotions as well as managing emotions induced by external stimuli. A relatively large body of research focused on ER and modulation using biofeedback and neurofeedback (Barrett & Popovic, 2015; Johnston, Boehm, Healy, Goebel, & Linden, 2010). These studies suggested that individuals can initiate emotional reactions and modulate them at will, and that some people find these tasks easier than others (Koole, 2009). Can EI play a role in how effectively people produce and manage emotional responses at will?

1.1. The current study

In the current study we examined individuals' ability to self-induce an emotional state (positive or negative) on request and then return to baseline effectively (i.e., to relax after experiencing the self-invoked emotions) using both self-report and physiological indicators of emotional arousal (heart rate and blood pressure [BP]).

Heart rate (pulse) is one of the most common physiological indicators of transitory, short-term arousal levels, acceptable in the health as well as behavioral sciences (Appelhans & Luecken, 2006). This measure is a common indicator of emotional responses as one of the essential components of sympathetic response patterns (Omiya et al., 2009). Heart rate deviation- from- baseline measures have been associated with emotional responses such as anxiety, fear, excitement and so on (Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000). While such measures may be considered somewhat crude and will not differentiate between specific emotional experiences, heart rate is still a basic yet widely agreed upon measure of arousal, highly associated with the magnitude of emotional reactions or experiences (Laborde et al., 2014; Mauss & Robinson, 2009; Shenk & Fruzzetti, 2011).

BP, on the other hand, is widely acceptable as an indicator of long-term emotional regulation and management and is therefore also included as an indicator of ER effectiveness (Gerin, Davidson, Christenfeld, Goyal, & Schwartz, 2006). BP is considered the mechanism linking emotional reactions and long-term health outcomes; High BP is often a symptom of ongoing stress, ineffectively managed (Carroll, Phillips, Der, Hunt, & Benzeval, 2011). Based on the existing evidence, we may view heart rate as a short-term, and BP as a long-term indicator of ER.

We hypothesized that ability and trait EI will show positive associations with heart rate variability during self-induced emotional arousal and relaxation, and negative associations with base-line BP. We tested these models controlling for some of the major correlates of emotional regulation and reactivity appearing in the literature: gender, age and trait anxiety (Dennis, 2007; Gross & John, 2003).

2. Method

2.1. Study design and settings

The procedure and data we describe herein are part of a larger study examining the associations between emotional abilities and physiological indicators of arousal and relaxation. We used an experimental laboratory-based design to test the study hypotheses. We asked participants to use any mental method they choose (as long as they remained seated and physically inactive while doing so) to reach emotional arousal and then again to use any mental strategy they choose to relax, while being monitored for heart rate and BP.

2.2. Sample

We recruited a sample of 127 undergraduate students (72% women). The sample size slightly exceeded the minimum sample size (n = 119) calculated by Gpower (Faul, Erdfelder, Lang, & Buchner, 2007) software package given a statistical power of 0.95 and the number of our independent factors. Ages ranged from 19 to 39 years (M = 24.71, SD = 2.45). Exclusion criteria included pregnancy, debilitating physical or mental conditions, or use of medications. Participants were given course credit according to their academic requirements.

2.3. Instruments and measures

2.3.1. Trait EI

We assessed Trait EI levels with the TEIQue-SF (Trait Emotional intelligence Questionnaire-Short From; Cooper & Petrides, 2010). This self-report questionnaire includes 30 items covering various aspects of trait EI. Participants indicate their responses on a 7-point Likert scale, ranging from 1 (*completely disagree*) to 7 (*completely agree*). The TEIQue-SF is one of the most commonly used measures of EI in health-related research (Martins, Ramalho, & Morin, 2010). The Cronbach's alpha for the current sample was 0.89.

2.3.2. Ability EI

We assessed Ability-EI levels using the Audio-Visual test of Emotional Intelligence (AVEI; Zysberg, Levy, & Zisberg, 2011). The AVEI is a 27-item computer-based test of EI predicated on the ability-EI approach. The test contains still images and short video clips depicting various people in diverse social and emotional situations. Test-takers are asked to identify the emotion experienced by a target person in the picture/clip from a list of 10 options. The test produces a single score ranging 0 to 27. Higher scores represent higher levels of emotional recognition and integration—two of the four aspects of ability EI. This test showed good reliability and predictive validity in both educational and health-related settings as a measure of general ability EI (Raz, Dan, Arad, & Zysberg, 2013; Zysberg, 2014).

2.3.3. Trait anxiety

We measured Trait anxiety with the Y2 (trait) scale from the Spielberger State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). This scale consists of 20 items that require the participant to respond to a number of statements about how they generally feel. Participants indicate their response on a scale of 1 (*almost never*) to 4 (*almost always*). Scores range from 20 (*low anxiety*) to 80 (*high anxiety*). The Cronbach's alpha for the current sample was 0.92.

2.3.4. Heart rate

We used these measures as physiological indicators of self-induced emotional arousal and emotion modulation (relaxation) in real time using an ambulatory digital arm-cuff pulse and BP monitor (My Check, Artsana S.p.A. [Pic Solution], Italy).

2.4. Procedure

The procedure was approved by the institutional review boards of both participating colleges and is in accordance with the declaration of Helsinki. Participants were tested individually in a quiet room. We instructed them to refrain from smoking or drinking caffeine or alcohol for at least 30 min before their arrival at the laboratory. Upon arrival, participants received basic information about the aims of the study and the procedure, provided informed consent, and spent a few minutes completing a demographic questionnaire. Then the baseline measurement of BP and pulse took place, twice, at 30-second intervals. Participants sat comfortably on an office chair with arms, with their feet flat on the floor, and the cuffed arm resting loosely on a firm surface at heart level. We instructed participants to keep still and silent during the readings. Following the two baseline measurements, participants completed the TA, TEIQue-SF, and AVEI in random order and then received instructions for self-inducing emotional arousal, after which we took both measures twice within a 30 second interval. Following a 2-minute rest they were given instructions for modulation (see Appendix 1 for details) and measures were taken again.

2.5. Statistical analysis

Mean heart-rate scores reflected the two measures at each time point (baseline, arousal, and relaxation). We then calculated difference scores based on the differences between arousal data minus the baseline, and the arousal condition minus the relaxation condition, to create two difference scores, the first representing self-induced emotional arousal and the second representing emotion modulation (relaxation after arousal). We used structural equation modeling (SEM) to create a latent variable representing ER (a combination of both the above difference scores) to test the hypotheses within a single model, to minimize capitalization on chance, a by-product of multiple repetitions of similar statistical procedures on the same dataset (Shaffer, 1995). We calculated a latent variable representing BP based on both systolic and diastolic mean measures taken at the baseline measurement time point, for our second analysis. Due to the terms of the informed consent signed by the participants we could not share the data publicly.

3. Results

We examined the descriptive statistics for the main study variables: The results are summarized in Table 1.

The results suggest an acceptable distribution (close to normal) for most measures, acceptable to good reliability, and no ceiling or floor effects. Table 2 presents the zero-order associations between the main variables as a preliminary indicator of association patterns between EI, anxiety, and the measures of self-induced emotion and regulation.

The correlation matrix shows a positive association between ability EI and self-induced emotion, and positive associations between trait anxiety and all three measures of pulse rate, as well as a positive association with self-induced arousal and regulation. A moderate positive association was found between the two EI measures. We also found negative associations between ability EI and both measures of BP. In addition, we calculated gender differences for the main study variables. Women showed higher Trait EI scores and higher Trait anxiety scores than men, but no other differences were found (see Appendix 2).

3.1. Hypothesis testing

We defined a latent variable representing the underlying factor of both difference measures mentioned above (difference in pulse between mean arousal state and baseline as well as the difference between mean arousal and relaxation states). We then ran the analysis using age, gender, trait anxiety, and both EI measures as predictors and the respective latent variables for heart rate differences and BP as criterion. Fig. 1 summarizes the statistical model supported by the evidence, after omitting non-significant paths and variables.

The model provides partial support to our hypotheses: ability EI, trait anxiety, and gender accounted for the variance in the ER factor, but not age or trait EI. Ability EI showed a positive association with the factorial score. Trait anxiety showed a negative association with the factorial score, whereas gender's association suggested that women showed a higher factorial score (i.e., greater heart-rate variability). We also tested for potential interaction effect between EI and gender (since such interactions appear in some of the literature on EI and emotional decoding, Wojciechowski, Stolarski, & Matthews, 2014). We found no interaction effect (and therefore did not add such term in the model).

We then examined the associations between the independent variables and both measures of BP taken at baseline—representing a latent factor that, may reflect a longer-term ER. Fig. 2 summarizes the path analysis using ability and trait EI, trait anxiety, age, and gender as predictors. Only gender and ability EI showed significant association with the latent BP factor.

The results provide additional support to our hypotheses, suggesting that beyond the effect of gender, people with higher ability EI tend to show lower levels of BP, which is often associated with more effective long-term ER. Here too we found no interaction effect between the exogenous variables.

Table 1
Descriptive statistics of the study variables (N = 127).

Variable	Mean	*SD*	Minimum	Maximum
Age	24.71	2.45	19.00	39.00
AVEI	17.99	3.00	8.00	24.00
TEIQue-SF	153.23	22.12	95.00	194.00
TA	38.55	9.96	20.00	64.00
Pulse baseline	73.65	12.04	48.00	112.00
Pulse arousal	76.12	11.37	51.00	113.00
Pulse relaxation	73.86	10.62	51.00	101.00
Dif1	2.25	5.26	−15.00	16.50
Dif2	2.46	6.08	20.00	−15.00
Systolic BP	113.70	14.91	88.00	180.00
Diastolic BP	71.35	11.20	51.50	149.00

Note. AVEI = ability EI; BP = blood pressure; Dif1 = pulse at arousal-baseline; Dif2 = pulse at arousal-relaxation; TA = trait anxiety; TEIQue-SF = trait EI.

4. Discussion

In this study we focused on two physiological indicators of transitory and long-term ER: heart rate and BP. Instead of measuring general ER, we asked our participants to actively regulate their emotions, upon request, after assessing their EI and recording background variables pertinent to both EI and ER. The results suggest that EI is positively associated with the latent variable representing ER through heart-rate differences. Participants with higher EI showed greater differences in heart rate that may represent more effective self-induced emotional arousal and more effective modulation (relaxation after arousal) of their emotions upon request. “The ease with which an individual can transition between high and low arousal states is dependent on the ability of the ANS to rapidly vary heart rate” (Appelhans & Luecken, 2006, p. 230). As proposed in the literature, a person's ability to effectively adjust physiological arousal is a key factor in ER (Gross & Thompson, 2007). Flexibility of the autonomous nervous system (ANS) promotes a rapid generation or modulation of physiological and emotional states in accordance with situational demands. Rigidity of the ANS, by contrast, may result in lower effectiveness of emotional responses modulation and therefore lessened capacity to optimally handle environmental changes and challenges (Appelhans & Luecken, 2006). Our results suggest that individuals with higher ability EI may have higher autonomic flexibility, as reflected by greater heart-rate variability throughout the different conditions of the task.

We ran a similar analysis using BP (systolic and diastolic) as an indicator of long-term ER, based on the evidence reviewed above. We viewed BP as an index of long-term dynamics (Carlson, Speca, Faris, & Patel, 2007). As expected, a negative association was found between EI and BP. This result supports the hypothesis that individuals with higher EI regulate emotions (among them stress) more effectively, not only when asked to do so but in an ongoing manner, which in turn may be reflected in lower levels of BP. These results, though novel, sit well with trends appearing in the literature (Krueger et al., 2009; Yu, Funk, Hu, & Feijs, 2017).

The lack of association between Trait EI and our outcome variables was a less expected result. There is a debate on the nature of the overlap (if any) between trait-EI and ability-EI (Brackett, Rivers, Shiffman, Lerner, & Salovey, 2006). The study of similarities and differences between trait and ability EI is yet to reach maturation. The literature mentions varying approaches and methods of assessing EI (for a more comprehensive treatment of the matter see: Ashkanasy & Daus, 2005). However, in the case of EI these are not just different measures but also different conceptualizations of the essence being measured: Ability EI draws on traditions of intelligence assessment and views EI as a potential for skill development (Mayer, Caruso, & Salovey, 1999). Trait EI

Table 2
Zero-order correlations among the study variables (N = 126).

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Age	–										
2. AVEI	−0.16*	–									
3. TEIQ	−0.06	0.17*	–								
4. TA	0.05	−0.05	−0.04	–							
5. Pulse baseline	−0.15*	0.00	0.09	0.24**	–						
6. Pulse arousal	−0.23*	0.07	0.12	0.16*	0.86**	–					
7. Pulse relaxation	−0.24*	0.04	0.04	0.25**	0.87**	0.88**	–				
8. Dif1	0.13	0.16*	−0.04	0.14*	−0.36**	0.15*	0.05	–			
9. Dif2	−0.03	0.07	−0.18*	0.15*	0.13	−0.37**	0.09	0.44*	–		
10. Systolic BP	0.25**	−0.19*	−0.10	−0.06	−0.02	−0.08	0.02	0.06	−0.03	–	
11. Diastolic BP	0.26**	−0.16*	0.05	0.00	0.10	0.06	0.02	−0.01	−0.05	0.78**	–

Note. AVEI = ability EI; TEIQ = trait emotional intelligence questionnaire; BP = blood pressure; Dif1 = pulse at arousal-baseline; Dif2 = pulse at arousal-relaxation; TA = trait anxiety.
* $p < .05$.
** $p < .01$.

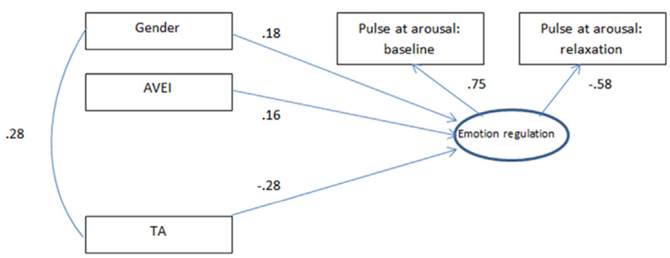

Fig. 1. SEM analysis summary of the statistical model (N = 126). Error terms were omitted for clarity of presentation. All coefficients presented are significant at $p < .04$ or better. AVEI = ability EI; TA = trait anxiety. Gender = 1 (male)/2(female).
Goodness of fit indices: Chi-square = 2.84 (4) p = .59, NFI = 0.94, CFI = 1.00, RMSEA = 0.00.

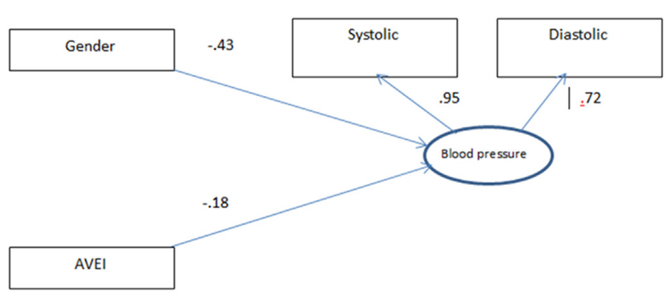

Fig. 2. Summary of path analysis accounting for general blood pressure (n = 127).
Error terms were omitted for clarity of presentation. All coefficients presented are significant at $p < .05$ or better. For clarification of indicators in the model see Fig. 1.
Goodness of fit indices: Chi-square = 1.96 (2) p = .37, NFI = 0.98, CFI = 1.00, RMSEA = 0.00.

views the concept (much like any trait related personality construct) as a predisposition or a tendency to behave and act in certain patterns beyond specific circumstances (Petrides & Furnham, 2003). It is too early to draw any solid conclusion regarding the relationships between the concepts of ability EI and trait EI (Daus & Ashkanasy, 2005). Our results may suggest that personality measures of EI and ability-EI differ in what they actually measure. Following this line of reasoning, we may suggest that personality traits relate to emotional performance through different channels than those associating abilities and emotional performance. Such suggestions are supported by evidence on how personality traits and abilities correspond with different brain processes (DeYoung et al., 2010), therefore producing different physiological indications.

In this respect the results also enrich our theoretical understanding of EI as an ability, which is at least partly independent of some of the major correlates of ER mentioned in the literature (Austin, 2004).

Our results indicated a consistent effect of gender on both outcomes. Women were generally more effective in regulating their emotions: the results suggested women were able to induce greater differences in heart rate between baseline, arousal and relaxation states, and also showed lower BP values representing (in our study context) more effective regulation of emotions. Women also showed higher means in the Trait EI measure (which eventually did not make it into our final models) but no significant gender differences were found in the ability-EI measure (which was included in our final models). This pattern is at times echoed in other studies focusing on Ability-EI – showing minimal and at times nonsignificant gender differences (e.g.: Brackett et al., 2006).

Although the experimental nature of this study reduces many of the threats to the internal validity of the results, readers should bear in mind the study limitations when interpreting or wishing to implement the results found here: we sampled participants from a specific population (students in Israel). Cultural and age-related restrictions may limit the generalizability of our findings. The magnitude of the effects found, though statistically significant, is moderate, and interpretation and future applications based on these findings should be viewed with care. Our measures, though supported and validated in the literature, may be limited in scope and in the extent to which they may represent specific emotions. Studies have suggested more specific measures (e.g. Richter & Gendolla, 2009) and these may be included in future studies.

Future studies may further explore the associations found in various samples as well as varying ER tasks, including both self-induced and external-induced emotional states. We treated both arousal and relaxation tasks as facets of the same concept in our models. Future studies may wish to compare competing models of separate tasks vs. unified ones to better understand how EI associates with different functions of ER. Further exploring the trait and ability EI differences is yet another theme emerging from our results. Studies that will test the two models of EI against additional outcome measures (as in organizational psychology, see Daus & Ashkanasy, 2005) while testing the inter-relations between the two measures may be of added value. Looking further into the role of EI vis-à-vis indicators of long-term ER and emotional well-being (BP included) may enrich our understanding of the potential role of EI in helping us make the most of our experiences, and to thrive even when circumstances are less than supportive.

Appendix 1. Detailed instructions for participants

Instructions for the arousal task:

I will ask you now to try, to the best of your ability, to put yourself in a state of emotional arousal and excitement. You have to do it with your eyes closed using your own thoughts and imagination only. When you feel that you have reached that state, please let me know and I will measure your blood pressure and pulse.

Participants were given 2 to 3 min to complete this task before the second heart rate reading took place (twice, at 30-second intervals). Next, participants rested for 2 min, after which they received the following instructions:

I will ask you now to try to put yourself in a state of emotional relaxation and calmness. Again, please do it with your eyes closed, using your own thoughts and imagination only. When you feel that you have reached a relaxed state, please let me know, and I will measure your blood pressure and pulse for the last time.

The last heart rate readings were performed twice, at 30-second intervals.

Appendix 2. Gender differences on the main study variables

Variable	Males (n = 36) Mean (SD)	Females (n = 91) Mean (SD)	t (df)	Cohen's d
AVEI	17.45 (3.41)	18.10 (2.90)	−1.20 (125)	0.21
TEIQue-SF	146.77 (23.50)	155.00 (21.10)	−2.09 (125)*	0.37
TA	35.55 (10.04)	29.70 (9.77)	−2.16 (125)*	0.59
Dif1	7.30 (8.40)	5.22 (7.89)	1.32 (125)	0.26
Dif2	0.51 (5.80)	−1.80 (6.20)	1.08 (124)	0.38
Systolic BP	113.61 (12.67)	102.32 (11.44)	4.85 (125)**	0.93
Diastolic BP	69.22 (9.19)	65.51 (8.26)	2.20 (125)*	0.42

* $p < .05$.
** $p < .01$.

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