A Meta-Analysis of the Possible Behavioural and Biological Variables Linking Trait Emotional Intelligence to Health

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Abstract

Trait Emotional Intelligence (trait EI) is a constellation of correlated emotion-related traits that capture an individual's typical way of processing emotion-related information and reacting in emotional situations. Numerous studies have shown that trait EI is a significant predictor of both subjective and objective health. This correlational meta-analysis (k = 106, N = 45,262) aims to explore the behavioural and biological variables that could account for these effects. It also aims to provide a roadmap for future research by identifying what should be studied (pinpointing dead-end roads and promising paths) and how (methodological improvements needed to draw stronger conclusions). The results revealed large associations of trait EI with social support, sleep quality, and hypothalamic-pituitary-adrenal axis activity in challenging situations as well as medium associations with dietary habits, physical activity, and substance use. Other candidate pathways have given rise to much less research. Based on both theoretical predictions and preliminary findings, the paper categorizes these pathways as promising or not promising. Future research would benefit from using more diverse samples, measuring behavioural variables more objectively, controlling for personality, and systematically examining to what extent *changes* in EI (e.g. following training) lead to changes in behaviours and/or biological parameters.

Keywords: Emotional competence, disease, illness, behaviours, physiology.

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Although we all experience and witness all sorts of emotions throughout our lives, we markedly differ in the way we process these emotions and, in particular, in the way in which we identify, express, understand, regulate and use our own and others' emotions. The concept of emotional intelligence (EI) — alternately labelled "emotional competence" (EC) or "emotional skills" — has been proposed to account for this idea (Mayer & Salovey, 1997; Mikolajczak, Quoidbach, Kotsou, & Nelis, 2009; Petrides & Furnham, 2003). Individuals with high EI can identify their emotions as well as those of others; express them in a socially acceptable manner; understand their causes and consequences; regulate them when they are not appropriate to the context or to their goals; and use them to enhance relationships, thoughts, and actions.

The status of EI as intelligence or trait has been a central concern and a source of debate among researchers from the very birth of the concept to the present day. As research on EI expanded, the field split off into two distinct perspectives, one perceiving EI as a set of abilities constituting a new form of intelligence (Mayer & Salovey, 1997) and the other perceiving EI as a set of correlated adaptive emotion-related traits (Petrides & Furnham, 2003). These debates have given rise to an integrative model of EI (see Mikolajczak, Petrides, Coumans, & Luminet, 2009), which is grounded in the idea that both perspectives have merits and that there is no evidence to date suggesting that one should be dismissed in favour of the other. This model posits three levels of EC: knowledge, abilities, and traits. The knowledge level refers to what people know about emotions and emotionally intelligent behaviours (e.g. *Do I know* which emotional expressions are constructive in a given social situation?). The ability level refers to the ability to apply this knowledge in a real-world situation (e.g. *Am I able to* express my emotions constructively in a given social situation?). The focus here is not on what people know but on what they can do; even though many people know that they should not shout when angry, many are simply unable to contain themselves. The trait level refers to emotion-related dispositions—namely, the propensity to behave in a certain way in emotional situations (*Do I typically* express my emotions in a constructive manner in social situations?). The focus here is not on what people know or what they are able to do but on what they typically do over extended periods in emotional situations. For instance, some individuals might be able to express their emotions constructively if explicitly asked to do so (so they have the ability) but do not manage to manifest this ability reliably and spontaneously over time. A former study by Lumley, Gustavson, Partridge, and Labouvie-Vief (2005) and a recent doctoral dissertation by Cardoso-Seixas (2016) demonstrated that there were only weak correlations among measures of EI defined as knowledge, abilities, and traits. That is, knowledge does not always translate into ability, which, in turn, does not always translate into usual behaviour (traits). Because there are not yet enough studies to reliably estimate the impact of the knowledge and ability levels on health-related variables[1], we will focus on the trait level in this paper. However, the dearth of studies on knowledge and ability levels and health itself constitutes a finding of the current study as we originally aimed to include all three levels in the meta-analysis. We shall come back to this issue in the General Discussion.

Research on the trait level of EI started two decades ago (Petrides & Furnham, 2001; Salovey, Stroud, Woolery, & Epel, 2002; Schutte, Malouff, Hall, Haggerty, Cooper, Golden, & Dornheim, 1998), and studies conducted since then have established

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[1] We originally aimed to include all three levels in the paper, and we did the literature search to this end. We also did the meta-analytical analysis. However, most cells in Table 1 were empty for knowledge and ability EI, and there was not a single cell for these two levels of EI where $k > 5$. We finally removed knowledge and ability EI from the paper.

that trait EI is a significant predictor of psychological, somatic, and social adjustment. At a psychological level, higher trait EI is associated with greater well-being (e.g. Austin, Saklofske, & Egan, 2005), less stress and distress in challenging situations (e.g. Mikolajczak, Roy, Luminet, Fillée, & de Timary, 2007), and fewer psychological disorders overall (e.g. Petrides, Pérez-González, & Furnham, 2007). At a somatic level, higher trait EI is associated with better health, on both self-reported (Martins, Ramalho, & Morin, 2010) and objective measures (Mikolajczak et al., 2015). Socially speaking, higher EI leads to better interpersonal relationships with partners, friends and colleagues (e.g. Malouff, Schutte, & Thorsteinsson, 2014; Quoidbach & Hansenne, 2009; Schutte et al., 2001). Experimental research shows that trait EI is causally involved in these outcomes: when trait EI is enhanced through training, psychological, somatic and social outcomes improve (Karahan & Yalçin, 2009; Kotsou, Grégoire, Nelis, & Mikolajczak., 2011; Nelis, Quoidbach, Mikolajczak, & Hansenne, 2009; Nelis et al., 2011; Sharif, Rezaie, Keshavarzi, Mansoori, & Ghadakpoor, 2013; Slaski & Cartwright, 2003; Vesely, Saklofske, & Nordstokke, 2014; Yalçin, Karahan, Ozcelik, & Igde, 2008). Beyond these outcomes, trait EI has been shown to be consistently related to a number of other important variables, such as job performance (see e.g. O'Boyle, Humphrey, Pollack, Hawver, & Story, 2011 for a meta-analysis), leadership (see Miao, Humphrey, & Qian, 2016 and 2018 for meta-analyses), work attitudes (Miao, Humphrey, & Qian, 2017a for a meta-analysis), or counterproductive work behaviours (see Miao, Humphrey, & Qian, 2017b for a meta-analysis). However, experimental studies that confirm causation direction are still needed.

In parallel, empirical evidence has accumulated against early fears that trait EI would not predict additional variance in the abovementioned outcomes beyond the Big Five personality factors and intelligence. A first meta-analysis by Van Rooy and

Viswesvaran (2004) showed that trait EI predicted work performance (in academic and job settings) beyond the Big Five personality factors. While this meta-analysis provided an interesting piece of evidence, it focused only on *one* criterion (performance) and tested the incremental validity of EI above each personality trait *in turn*. A stronger argument was provided a few years later by the meta-analysis of O'Boyle et al. (2011), which showed that EI predicted job performance beyond cognitive ability and the Big Five factors of personality, the latter being considered *together* in the model. This meta-analysis also focused on one criterion, but Miao, Humphrey, and Qian soon confirmed the incremental validity of trait EI over personality and cognitive ability regarding other criteria such as leadership (2016), work attitudes (2017a), and organizational citizenship behaviour and counterproductive work (2017b). Nearly at the same time, Andrei, Siegling, Aloe, Baldaro, and Petrides (2016) showed that even the trait EI instrument that correlated the most strongly with personality (e.g. the Trait Emotional Intelligence Questionnaire [TEIQUE]; see Van der Linden, Schermer, de Zeeuw, Dunkel, Pekaar, Bakker et al., 2017) has consistent and significant incremental validity beyond higher-order personality dimensions[2] and emotion-related personality constructs (such as optimism, alexithymia, or trait affect) in predicting a large range of criteria pertaining to different areas of functioning, including health. Thus, it is now clear that claims that EI does not have added value over existing constructs are empirically unfounded.

The ever more numerous meta-analyses about EI have allowed not only demonstration of the incremental validity of trait EI but also estimation of the effect size of trait EI on various outcomes more precisely. In light of the new norms provided by

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[2] As noted by Andrei et al. (2016), it is even more remarkable that analyses always test the incremental validity analyses of trait EI *at the global level* against either the Giant Three or the Big Five. Indeed, while the personality constructs comprise three or five different variables, trait EI at the global level represents only one. Based on this statistical advantage alone, higher-order personality dimensions are much more likely than trait EI to be significantly associated with criterion variables.

Bosco, Aguinis, Singh, Field, and Pierce (2015)[3] for interpreting effect sizes in applied psychology, the effect size is large for psychological well-being and mental health outcomes (see Schutte, Malouff, Thorsteinsson, Bhullar, & Rooke, 2007; and Martins et al., 2010 for meta-analyses); moderate to large for physical health (Martins et al., 2010; Schutte et al., 2007); large for marital satisfaction (see Malouff et al., 2014); moderate for job performance (O'Boyle et al., 2011); and large for work attitudes (Miao et al., 2017a), leadership (Miao et al., 2016; Miao et al., 2018), and citizenship and counterproductive behaviours at work (Miao et al., 2017b).

As pointed out by many commentators (e.g., Bisquerra, Perez-Gonzalez, & García Navarro, 2015; Joseph & Newman, 2010; Matthews, Zeidner, & Roberts, 2007; Peña-Sarrionandia, Mikolajczak, & Gross, 2015), the main challenge that the EI field must now take up is to understand the *processes* by which EI exerts its effects on each outcome. This is a major challenge in the health domain because the effect of a psychological factor on health can involve both behavioural and biological processes (Zeidner, Matthews, & Roberts, 2012). This paper aims to take up the challenge and to integrate the many and apparently disparate findings that relate EI to health. What is needed is an overarching model that would allow researchers and practitioners alike to integrate and organize the rapidly accumulating findings. Such a model should clarify the behavioural and biological variables that possibly underlie the effect of EI on health, give an indication of the weight of each variable in this relationship and identify under-researched variables in order to provide clear-cut directions for future research. The aim of the current work is to provide a model that meets these expectations.

[3] Effect sizes (aggregated correlations) smaller than .09 are considered small, between .09 and .26 are considered medium, and greater than .26 are considered large.

Trait Emotional Intelligence

Any discussion of the trait EI-health relationship presupposes an understanding of what trait EI is. There is a consensus among researchers that the trait level of EI reflects the *typical* way of processing emotion-related information and the *typical* way of behaving in emotional situations; there is also a consensus that, like personality, trait EI can be reliably measured using self-reports (Petrides, Mikolajczak, Mavroveli, Sanchez-Ruiz, Furnham, & Pérez-González, 2016). On looking at the instruments used to measure trait EI, one can infer that there is not yet a full consensus on which dimensions trait EI includes. Some instruments, like the TEIQUE (Petrides, 2009)—the most widely used instrument in trait EI research—include the major, correlated, and generally adaptive emotion-related facets of personality (Petrides, Pita, & Kokinaki, 2007, pp 287; Van der Linden et al., 2017). Other instruments, like the Schutte Self-Reported Emotional Intelligence Test (SREIT; Schutte et al., 1998, Revised by Austin, Saklofske, Huang, & McKenney, 2004) or the Profile of Emotional Competence (PEC; Brasseur, Gérgoire, Bourdu, & Mikolajczak, 2013), narrow their focus on the core emotional competencies (Emotion perception/expression, Emotion understanding, Emotion utilization, Emotion regulation; Saarni, 1990; Mayer & Salovey, 1997). Yet, these differences in views do not seem to threaten the validity of the construct of trait EI because (1) emotion perception, expression, utilization, and regulation are included in the TEIQUE (sometimes under a different label), and (2) the correlation between trait EI instruments is high (.77 between the PEC and the TEIQUE-SF, Brasseur et al., 2013; .73 between the SREIT and the TEIQUE, Gardner & Qualter, 2010) and much higher than the correlation between trait EI and ability EI (MSCEIT–TEIQUE = .08, Di Fabio, Saklofske, & Tremblay, 2016; MSCEIT–SREIT: .18, Brackett & Mayer, 2003).

Thus, empirical evidence summarized so far supports the view that (1) trait EI is a constellation of correlated and adaptive emotion-related traits that capture the typical ways of processing emotion-related information and behaving in emotional situations; (2) these traits form a latent construct that can be called EI (e.g. Cooper & Petrides, 2010; Nozaki & Koyasu, 2016; Schutte et al., 1998) and which emerges even in the presence of the Giant Three or the Big Five Factors of personality (see Petrides et al., 2007); and (3) this construct predicts a range of outcomes beyond cognitive ability, higher-order personality dimensions, and existing emotion-related personality constructs (such as optimism, alexithymia, or trait affectivity). Recent results regarding genetic and cerebral correlates of trait EI (see Petrides, Mikolajczak et al., 2016 for review) show that trait EI has identifiable biological underpinnings, and these findings add to the large body of evidence showing that trait EI is not an umbrella of uncorrelated personality facets.

Trait Emotional Intelligence and Physical Health

The relationship between trait EI and physical health has only recently become a focus of research in the EI field, partially because interest in EI originated from the context of organizational psychology, and partially because researchers focused first on outcomes that could be measured at a lower cost such as well-being or relationship quality. The expensive nature of health-related research may also explain why the first (and still many) studies investigating the relationship between EI and health used self-reported instruments to measure health. Most of these instruments consist of symptom reports such as the General Health Questionnaire (GHQ-28; Goldberg & Williams, 1988). Because this questionnaire has the dual inconvenience of including symptoms related to mental health (e.g., Have you been getting edgy and of bad tempered?) and of measuring *changes* in health status rather than health status itself (i.e., response choices are framed as “better than usual”, “same as usual”, “worse than usual”, “much worse than usual”), several researchers have preferred using the Pennebaker Inventory of Limbic Languidness (PILL; Pennebaker, 1983), a list of 54 specifically physical symptoms (e.g., runny nose, headache, vomiting, etc.) to be rated on a frequency scale (“never or almost never experienced”, “3-4 times per year”, “every month or so”, “every week or so”, “more than one a week”). The PILL can be adapted to measure health in general (like the frequency scale above) or health over a specific time period (last year, last month, etc.). Finally, other researchers have used “home-made” instruments measuring the general evaluation of one’s physical health (e.g., whether participants felt their health was above average, below average, or average compared to others of the same age and sex; Austin et al., 2005), and/or the self-reported frequency of medical consultations over a certain period of time.

The results of these studies have been gathered in two meta-analyses: one performed by Schutte and colleagues in 2007 and the other performed by Martins and colleagues in 2010. The results already shown that there was a dearth of studies investigating the relationship between the ability level of EI and physical health. As far as the trait level of EI is concerned, it was found to be significantly related to health, regardless of the measures of EI and/or health used. As expected given the high correlation between trait EI and mental health, trait EI was more strongly related to measures of physical health that include symptoms of mental health (r = .31 in Schutte et al. and .33 in Martins et al.) than it was with purer measures of physical health (r = .22 in Schutte et al. and .27 in Martins et al.). Yet, as argued below and later in the current meta-analysis, these results are unlikely to be the product of shared method variance (in this meta-analysis, both trait EI and health were measured using self-report) because trait EI is also a significant predictor of a number of biological variables that can explain its relationship with health. Moreover, although self-reports of health are subject to biases, research has suggested that they are not less valid than some so-called “objective” data such as hospital records. Indeed, self-reports of health have been shown to be good predictors of mortality over a 23-year interval (Heistaro, Jousilahti, Lahelma, Vartiainen, & Puska, 2001) and predicted functional disability better than medical records over a 15-year period (Ferraro & Su, 2000). This being said, and as pointed by the authors of these meta-analyses themselves, the link between EI and health needs additional evidence to be fully confirmed. First, the results need to be replicated in larger, both more diverse and more representative samples. Second, these results to be confirmed using more objective indicators of health. Third, the direction of causality needs to be validated in experimental designs with manipulations of EI. Both kinds of evidence have been provided in the years following the last meta-analysis.

The fact that higher trait EI predicts objective indicators of health was confirmed in a nationally representative sample that was used to investigate trait EI and health (Mikolajczak et al., 2015). In two studies (N_1 = 1310; N_2 = 9616) conducted in collaboration with the largest health insurance company in Belgium, the authors correlated responses on various trait measures of EI (the TEIQue in Study 1, and the PEC in study 2) with their healthcare consumption according to the records from the health insurance company. These studies first showed that trait EI is a significant predictor of various indicators of health (drug consumption by class of drugs, visits to a GP or specialist, hospitalizations in general or psychiatric hospitals) over a 12-year period, and the findings held even when controlling for other predictors of healthcare use such as age, sex, level of education, body mass index, dietary habits, physical activity, drinking and smoking habits and social support. When all predictors were entered in the model, trait EI turns out to be the most important predictor of health, in addition to age. These results held when psychotropic drug intake (e.g., anxiolytics, antidepressants, etc.), visits to psychiatrists and hospitalizations in psychiatric hospitals were removed. Finally, the findings showed that high trait EI can attenuate (and sometimes compensate for) the impact of other risk factors, such as aging, low education, low physical activity or high body mass index.

The evidence that trait EI is causally involved in the prediction of health was provided by several controlled studies in which trait EI was improved via training and health indicators measured before and after the training (up to a year after in some studies). These studies showed that when trait EI is enhanced through training, both subjective (e.g., symptom reports) and objective indicators of physical health (e.g., glycated haemoglobin in diabetic patients; hair cortisol and migraine frequency in migraine sufferers; diurnal cortisol in stressed managers) improve compared to a control group (e.g., Karahan & Yalcin, 2009; Kotsou et al., 2011; Miliche et al., 2017; Nelis et al., 2011).

Behavioural and Biological Variables Linking Trait EI and Health

Several behavioural and biological variables can contribute to explain the effect of EI on health. Regarding the behavioural variables, studies have investigated the relationship between EI and seven possible variables: diet, physical activity, substance use (mainly tobacco, alcohol, cannabis), risky sexual behaviours (unprotected sex and sexual promiscuity), reckless driving, sleep quality, and social support. As shown in Supplemental Table 1, all these behaviours have an established and significant impact on health. Showing that EI has at least a small aggregate impact on them would constitute a first piece of evidence that they could act as mediators in the relationship between EI and health. Full mediation studies measuring EI, at least two potential mediators and at least one objective indicator of health are relatively rare (although they exist; see for e.g., Mikolajczak et al., 2015), but the few existing ones are sufficient to double-check that the variables that would be identified as the strongest potential mediators in the correlational meta-analysis do act as the strongest mediators in mediation models.

For the reasons explained in the section “Trait Emotional Intelligence and Health”, much less research has been devoted to the relationship between EI and biological variables. Since the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal (HPA) axis are anatomically and physiologically connected to the nervous centres involved in emotions, most studies investigating the effects of EI on health have focused on these two systems or on more specific parameters that are controlled directly or indirectly by the ANS and HPA, like heart rate, heart rate variability, or anti-oxydants. Readers unfamiliar with biology will find a short explanation of the functioning of the HPA axis and of the two main branches of the ANS (i.e., the Sympathetic Nervous System, SNS and the Parasympathetic Nervous System, PNS) in Supplemental Table 1, along with a short explanation of all the other parameters cited above. For each variable, Supplemental Table 1 briefly explains what it consists of, how it is related to health, and what the theoretical reasons are to expect (or not) an effect of trait EI on these variables. The way each variable was measured in the studies included in the meta-analysis figures in Supplemental Table 2. Other candidate variables that have not yet been investigated in relationship to EI and that will be presented in the Discussion are also included in Supplemental Table 1.

Goals of the Current Study

As stated above, this meta-analytic review aims to synthetize and organize the many findings that relate EI to health-related behaviours and physiology. The first goal is to derive a working model that helps to clarify the behavioural and biological variables that possibly account for the impact of EI on health. The second goal, as important as the first, is to provide a roadmap for future research by identifying what should be studied and how; the paper under-researched variables as well as the limits and biases of existing studies and the methodological improvements needed to draw stronger conclusions.

This meta-analysis was semi-exploratory in the sense that we did not have strong hypotheses about the *size* and *relative size* of the effects. We could only make predictions about the *possibility* and *direction* of the effects. The theoretical foundations for each hypothesis are presented in Supplemental Table 1 (right column). For the theoretical reasons explained in this table, we anticipated that EI would be positively related to healthy diet, physical activity, sleep quality and duration, and social support and that it would be negatively related to substance use, reckless driving, and risky sexual behaviour (see Figure 1). Regarding the biological variables, we anticipated that EI would be negatively related to SNS and HPA activity in anticipation of and amidst negative or stressful events but not to baseline SNS and HPA activity or PNS activity. We also anticipated that EI would be negatively related to heart rate (and possibly positively related to heart rate reactivity) in anticipation of and amidst negative or stressful circumstances but not at baseline. We finally anticipated the possibility of a small negative relationship with Body Mass Index (BMI) (see Figure 1). Supplemental Table 1 also presents hypotheses regarding other biological variables that could be evaluated in relationship to EI in future studies because they are usual candidate pathways in health psychology. As shown in Supplemental Table 1 and as explained in the General Discussion (and depicted in Figure 3), only a portion of them appear promising.

Figure 1. Hypothetical model of the variables explaining the relationship between EI and physical health based on existing literature

Method

Broad Literature Search

We employed several methods to locate possible eligible studies. First, we conducted a database search on EI/EC, physical health, and the variables linking the two to retrieve all relevant articles published until March 2018.

First of all, a general search in PsycINFO, Scopus and PubMed was conducted in order to have an overview of the literature regarding EI/EC and physical health (see upper part of Supplemental Table 3 for search terms). Then, the search was narrowed down to the behavioural and biological variables that could possibly account for the relationship between EI/EC and health. The keywords included were the behavioural and biological variables that had already been found to mediate the relationship between psychological factors (personality traits, abilities, etc) and health. This search was done in PsycINFO, Medline and Researchgate (see lower part of Supplemental Table 3 for search terms).

Second, we searched the reference lists of the relevant papers in this field in order to complete the systematic bibliographic search. We also contacted the main authors in the domain of EC/EI and health in order to obtain unpublished or in press manuscripts and data sets. In particular, we contacted 12 authors and 10 of them replied. None of them had any unpublished or in press papers.

Because this broad literature search revealed that there were not enough studies to compute reliable effect sizes between EI/EC and health for ability EI and for each emotional competence separately (i.e. emotion identification, emotion expression…), we decided to focus the current meta-analysis on global trait EI. Note that the scarcity of the literature about ability EI and health and about each emotional competence and health is the first finding of this meta-analysis. It calls for more research on the ability level of EI and on the sub-dimensions of EI.

Inclusion Criteria

We included a study if it reported first hand data (cross-sectional, longitudinal or experimental) about the relationship between global trait EI and any variable that has been previously shown to explain the relationship between psychological factors and health (i.e., behavioural or biological variables). Thus, theoretical articles, review articles, commentaries or duplicates were excluded.

More specifically, a study was included in the meta-analysis if it met the following criteria:

1. the study was conducted on humans
2. the study used an adult sample
3. the study was published in a journal article with peer-review
4. the study was published in English

After reviewing the articles, 522 were assessed for eligibility. Among these 522 studies, 416 (79.7%) did not meet the inclusion criteria (e.g., although it was not written in the abstract, the sample was adolescent). Thus, we included a total of 106 studies in the meta-analysis (see Supplemental Table 2 and References in the SOM Reference list 1). Figure 2 shows a flow-diagram that depicts the search process and its outcome at each stage.

Among the 522 full-text articles assessed for eligibility, when a study did not provide enough data to calculate effect sizes, we contacted the authors. Among all of the requested authors (82), 51 (62.7%) replied. Twenty-three of them explained that they did not have access to those data because the data were collected too long ago. Twenty-eight other authors provided data for twenty-eight studies.

Figure 2. Flow diagram of the papers identified and included in the meta-analysis

Exclusion Criteria

In addition to excluding studies that did not meet the inclusion criteria cited above, studies (or individual measures within a study containing several measures) were excluded when they did not measure the relationship between EI and a variable clearly related to health. For example, a study reporting the association between EI and weight (Lana, Baizán, Faya-Ornia, & López, 2015) was excluded because weight without height is misleading. Given that this meta-analysis focuses on trait EI as a whole, studies evaluating alexithymia were also excluded from the meta-analysis. Alexithymia is a multi-faceted construct comprising (a) a difficulty in identifying feelings, (b) a difficulty in describing feelings to others, and (c) an externally oriented thinking style with a poor ability to fantasize and low interest for one's inner life (Taylor & Bagby, 2000). The first dimension of alexithymia inversely corresponds to the first dimension of EI (emotion identification), and the second dimension of alexithymia (i.e., a difficulty in describing feelings to others) inversely corresponds to the second dimension of EI (emotion expression). Although alexithymia and trait EI are negatively correlated, the two constructs cannot be equated (Parker, Taylor, & Bagby, 2001), not only because they share only half of their variance (ibid.) but also because conceptually alexithymia takes into account only two dimensions of EI (i.e., emotion identification and emotion expression).

Coding of the Studies

The following information was retrieved and encoded for each study (see Supplemental Table 2):

1. Authors
2. Sample size
3. Sample type (university students, general population, etc.)
4. Mean age
5. Gender distribution
6. Type of study (observational, quasi-experimental, experimental)
7. Environment (field, laboratory)
8. Duration (cross-sectional, longitudinal)
9. Trait EI measure (i.e., the test/questionnaire used)
10. Correlation between trait EI and the variable measure
11. Variable measure (i.e. name of the questionnaire or objective measure used)
12. Variable name (and measure type: self-report questionnaire [SRQ] or objective measure [OM])
13. Effect size with confidence interval.

Meta-Analytic Statistics

All analyses were conducted using Comprehensive Meta-Analysis software, Version 3. A random-effect model was used in order to take into account that the true effect may vary from study to study.

Individual effect size calculations. Because most studies reported correlations, effects sizes in individual studies are presented in the form of Pearson's *r* (see Supplemental Table 2).

Aggregated effect size calculations. Behavioural and biological variables were classified based on features of the measure used to evaluate them. Four experts in the field independently classified the measures used in the studies included in the meta-analysis. The inter-rater reliability was computed using the Intraclass Correlation Coefficient (ICC). ICC estimates and their 95% confident intervals were calculated using SPSS statistical package version 24 based on a mean-rating (k = 4), absolute-agreement, 2-way mixed-effects model. The average measure ICC was .907 with a 95% confidence interval from .862 to .940 ($F_{(59,177)}$= 10.882, p<.001). Based on the 95% confident interval of the ICC estimate, values greater than .90 are indicative of excellent reliability. Thus, the classification of the measures presents an excellent degree of reliability.

When a study provided more than one effect sizes for the same outcome variable (e.g., two different measures were used to measure the relationship between trait EI and drugs in Brackett & Mayer, 2003), we aggregated these effect sizes into a single effect in order to take the dependency between measures into account. After doing this, we aggregated the relevant effect sizes to obtain the aggregate effect size of trait EI with the different variables (biological/behavioural variables). As explained below and as suggested by Lipsey and Wilson (2001), more weight was given to the effect sizes coming from studies with larger samples. The last step consisted of calculating the confidence intervals around these aggregated effect sizes by taking into account both the effect size and the standard error. The aggregated effects (see Tables 1 and 2) are expressed in Pearson's *r*. Results have been interpreted using Bosco et al. (2015) benchmarks. According to Bosco et al. (2015), a median effect size is r = .16. Split into thirds, the upper boundary is .26, and the lower boundary is .09. Thus, effect sizes smaller than .09 are considered small, those between .09 and .26 are considered medium, and those larger than .26 are considered large.

Homogeneity test. Heterogeneity in meta-analysis refers to the variation in study outcomes between studies. As it does not make sense to combine “apples and oranges”, a certain level of homogeneity is needed to ensure that studies included in the meta-analysis are “combinable”. In the current meta-analysis, the *Q* homogeneity statistic was used (Cochran, 1954) as it is well adapted to correlational meta-analyses (Maeda & Harwell, 2016).

Publication bias. Considering that studies reporting significant effect sizes are more likely to be published than studies with non-significant results, and that published studies are more likely to figure in a meta-analysis, any publication bias in the literature would be reflected in the meta-analysis: individual effect sizes would be distributed a symmetrically around the mean effect size and the aggregated effect size would be overestimated (Borenstein et al., 2009). It is therefore essential to compute the Egger’s (1997) regression to test for publication bias before interpreting the results. Intercept terms far from 0 at $p < .10$ suggest the presence of publication bias.

Risk of bias. To assess the quality of the studies included in the meta-analysis and to accurately interpret the findings of the present meta-analysis, a risk-of-bias assessment was performed for each individual study. There are many tools to assess the risk of bias in individual studies, but most of them concern intervention or cohort studies. The Joanna Briggs Institute (JBI; Moola, 2017) offers a tool to assess the quality and risk of bias in cross-sectional studies: The JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies. Based on this instrument, six aspects were evaluated for each study included in this meta-analysis: study design, sample characteristics, measurement of predictor, measurement of outcome, statistics, possible confounding variables. A summary of the assessment of the risk (unclear, low, moderate, high) for each criterion for each individual study is provided in Supplemental Table 5.

Results

Analyses of the relationship between EI and the variables included 206 effect sizes and 45,262 participants from a total of 106 studies.

Supplemental Table 2 summarizes the characteristics of the 106 studies included in the meta-analysis: the authors, sample size, sample type, mean age, gender distribution, type of study, environment, duration, the instrument used to measure trait EI, the individual effect size (*r*), the behavioural or biological variable, the instrument/method used to assess the variable, and the effect size (*r*) with its confidence intervals as they have been used in CMA. Supplemental Table 5 provides a Risk-of-Bias Assessment for each study included in the meta-analysis. No study deserved to be dismissed based on this assessment, but it nonetheless allowed qualification of the results and identification of several directions to improve the methodology of future studies. We shall come back to this issue in the General Discussion.

Trait EI and Behavioural Variables

As shown in Tables 1 and 2, there are significant differences in the number of studies evaluating how each of these variables relates to EI. In particular, social support, substance use, physical activity, and diet are the most studied variables (k = 46, 20, 20, and 9 respectively) while sleep quality, reckless driving, and risky sexual behaviours have been studied less (k = 5, 2, and 1 respectively).

As Tables 1 and 2 also show, trait EI is not equally related to the different behavioural variables. Sleep, social support, diet and physical activity are the variables that show the strongest relationships with trait EI (r = .36, .33, .20, and .17 respectively) with social support showing the most consistent pattern across studies (smaller confidence interval around r than for sleep). Reckless driving and substance use ($r = -.11$ and $r = -.10$ respectively) are the variables that show the smallest relationship with trait EI. According to Bosco et al.'s (2015) benchmark for interpreting effect sizes in applied psychology, trait EI has a large relationship with sleep, social support, diet, and physical activity and a medium relationship with reckless driving and substance use.

Based on Fisher's r to z transformation to compare effect sizes, all the differences between behavioural variables are significant (except for the difference between social support and sleep, and reckless driving and substance use). In fact, there are statistically significant differences between reckless driving and diet ($z = 2.84$, $p < .01$), reckless driving and physical activity ($z = 1.91$, $p = .05$), reckless driving and sleep ($z = 7.34$, $p < .01$), reckless driving and social support ($z = 7.33$, $p < .01$), social support and physical activity ($z = 17.89$, $p < .01$), social support and diet ($z = 12.68$, $p < .01$), social support and substance use ($z = 18.24$, $p < .01$), physical activity and substance use ($z = 5.04$, $p < .01$), physical activity and diet ($z = 2.58$, $p = .01$), diet and substance use ($z = 6.74$, $p < .01$), sleep and diet ($z = 8.34$, $p < .01$), sleep and physical activity ($z = 10.19$, $p < .01$), and sleep and substance use ($z = 12.48$, $p < .01$). However, there is no a significant difference between sleep quality and social support ($z = 1.74$, $p = .08$) and reckless driving and substance use ($z = 0.3$, $p = .76$).

Trait EI and Biological Variables

As Tables 1 and 2 show, there are far fewer studies examining biological variables than behavioural variables. The scarcity of research on the effect of trait EI on (most) biological variables should be highlighted, and this lack of research should be considered as the main finding of this section, especially as not less than 17 specific hypotheses could be made about the relation between EI and biological pathways (see

Supplemental Table 1, right column). In fact, only two biological variables were investigated in more than five studies: BMI (six studies) and HPA activity (six studies investigating trait EI and cortisol AUCg and seven studies investigating trait EI and cortisol AUCi[4]). And only four variables were investigated in more than one study but less than five: Heart Rate at baseline (two studies), blood glucose (two studies), Heart Rate in challenging situation (three studies), and HPA activity at baseline (four studies).

Blood glucose (BG) is the biological variable that seems most related with trait EI (r = -.75). However, only two studies have evaluated this relationship and the confidence interval includes zero. Apart from blood glucose, cortisol AUCg is the biological variable that is the most correlated with trait EI; their relationship can be considered large (r = −.27). On the contrary, the effect size between trait EI and cortisol AUCi is null (r = .04), as is the effect size between trait EI and BMI (r = −.07) and trait EI and HR at baseline (r = -.02). As for HR in challenging situation and HPA activity at baseline, they have a medium relationship with trait EI (r = -.15 and r = -.11 respectively). The fact that EI has a stronger relationship with cortisol AUCg than with cortisol AUCi suggests that trait EI has a stronger influence on the anticipation of stressors than on reactivity to them[5].

Based on Fisher's r to z transformation, there are significant differences between AUCg and BMI (z = 7.05, p < .01), between AUCg and AUCi (z = 3.49, p < .01), between HR at baseline and AUCg (z = 2.4, p = .01), between HPA activity at baseline and AUCg (z = 2.04, p < .05), between BG and BMI (z = 10.35, p < .01), BG and HR at

[4] AUC refers to cortisol Area Under the Curve. The Area under the Curve is the total amount of cortisol secreted during the time under consideration. The AUC**g** refers to Cortisol Area Under the Curve with respect to **g**round (zero); it thus reflects the total amount of cortisol during the time under consideration. The AUC**i** refers to Cortisol Area Under the Curve with respect to the Increase; it thus reflects the amplitude of the increase in cortisol secretion from baseline to peak (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

[5] In case of anticipatory stress before the experiment (influencing "baseline" cortisol secretion), the AUCg will reflect the total stress experience better than the AUCi (see Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

baseline ($z = 7.39$, $p < .01$), BG and HR in challenging situation ($z = 6.79$, $p < .01$), between BG and HPA at baseline ($z = 7.92$, $p < .01$), between BG and AUCg ($z = 7.02$, $p < .01$), and between BG and AUCi ($z = 9.43$, $p < .01$). However, there is no a statistically significant difference between BMI and AUCi ($z = 0.62$, $p = .53$), HR at baseline and BMI ($z = 0.52$, $p = .60$), HR at baseline and HR in challenging situation ($z = 1.03$, $p = .30$), HR at baseline and HPA at baseline ($z = 0.78$, $p = .43$), HR at baseline and AUCi ($z = 0.19$, $p = .85$), HR in challenging situation and BMI ($z = 0.95$, $p = .34$), HR in challenging situation and HPA at baseline ($z = 0.38$, $p = .70$), HR in challenging situation and AUCg ($z = 1.29$, $p = .19$), HR in challenging situation and AUCi ($z = 1.15$, $p = .25$), HPA activity at baseline and BMI ($z = 0.61$, $p = .54$), and HPA activity at baseline and AUCi ($z = 0.87$, $p = .38$).

Another noteworthy finding concerns confidence intervals; only one confidence interval (out of 16) do not include zero. Thus, there is just one statistically significant effect among the biological variables: trait EI–cortisol AUCg ($r = -.27$; k = 6). The lack of significance could be explained by the fact that the relationship between trait EI and most biological variables has been investigated in only one or two studies, generally based on small samples.

It is also worth mentioning that in terms of research design, there are only two studies that use experimental research (i.e., research in which EI was manipulated). The first (Kotsou et al., 2011) evaluated the impact of improving trait EI on diurnal cortisol. The second (Karahan & Yalcin, 2009) evaluated the impact of improving trait EI on blood glucose (glycated hemoglobin). The results show that, compared to a control group, improving trait EI reduces cortisol and blood glucose.

Risk of Bias Assessment for Individual Studies

A risk of bias assessment was performed to evaluate the quality of the studies included in the meta-analysis (see Supplemental Table 5). For that purpose, study design, sample characteristics, measurement of predictor, measurement of outcome, statistics, and possible confounders were assessed. Each study was given a score of low, moderate, high, or unclear risk of bias on each assessment criteria.

Study design. Study design refers to the methods and procedures that are used to measures and/or manipulate variables. There are different types of study designs (e.g., descriptive, correlational, experimental). Experimental designs allow drawing stronger conclusions in terms of causality. Study design is, among all sources of bias, the major source of bias in this meta-analysis because 98% of studies did not use a design allowing us to disentangle cause–effect relations. Causation direction can only be ascertained using experimental/intervention designs. Cross-sectional observational designs do not allow establishing causation direction. Because 98% of studies included in this meta-analysis were observational cross-sectional (especially for behavioural variables), results can only be interpreted in terms of association between EI and outcome and not in terms of causation. We shall come back to this issue in the Discussion.

Sample characteristics. A sample is a small part taken from a larger group. A representative sample is a sample that accurately represents the target population (in the present case: the whole population). Sample characteristics refer to the type of sample, age of participants, sex, socioeconomic status and ethnicity. There would be a high risk of bias if samples are not representative of the general population (the relation between trait EI and several outcomes might be different in specific populations compared to the general population); if males/females accounted for more than 66% or less than 33% of the sample (more/less than two thirds of the sample); if the mean age of the participants was less than 25 (which would be equivalent to a student sample) or more than 60 (which would be equivalent to a senior sample); if the sample of a study is predominantly composed of people of a certain SES; and if a study sample contains more than two thirds of people from the same ethnicity (the results might not be generalizable to the general population).

Regarding the type of sample, a high risk of bias is present in 60.7% of the studies included in the meta-analysis as they used very specific samples that were not representative of the general population (e.g. university students, adults with diabetes, etc.). Conversely, 24.3% of studies present low risk of bias as they used samples that represented the general population. Finally, the risk of bias of 14.9% of studies is unclear. The vast majority of these studies used university student samples (specific samples). However, the direction (overestimation or underestimation of the risk) cannot be ascertained. Regarding sex, 51% of studies present a predominance of males or females, showing a high risk of bias related to sex. Specifically, of the 51% of studies that present a predominance of one sex over the other, in 90% of the cases the predominant sex is female. Likewise, 46.1% of studies present a similar percentage of males and females, suggesting a low risk of bias. Finally, 2.9% of studies do not report the percentage of males/females and the risk of bias is therefore unclear. Thus, overall, the risk of bias related to sex in this meta-analysis is moderate. Results are probably more generalizable to women than men. Regarding age, among the studies included in the meta-analysis, 41.2% present a mean age of 25-60 suggesting a low risk of bias. Conversely, 55.8% of studies are conducted on specific samples suggesting a high risk of bias. Among the latter studies, 91% of these studies use young samples (participants aged under 25) and 9% older samples. Finally, 3% of studies do not provide information about participants' age, showing an unclear risk of bias. Thus, the risk of bias related to age in the current meta-analysis would be moderate; the results might not be generalizable to seniors. Regarding SES, only 7 studies included in this meta-analysis reported SES. Among these, 71.4% of them present low risk of bias as the sample was stratified on SES or because the majority (more than two thirds) of participants originated from middle-class populations (this class covers more than two thirds of the population). Likewise, the 14.3% of studies present moderate risk of bias as participants come from middle and high SES, and 14.3% of studies show a high risk of bias because participants come from high SES. Bearing in mind that 93% of studies do not report the SES of their participants, the risk of bias related to SES is unclear. Regarding ethnicity, only 28 studies report information about ethnicity (out of 106). 82.1% of them are based on a specific ethnicity. Among these, 69.5% of the studies which focused on a specific ethinicity rely on Caucasian samples and 30.5% of the studies on other ethnicities (Chinese, African-American, etc.). Thus, the results of the current meta-analysis might be more generalizable to Caucasian people.

Measurement of the predictor. According to the Scientific Advisory Committee, an evaluation instrument is considered as of good quality when the concepts subject to evaluation are fully represented by the items in the questionnaire; when the items of different subscales are correlated among them; when the internal reliability is higher than 0.70; when the scores of an instrument correlate with other measures; when, upon using the same instrument with the same people, the answers are similar; when the evaluation instrument is able to detect significant changes over time; when there is no floor or ceiling effect; and when it is possible to assign qualitative meaning to quantitative scores (Terwee et al. 2007). In sum, there would be a low risk of bias if EI was assessed using a validated trait EI instrument, and there would be a high risk of bias if EI was assessed using a non-validated instrument. Although the psychometric properties of the EI measure have not been specified in three papers, the rest of the studies included in the meta-analysis (97%) used validated EI measures. Thus, the present meta-analysis does not present a risk of bias regarding the measurement of trait EI.

Measurement of the outcome. Outcomes can be measured using different ways such as self-reports or objective measures. The use of self-reports entails several limitations: people may not remind their experience accurately, they may give an overly positive image of themselves; they may not be able to evaluate themselves properly (lack of introspective ability), and they may interpret questions in different ways. Thus, there would be a low risk of bias if the behavioural/biological variables were assessed using an objective measure (using proper apparatus) or using a self-report questionnaire unlikely to be biased by the factors mentioned above (e.g. frequency of exercise practised during the last week). By contrast, there would be a moderate risk of bias if the outcome was assessed using a self-report questionnaire subject to social desirability or memory bias (e.g. average number of alcohol units per month). Among the studies included in the meta-analysis, 36.4% assessed the outcomes using objective measures; by contrast, 63.6% used self-report questionnaires. This being said, it is almost impossible to know if the reporting biases affected the *correlation* between EI and the outcome. Indeed, if every participant slightly under-reported socially undesirable outcomes and slightly over-reported socially desirable outcomes, this creates a systematic bias that does not necessarily influence the size of the correlation with EI. If socially desirable responding was so strong that it severely altered the reporting of socially undesirable behaviours (e.g. heroin use), then the mean and variance would be so low that the correlation with EI would be underestimated rather than overestimated.

The statistics used in the studies included in the meta-analysis refer to the statistical analyses that have been performed to analyse the data. There would be a low risk of bias if the authors computed parametric correlational analyses in normally distributed outcomes and non-parametric correlational analyses in non-normally distributed outcomes. Conversely, there would be a high risk of bias if the authors computed parametric correlational analysis in non-normally distributed outcomes. Using parametric correlations on non-normally distributed variables would lead to overestimate the effect, and, therefore, the effect size would bear the risk of being slightly inflated. Of the studies included in the meta-analysis, 43.9% do not present a risk of bias related to the statistic. On the contrary, 5.6% of the studies present a high risk of bias. Finally, half of the studies (50.5%) included in the meta-analysis do not specify which type of correlations they performed. Thus, risk of bias is unclear. In general, the risk of bias concerning the statistics would be low, although more information is needed to confirm this.

Confounders. Confounding refers to possible (partial) explanations of relationships (effect sizes) by other variables. Thus, confounding variables are third variables that have not or could not be controlled by the researcher and that could have explained the relationship between the trait EI and the outcome. Among the possible confounders that may have influenced the results of the present meta-analysis, two were reviewed for each study: Social desirability and personality.

Social desirability is a response bias that refers to the tendency to respond in a way that gives an overly positive image of oneself. Usually, people over-report "good behavior" and under-report "bad" or undesirable behavior. Concerning this confounder, there would be a low risk of bias if social desirability would not contaminate the relation between trait EI and the outcome (e.g., the relation between trait EI and heart rate amidst stress cannot be inflated by social desirability) or if social desirability's influence was controlled for in the design or analyses (e.g. the relation between trait EI and substance abuse could not be contaminated by social desirability if the authors controlled for social desirability in their analyses). Conversely, there would be a high risk of bias if social desirability potentially contaminated the relation between trait EI and the outcome and if its influence was not controlled in the design or analyses. Among the studies included in the meta-analysis, 40.2% present low risk of bias as they controlled for social desirability and/or they used objective measures or self-reports that are unlikely to be biased by memory or social desirability. To the contrary, 7.8% of the studies show a high risk of bias because social desirability was not controlled. Thus, social desirability could potentially contaminate the relation between trait EI and the outcome. The rest 52% of studies present an unclear risk of bias as information about this confounder was not available in the paper. However, as these studies have used self-reports to measure the outcome it could be thought that social desirability could indeed influence the relationship between trait EI and the outcome. Thus, the risk of bias related to social desirability in the current meta-analysis cannot be totally excluded for behavioural outcomes.

Personality refers to individual differences in the way people think, feel and behave. Since EI and personality are highly correlated (e.g., Van der Linden, Tsaousis, & Petrides, 2012), personality could explain the relationship between trait EI and the behavioural/biological variables. Thus, there would be a low risk of bias if personality was controlled when measuring the relationship between trait EI and the outcome, and there would be a high risk of bias if personality was not controlled for. Among the studies included in the meta-analysis, 3.8% present low risk of bias as personality was controlled. On the contrary, 96.2% of the studies show a high risk of bias because personality was not controlled for, and this could potentially contaminate the relation between trait EI and the outcomes. Thus, the risk of bias related to personality in the current meta-analysis is high.

In summary, and in light of the foregoing analysis, the results of this meta-analysis must be interpreted with caution. Results are probably more generalizable to young Caucasian women from middle to upper-class.

Publication Bias Assessment

As can be seen in Tables 1 and 2 (Egger t statistic), the effects presented in the meta-analysis come generally from homogeneous samples of studies, which are generally (in 90.9% of the cases) not contaminated by publication bias, making the results relatively reliable. However, one finding needs to be interpreted with caution: Egger's regression suggests a significant publication bias between trait EI and AUCi. The direction of asymmetry suggests that the effect was overestimated. As this effect is nearly null (.04), it suggests that the "true" effect might be slightly negative, which would be in accordance with the theoretical hypothesis (see Supplemental Table 1, right Column).

Discussion

The current meta-analysis included findings from over 45,262 individuals across 106 papers. In the next sections of the paper, we will first take stock of the findings and summarize what is currently known about the behavioural and biological variables that could link EI to health. We will then offer guidelines for future research on EI and physical health, highlighting gaps in the literature (under-researched behavioural and biological variables and under-researched levels of EI) and the methodological improvements needed to draw stronger conclusions. Finally, we will discuss the limitations of the meta-analysis and the bidirectional nature of the relation between EI and physical health.

Towards a Process Model of EI and Health

The results confirmed most of the hypotheses presented in the Introduction and Supplementary Table 1 (right column). As can be seen in Figure 3, all the hypothesised directions were confirmed for behavioural variables; trait EI is positively related to social support, sleep, physical activity, and diet and negatively related to substance use, reckless driving, and risky sexual behaviour. Regarding biological variables, results confirmed hypotheses regarding the expected negative relations between trait EI and HPA reactivity (cortisol AUCg) in the general population. Although there are not enough studies ($k < 5$), findings seemed to confirm the expected negative relations between trait EI and atherosclerosis and between trait EI blood glucose levels in diabetics. They also confirmed the direction of the relation between EI and both heart rate and blood pressure in response to challenge (negative relations), although the confidence interval included zero in both cases. They confirmed the expected null relation between trait EI and PNS activity at baseline, PNS reactivity, and baseline heart rate. However, they failed to confirm the expected negative relation between trait EI and BMI (the effect is negative, but its size is trivial), and they failed to confirm the expected positive relation between trait EI and antioxidants (the effect is positive, but its size is trivial).

Figure 3. Current state of knowledge about the effect of EI on physical health

As shown in Figure 3, the results of this meta-analysis suggest that trait EI most probably affects physical health through several behavioural variables, among which social support and sleep seem to play a major role. The current results suggesting that

EI influences health via improved social support is consistent with the results of Mikolajczak et al. (2015), who tested a full mediation model (EI → social support → health) with objective indicators of health. Furthermore, the causal effect of EI on social support is supported by experimental studies showing that when EI is experimentally improved by training, social relationships also improve, regardless of whether they are assessed by self- or informant-report (Kotsou et al., 2011; Nelis et al., 2011). The current results suggest that future studies would benefit from testing the same mediation model and running the same experimental study regarding sleep.

Beyond social support and sleep, the results of this meta-analysis suggest that diet, physical activity, and substance use (in that order) also play a role in explaining the relation between EI and health. Reckless driving and risky sexual behaviours may also be related, but there are not enough studies to form a conclusion. In all these cases, future studies that experimentally manipulate EI and examine the effect of EI changes on these variables are needed to ascertain causality.

The current meta-analysis also shows that there is comparatively much less research on the relation between EI and biological variables, and the few results accumulated so far do not appear very promising. Comparing the small effect[6] observed on most of the biological variables to the medium-to-large effect observed on the majority of the behavioural variables, one could be tempted to conclude that the relation between EI and behavioural variables is only the product of shared method variance, as both factors were often measured by questionnaires. However, this conclusion would be erroneous because the impact of EI on behavioural variables holds even when the independent and dependent variables are measured using different methods (see e.g. Mikolajczak, Roy et al., 2007 or Salovey et al., 2002).

[6] with the exception of the large effects observed on HPA reactivity and blood glucose.

Because most behavioural variables exert their effect on health indirectly (by prompting physiological changes) and not directly (by causing direct injury or accidents), EI *must* have an effect on biological parameters in order to influence health. Pursuing research on the relation between EI and biological parameters is therefore necessary. But the right parameters need to be chosen. The current meta-analysis offers interesting insights in this regard. By showing that social support is the most robust behavioural mediator between EI and health, this study suggests that our understanding of the biological mediators by which EI influences physical health may be fostered by understanding how social support influences physical health.

There has been much research on the physiological processes explaining the impact of social support on health, and this literature has been synthetized by Uchino in 2006. What Uchino's (2006) paper clearly brings to light is that social support rarely exerts a main effect on biological parameters. Rather, its effect is moderated by several factors, such that it is more evident in some specific circumstances or specific people. For instance, the effect of social support on immune function is most evident when immunity is solicited (e.g., in cancer or HIV patients) or in people experimentally wounded. In the same vein, the effect of social support on cardiovascular function is also subject to moderation. First, social support is associated with lower resting blood pressure primarily in *older adults*, which can be explained by the fact that the "buffering effect" of social support does not generally occur "amidst stress" (or, in the laboratory) but after the stressor (or, outside the laboratory), and it is the cumulative influence of social support across the years that finally reduces the harmful increases in cardiovascular reactivity associated with stressful life events. Second, when daily life is stressful, supports predicts *evening reduction* in ambulatory systolic blood pressure rather than in blood pressure itself (Steptoe, Lundwall, & Cropley, 2000). Finally, the effect of social support on cardiovascular parameters/conditions that concern only a limited number of people, such as atherosclerosis, is more evident when using imaging techniques that are able to detect it at early stages, such asby use of B-mode ultrasonic imaging to detect *underlying* atherosclerosis (e.g., Knox et al., 2000). As can be expected, the effect of social support on cardiovascular parameters is also more evident in *people at high risk* of developing heart disease.

The foregoing suggests that future research on the influence of EI on biological variables would benefit from taking inspiration in research conducted on the relation between significant behavioural variables and health (and social support in particular). Based on the findings concerning social support, and on the results of previous studies showing that the impact of EI on health is stronger in people who are more likely to be in poor health (e.g., older people, people with low education, people who do not eat healthily or who do not exercice regularly), relevant choices must be made in future studies regarding the type of samples, the parameter(s) that are tested, and the techniques of investigation.

In the studies that evaluate behavioural variables, most studies are cross-sectional. Thus, formal establishment of cause–effect relations cannot be made. In the present meta-analysis only two studies use an experimental design in which trait EI was manipulated. The results show that, compared to a control group, improving trait EI reduces cortisol and blood glucose. These studies are of high importance as they suggest cause-effect relationships between trait EI and these variables.

Implications and Future Directions

The current meta-analysis has many implications for future research on EI and health. As indicated in Figure 3, some variables have not yet been investigated and ~~are~~ probably should probably not be prioritized in future investigations; others have not yet been investigated either but seem to deserve attention. We will discuss these in the next two sections. We will then turn to methodological improvements needed to derive stronger conclusions in the field.

Underinvestigated biological variables. In EI research, biological variables have generally received much less attention than behavioural variables. The scarce research dealing with biological variables has mainly concentrated on the HPA axis and the SNS, with a particular focus on cortisol and cardiovascular activity. This is not surprising as these are the most researched variables in health psychology research. However, both the theoretical predictions (see Supplemental Table 1, right column) and the results of the few studies available so far suggest that researchers should not prioritize the study of the relation between trait EI and the SNS and PNS branches of the autonomous nervous system. Based on the current findings, it appears more useful to deepen the investigation of the link between trait EI and behavioural pathways (see next section) and, for those who cannot resist the appeal of biology, the link between trait EI and other biological candidates, less directly or not only influenced by the SNS. On looking at the theoretical predictions made in Supplemental Table 1, BMI, cholesterol, and blood pressure do *not* appear to be good candidates.

Intestinal permeability, intestinal microbiota, oxidative stress and DNA damage are much more likely candidates (see Supplemental Table 1 for explanations and hypotheses). All these mechanisms have long been shown to have an impact on health, but the influence of psychological factors on these variables has only been recently examined. This research has shown that intestinal permeability, intestinal microbiote and oxidative stress are all three influenced by psychological stress (for rewiews of the impact of stress on interestinal permeability, see Söderholm & Perdue, 2001; on interestinal microbiote, see Bailey, 2012; and on oxidative stress and DNA damage: see

Gidron, Russ, Tissarchondou, & Warner, 2006). Given that higher EI is a strong predictor of (lower) stress in both prospective and experimental studies (e.g., Gupta, Singh, & Kumar, 2017; Kotsou et al., 2011; Mikolajczak et al. 2007), it would be reasonable to expect that EI would influence intestinal permeability and intestinal microbiote as well as oxydative stress and DNA damage.

Underinvestigated behavioural variables.

The results of this meta-analysis suggest that, research on behavioural pathways should be given strong preference and priority over research on biological pathways. Behaviours influence health because they ultimately change our physiology. So, obviously, there are biological pathways that mediate the link between EI and health. However, research on EI and behavioural pathways should be conducted first to know precisely which behavioural pathways are the strongest mediators. EI researchers could then turn to the relevant literatures to infer how EI influences health through these pathways. There is indeed literature on how each behavioural pathway influences health (e.g. there is a huge literature on how social support influences health, both behaviourally and biologically), and this literature can then be used to derive stronger hypotheses about the most likely biological candidates.

Our meta-analysis also shows that while some behavioural variables have been thoroughly researched (e.g., alcohol and tobacco use or social support), others have received much less attention. While there are over 46 studies evaluating the link between EI and social support, 20 evaluating physical activity and 20 evaluating substance use, there are just nine evaluating diet, five evaluating sleep quality, two evaluating reckless driving, and one measuring the relation between EI and risky sexual behaviours. Other behavioural pathways such as treatment compliance or medication use and abuse still await investigation. The latter appear of particular interest. Indeed, pain includes both a sensory and an affective component (e.g. Tölle, Kaufmann, Siessmeier, Lautenbacher, Berthele, Munz et al. 1999), and research shows that medication is often used to alleviate the affective component of pain, even when the drug has no effect on the sensory component (e.g. Kupers, Konings, Adriaensen, & Gybels, 1991). EI reduces negative affects in unpleasant situations (e.g., Mikolajczak, Petrides et al., 2009) and has thereby been shown to increase pain tolerance and pain ratings in painful situations (Ruiz-Aranda, Salguero, & Fernández-Berrocal, 2011). Therefore, it is reasonable to expect that EI would decrease the risk of medication abuse.

Under-investigated levels, dimensions, and facets of EI

This meta-analysis revealed a dearth of research on knowledge/ability levels of EI (‘performance-based’ measures of EI) and health-related variables. As explained in the introduction, we originally aimed to include all levels of EI on our meta-analysis. However, not enough studies used performance-based measures of EI to derive reliable effect sizes. We therefore focused this paper on the trait level of EI, but research on the other EI levels is obviously needed. In the same vein, we originally intended to evaluate and compare the associations of the various dimensions of EI (e.g. emotion identification, understanding, expression, regulation, and use) with the various health-related variables. Indeed, there is evidence that these competencies each have an impact on health (see Supplemental Table 2), but it is possible and even likely that these dimensions do not influence health through the same pathways. Unfortunately, there were not enough studies using either self-reports or performance-based measures of EI to derive reliable effect sizes of the independent effect of each dimension on each health variable. It is our hope that future studies will pursue this research.

Finally, in a more distant future, studies will benefit from disentangling the contribution of the intra- and inter-personal facets of EI for a given outcome. Investigating this question has been facilitated by the development of the PEC (Brasseur et al., 2013), an instrument that distinctly measures each of the five core emotional competences separately for one's own and others' emotions. This instrument allowed researchers to show that several outcomes are better predicted by the intrapersonal facet of EI while others are better predicted by its interpersonal facet (e.g. Brasseur et al., 2013; Nozaki & Koyazu, 2013; Nozaki, 2015). This is particularly true in the case of physical health, which seems to be mainly predicted by intrapersonal dimensions in Western countries (see Brasseur et al., 2013 for subjective health indicators; see Mikolajczak et al., 2015 for objective health indicators) and by both intra- and inter-personal dimensions in Eastern countries (Nozaki & Koyasu, 2016). This also suggests that the pathways through which EI influences health may not be exactly similar across cultures, and this issue also deserves investigation.

Methodological Improvements

This meta-analysis also highlights several methodological issues. The first one concerns the design of studies. In the studies investigating behavioural variables, the vast majority of studies are cross-sectional, which prevents formal establishment of cause–effect relations. There is a lack of experimental/interventional studies investigating the extent to which a change in EI leads to a change in behaviours and/or biological parameters. A few studies have shown that changes in EI following EI training leads to changes in the health behaviours and/or biological parameters under investigation (i.e. glycaemia in Karahan & Yalçin, 2009; healthy diet in Kidwell et al., 2015; diurnal cortisol in Kotsou et al., 2011). These studies are important, not only because they are the only ones that can ascertain a causal link between EI and the behavioural/biological parameter under consideration, but also because they enable the quantification of the extent of the changes/improvements that can be expected following an intervention targeting EI or EC.

The second methodological improvement concerns pathway measures. Too many studies investigating behavioural variables rely on self-reports of the target health behaviour (65% of the studies included in the present meta-analysis; see Supplemental Table 5), which are subject to both social desirability and memory bias. Complementing these self-reports by objective measures of the target health behaviour, such as an actimeter or pedometer for physical activity, would increase the validity of the findings. If no objective measure of the criteria can be obtained, the use of informant-reports may reduce desirability biases (e.g., asking the partner about the subject's substance use). If neither objective nor informant measures can be obtained, the use of daily diaries or experience sampling methodologies would help solve the problem of memory bias associated with retrospective self-reports. They will not totally overcome the problem of social desirability bias, but the latter threatens the validity of findings less than is generally thought (see Chan, 2009 for discussion).

The third methodological improvement concerns sampling. Representative samples are essential to enable the generalization of the results. Fifty percent of the studies included in the meta-analysis are based on university students (in 90% of these studies the majority of subjects are females). More than eighty percent of studies are conducted on Caucasian samples and the vast majority of studies are conducted within healthy and middle to upper-class populations. In order to allow results to be generalizable beyond healthy young Caucasian women from middle to upper-class, future studies would benefit from drawing on more diverse samples, including not only older people but also people from lower socioeconomic backgrounds and people who are not healthy (university students are necessarily healthy enough to be able to pursue a demanding higher education curriculum).

The fourth improvement concerns the confounding effect of personality and, relatedly, the incremental validity of EI. When very small to small relations are observed between trait EI measures and health, an alternative explanation for the findings is that these relatively small effects must be attributed to broadband personality traits such as neuroticism, extraversion, conscientiousness, agreeableness, and openness rather than to trait EI in particular. To both rule out this alternative explanation (or not) and accumulate knowledge about the percentage of incremental variance that EI explains beyond the Big Five personality traits for each criterion (it is likely that the percentage will vary across criteria), it is important that future studies systematically include a measure of the Big Five.

Investigation of bidirectional relations between EI and health

By trying to understand how EI influences health, the current paper expands on only one side of the EI-health relation. The "EI → health" direction of causality was chosen because it is the one that has been most documented so far, with experimental studies showing that changes in EI leads to changes in health, as well as in health behaviours and/or biological states. However, the fact that EI influences health does not preclude the opposite to be true as well, i.e. that health may also influence EI. It is indeed possible that temporary or long-term alterations in health parameters may induce temporary or long-term alterations in EI. For instance, sleep has been found to have a bidirectional relation with emotion regulation: Poor emotion regulation impairs the quality of sleep, but poor sleep impairs the quality of emotion regulation in return (Palmer & Alfano, 2017). Other health behaviours, such as alcohol abuse or a diet high in fat could also reduce EI via the gut-brain axis (e.g., Leclercq et al., 2012): alcohol and fat diet both increase gut permeability, which in turn induces low-grade inflammation, which has been shown to increase negative mood. Inflammatory diseases too are commonly associated with depression and negative affect, and the variables involved in this inflammation-induced mood deterioration are increasingly understood (Harrison et al. 2015). The foregoing makes it highly likely that the " EI → health" relation is only one side of a complex bidirectional and circular relation, and research is much needed to shed light on this matter. It is our hope that this paper will stimulate such research.

Conclusions

This paper offers a working model that helps to clarify the current state of the literature regarding the behavioural and biological variables that may account for the impact of EI on health. It also provides a roadmap for future research by identifying what should be studied (pinpointing dead-end roads and promising paths) and how (methodological improvements needed to draw stronger conclusions). The results of our meta-analysis suggest that EI affects physical health through several behavioural variables, among which social support and sleep play a large role and diet, physical activity, and substance use play a medium role. The role of reckless driving and sexual behaviours needs to be clarified. Among the biological variables, our results suggest that HPA axis (and possibly blood glucose but $k = 2$ and atherosclerosis but $k = 1$) is a likely mediator of the impact of EI on health. There is less convincing evidence for other pathways. At this stage, it seems more promising to focus on behavioural pathways than on biological pathways. If biological pathways must be investigated, our theoretical review suggests that, among the pathways that have not yet been investigated, inflammation, intestinal permeability, and microbiota appear particularly promising. Methodologically speaking, future research would benefit from conducting studies in much more diverse samples (including older people, people from lower socioeconomic backgrounds, and unhealthy people — the results of this meta-analysis are probably more generalizable to young Caucasian women from middle to upper-class), from measuring behavioural variables using more objective indicators, and from systematically examining the extent to which *changes* in EI (e.g. following EI training) lead to changes in behaviours and/or biological parameters.

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Note: References cited in the Supplemental Tables Figure in Supplemental Reference List 1; References of all the studies included in the meta-analysis figure in Supplemental Reference List 2.

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Table 1

Linking Trait Emotional Intelligence to Behavioural Variables

	k	N	*r*	CI	Homogeneity	Publication bias
Diet	9	11.365	.20	.13, .26	$Q(8) = 10.24$, $p = .25$	t(7)= 1.02, $p = .34$
Physical activity	20	17.398	.17	.13, .20	$Q(19) = 33.15$, $p = .02$	t(18) = 0.02, $p = .97$
Reckless driving	2	1.034	-.11	-.17, -.05	$Q(1) = 0.01$, $p = .75$	—
Risky sexual behaviour	1	274	-.72	-.78, -.66	—	—
Sleep quality	5	2.877	.36	.10, .58	$Q(4) = 3.77$, $p = .50$	t(3)= 1.42, $p = .25$
Social support	46	29.359	.33	.29, .37	$Q(45) = 70.79$, $p = .01$	t(44) = 1.44, $p = .15$
Substance use	20	7.010	-.10	-.15, -.05	$Q(19) = 21.31$, $p = .25$	t(18) = 1.56, $p = .13$

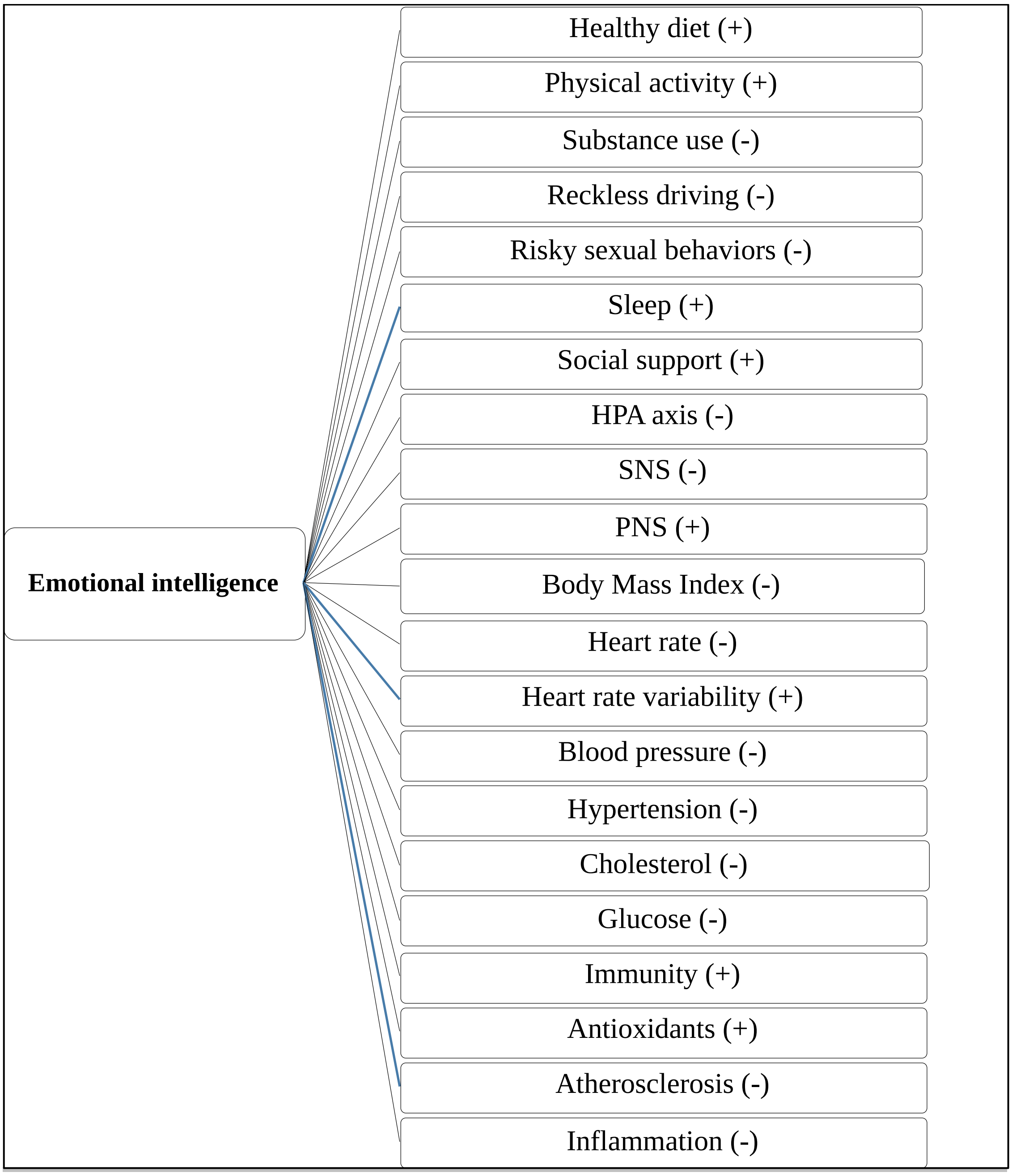
Table 2

Linking Trait Emotional Intelligence to Biological Variables

	k	N	*r*	CI	Homogeneity	Publication bias
Antioxydants	1	50	.08	-.19, .35	—	—
Body mass index	6	10.416	-.07	-.18, .04	$Q(5) = 8.87$, $p = .15$	$t(4) = 0.25$, $p = .81$
Atherosclerosis	1	150	-.07	-.23, .09	—	—
Diastolic BP in challenging situation	1	48	-.12	-.39, .17	—	—
Blood glucose	2	136	-.75	-.98, .33	$Q(1) = 1.00$, $p = .30$	—
Heart rate at baseline	2	113	-.02	-.27, .23	$Q(1) = 1.00$, $p = .30$	—
Heart rate in challenging situation	3	143	-.15	-.45, .19	$Q(2) = 2.11$, $p = .35$	$t(1) = 0.30$, $p = .81$
HRV at baseline	1	96	.18	-.67, .49	—	—
HRV in challenging situation	1	110	-.15	-.33, .03	—	—
HPA activity at baseline	4	233	-.11	-.24, .01	$Q(3) = 0.92$, $p = .80$	$t(2) = 2.68$, $p = .11$
HPA in challenging situation (AUCg)	6	433	-.27	-.40, -.12	$Q(5) = 5.40$, $p = .35$	$t(4) = 0.72$, $p = .51$
HPA in challenging situation (AUCi)	7	443	.04	-.19, .10	$Q(6) = 6.38$, $p = .35$	$t(5) = 2.82$, $p = .04$
PNS activity at baseline	1	51	.04	-.24, .31	—	—
PNS in challenging situation	1	51	.02	-.25, .29	—	—

	k	N	*r*	CI	Homogeneity	Publication bias
SNS reactivity in challenging situation[a]	1	84	-.03	-.24, .18	—	—
Systolic BP in challenging situation	1	48	-.08	-.35, .21	—	—

Note. AUC refers to cortisol Area Under the Curve. The Area under the Curve is the total amount of cortisol secreted during the time under consideration. The AUC**g** refers to Cortisol Area Under the Curve with respect to **g**round (zero), it thus reflects the total amount of cortisol during the time under consideration. The AUC**i** refers to Cortisol Area Under the Curve with respect to the Increase, it thus reflects the amplitude of the increase in cortisol secretion from baseline to peak; BP = Blood Pressure; HPA = Hypothalamic-pituitary-axis; HRV = Heart Rate Reactivity; PNA = Parasympathetic Nervous System; SNS = Sympathetic Nervous System; [a] SNS activity at baseline was not evaluated.



HPA: Hypothalamic Pituitary Adrenal; SNS: Sympathetic Nervous System; PNS: Parasympathetic Nervous System

Figure 1. Hypothetical model of the variables explaining the relationship between EI and physical health, based on existing literature

Identification

12.793 records identified through database

18 additional records identified through

9.785 records after duplicates removed

Screening

9.785 records screened

9263 records excluded

Eligibility

73 Not English

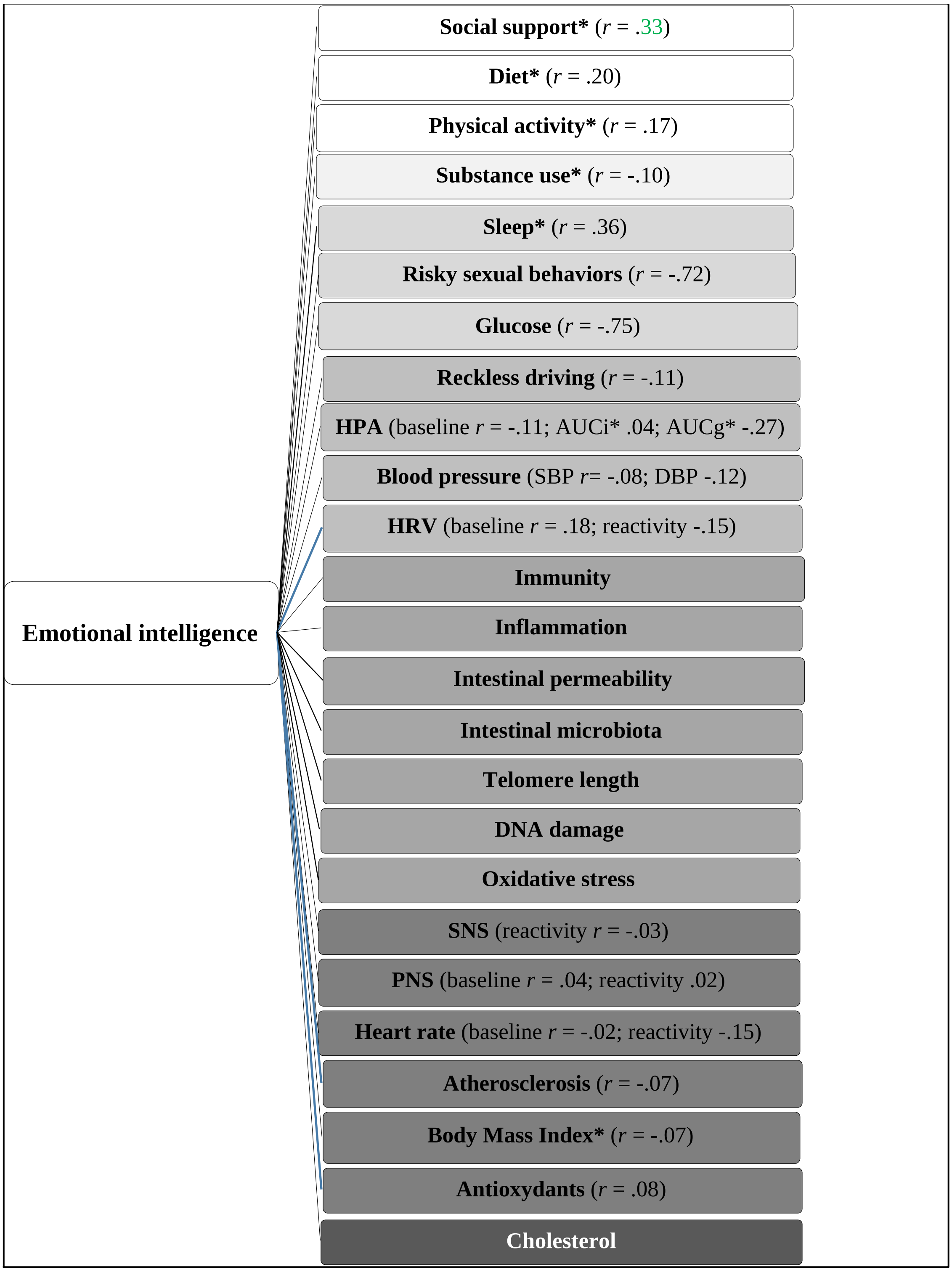
522 full-text articles assessed

416 full-text articles excluded

Included

106 studies included in meta-analysis

Figure 1. Flow diagram of the papers identified and included in the meta-analysis



DNA: deoxyribonucleic acid; HPA: Hypothalamic Pituitary Adrenal; SNS: Sympathetic Nervous System; PNS: Parasympathetic Nervous System

Figure 3. Current state of knowledge about the effect of EI on physical health

Uninvestigated and theoretically not promising (cholesterol)
Slightly investigated and not very promising (SNS, PNS, HR, BMI, atherosclerosis, anti-oxydants)
Uninvesigated and possibly promising (immunity, inflammation, intestinal microbiote, intestinal permeability, telomere length, oxidative stress and DNA damage)