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A Biological and Psychological Profile of Eudaimonia as High Psychological Well-Being

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A Biological And Psychological Profile of Eudaimonia as High Psychological Well-Being

Submitted by Sofia Andersson Szabo to the University of Skövde as a final year project towards the degree of B.Sc. in the School of Bioscience. The project has been supervised by Kristoffer Ekman.

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I hereby certify that all material in this final year project which is not my own work has been identified and that no work is included for which a degree has already been conferred on me.

Signature: _____

Abstract

Aristotle (4th century B.C.E/1925) described eudaimonia as "the good life", and is today commonly understood as eudaimonic well-being (EWB) within research. Despite the long history, the definitions and operationalizations of EWB are diverse and no coherent description or explanation for the biology of EWB exist. Hence, the present thesis reviews current neuroscientific- and additional biological research on EWB. This review reveals EWB to be most frequently operationalized as psychological well-being (PWB) (Ryff, 2014), and is here used as basis for an attempt to explain the biological and psychological profiles of EWB as high PWB. High PWB was characterized by brain activity linked to the reward circuitry, dorsolateral and left prefrontal cortex (PFC) and grey matter (GM) volume in areas of the brainstem and insular cortex. High PWB was also positively related to lower levels of several harmful biomarkers. The proposed psychological profile of high PWB included the psychological functions goal directed behaviour and emotional control. It is hoped that the proposed profiles will serve as inspiration for further exploration of the biology and psychology of human well-being (WB).

Keywords: well-being, eudaimonia, psychological well-being, biology, neuroscience, psychology

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Introduction

The nature and composition of well-being (WB) has been a theme of great philosophical interest for centuries (Linley, Maltby, Wood, Osborne & Hurling, 2009). This interest has generated various interpretations and several conceptualizations of the concept have been formulated (Urry, et al., 2004). Despite this diversity, the majority of scientists in the field of WB research use the Greek philosopher Aristotle's (4th century B.C.E/1925) division of *hedonia* and *eudaimonia* when addressing WB. Purposely, the concepts are further conceptualized as *hedonic well-being* (HWB) and *eudaimonic well-being* (EWB) in research (Deci & Ryan, 2008; Kashdan, Biswas-Diener & King, 2008; Ryan & Deci, 2001). In this thesis the biological and psychological concept of EWB will be explored from the Aristotelian view, which have been further conceptualized by Ryff (1989a) as *psychological well-being* (PWB). The scope will be limited to studies using Ryff's (1989a) *Six Factor Scales of Psychological Well-Being* (SPWB).

The aim of this paper is to present neuroscientific- and additional biological research on PWB to subsequently suggest a biological and psychological profile of eudaimonia as high PWB. The studies on the biological underpinnings of PWB are to date limited and need further investigation to be able to explain the underlying biology and psychology of a fully functioning person (i.e. high PWB). Hence, it is area of growing interest, especially with neuroscientific and biomarker measures (Ryff, 2014). The focus will be on research within the field of neuroscience, where linkages between PWB and asymmetrical prefrontal activation, prefrontal cortex (PFC) functioning, grey matter (GM) volume and reward circuitry and stress will be explored. Additional biological research related to PWB has also been conducted and includes studies on; neuroendocrine measures of cortisol and catecholamines; immunological measures of interleukin-6 (IL-6); cardiovascular measures of glycosylated hemoglobin (HbA1c) and cholesterol; and supplementary research on physical

malfunction and disease, including physical symptoms, Alzheimer's disease (AD) and mortality.

The thesis will begin with a presentation of the concept WB and the current state of definition problems, to later narrowing the scope to the eudaimonic approach. After this, a more detailed description of the development of Ryff's (1989a) view of eudaimonia as PWB, and the shaping of SPWB will be provided. Then the results from neuroscientific- and additional biological research on PWB will be addressed. Following this, the discussion will start with a presentation of the general neuroscientific findings. These neuroscientific findings will then be combined with the additional biological research with the aim of creating a proposal of a biological and psychological profile of a person with high PWB. The discussion will after the proposals include limitations for the current thesis, and suggest future directions for the field of WB research. The discussion will end with a summary of the central findings.

Well-Being and Definitions

The composition of well-being (WB) has interested philosophers for centuries (Linley et al., 2009). The generation of interpretations and conceptualizations has therefore been manifold (Urry et al., 2004). Among the most known views we can find perspectives such as desire fulfilment theories (e.g Heathwood, 2006), addressing the subjective satisfaction of desire; subjective state theories (e.g. Mill, 1861/1979) in which the focus is on pleasure, enjoyment and absence of negative feelings; objective list theories (e.g. Gert, 1998) where the centrality is on listing items individuals consider contribute to their happiness (Crisp, 2008); life-satisfaction theories (e.g. Sumner, 1996), concerning the individuals own interpretation of if one is satisfied with life as a whole (Feldman, 2008) and nature-fulfilment theories (e.g. Aristotele, 4th century B.C.E/1925; Kraut, 2007) where the fundamental belief is that WB emerges when we live in accord with our true nature (Haybron, 2008), which will

be the theory considered later in this thesis.

The diversity is by some considered to exist due to the multifaceted philosophical descriptions of WB being too complex to quantify, resulting in scientists taking different perspectives and creating own theories (Biswas-Diener, Kashdan & King, 2009). This kind of variety of theories can be considered as the foundation from where the current problem of definitions origin, as there still is no unified or systematic overview of WB (Huta och Waterman, 2013; Ryan & Deci, 2001). Further aggravating circumstances regard the term happiness, which by some are used interchangeably with WB (Delle Fave, Brdar, Freire, Vella-Broderick & Wissing, 2011). This duality has caused confusion in the operationalization processes leading to the different approaches and hence a lack of comparable results (Huta & Waterman, 2013). Further concern is raised regarding currently used measurements of WB, mostly self-reported scales, which some scientists think limit participant's own perceptions of WB (Delle Fave, Brdar et al., 2011). In addition, Lu and Gilmour (2006) have found cultural differences in defining and evaluating WB. The main issue Lu and Gilmour (2006) found was that Euro-Americans tend to take an individualistic perspective when evaluating their WB, meaning that one's WB largely depends on degree of personal agency, free will and individual reason. In comparison, the majority of East-Asians evaluate their WB as more depending on a socially oriented- and relational perspective of being, with emphasis on evaluating collective welfare above individual interests (Markus & Kitayama, 1998). Consequently, these cultural differences further add to the difficulty of assessing WB cross-culturally (Lu & Gilmour, 2006). Moreover, Lu and Gilmour's (2006) findings add to previous scepticism regarding concerns for the currently used instruments assessing WB being solely built on Western individualism (Christopher, 1999). To be noted, the current thesis will primarily review studies in line with the Western perspective.

With all concerns taken together, research aimed at understanding the theoretical

underpinnings of WB has been complex (Ryff, 1989a). Nevertheless, is should be put fourth that the majority of scientist addressing the topic agree that WB is comprised of optimal psychological functioning and experience (Ryan & Deci, 2001).

In one recent article, Huta and Waterman (2013) suggested a unified terminology and classification system for WB research. The suggestion comprised of summaries, operational and conceptual definitions employed by established social scientists in the field, thus building on currently utilized elements within WB research. In this proposal they also recommend that scientists in each study should clarify certain aspects in their view of WB; the degree of centrality, category of analysis and level of measurement. Huta and Waterman (2013) claim this classification system could be used to solve currently existing problems by having better conditions for discussing the concept in an organized way, hopefully leading to an improved overall study of WB in the future.

With the current diversity of WB in mind, the scope of this thesis will be limited to a common understanding of WB, namely the conceptual division of hedonia and eudemonia (Deci & Ryan, 2008; Kashdan et al., 2008; Ryan & Deci, 2001). The scope will later be narrowed to focusing on one aspect of WB in order to mediate a coherent and comparable examination of WB from a biological perspective in subsequent sections.

Two Traditions of Well-Being Research

Despite the diversity and complexity surrounding the WB concept, the majority of scientists employ a common way of understanding WB. This understanding constitutes of two approaches; hedonia and eudaimonia, which have established and shaped two traditions of investigating WB in modern research (Deci & Ryan, 2008; Ryan & Deci, 2001). Purposely, the concepts have been further conceptualized as *hedonic well-being* (HWB) and *eudaimonic well-being* (EWB) in studies (Deci & Ryan, 2008; Kashdan et al., 2008; Ryan & Deci, 2001). Even if the duality versus unity of these two constructs has been argued (see

Henderson & Knight, 2012), the two traditions have particularly taken hold in a branch of psychology called positive psychology (PP), in which research on WB is particularly widespread (Deci & Ryan, 2008; Ryan & Deci, 2001). PP is usually described as the scientific study of optimal human functioning and experience (Linley et al., 2009; Ryan & Deci, 2001) with a focus on what makes life worth living. PP includes research on subjective experiences, positive individual traits and institutions contributing to a more altruistic and caring society, all factors involved in obtaining an increased WB (Seligman & Csikszentmihalyi, 2000).

It is within the framework of PP the current thesis will be presented, and the focus will be on eudaimonia. Nevertheless, a brief presentation of hedonia will be included as the concepts often are investigated simultaneously, compared and discussed in the same contexts (Kashdan et al., 2008).

Hedonia

The hedonic view was first described by the Greek philosopher Aristippus, who argued that pleasure was the ultimate goal in life (Ryan & Deci, 2001). Influenced by Aristippus, many have followed his notion of WB (Kashdan et al., 2008; Ryan & Deci, 2001). Hedonia has during the years been described as; successfully fulfilling human appetites, sensation and pleasure seeking, and everything from a narrow focus solely based on physical pleasure, to wider understandings including self-interests and desires (Ryan & Deci, 2001).

Today the majority of existing research on WB has been done within the hedonic tradition. This information is based on Psychinfo reviews (from February 2008) where a search generated over 10200 entries for happiness or hedonically related terms, and only 76 for eudaimonic related terms. This overrepresentation is mainly said to exist as studies of hedonia has been around for about twice as long as of eudaimonia, which has been present

for just over 20 years (Waterman, 2008). Hence, there is no surprise that there are clearer conceptions, definitions and a more widespread understanding of hedonia than eudaimonia, particularly within biology (Linley et al., 2009). This advantage has been largely due to the investigation of hedonia by Diener (1984), and no corresponding work was done on eudaimonia (Deci & Ryan, 2008). Diener (1984) coined his own notion of hedonia as *subjective well-being* (SWB), consisting of the three parts; high frequency of positive affect (PA), low frequency of negative affect (NA) and high satisfaction with life (Deci & Ryan, 2008). The now established connection between hedonia and SWB emerged as the book by Kahneman, Diener and Schwarz (1999), *Well-Being: The Foundations of Hedonic Psychology*, was published, and since then HWB and SWB are often used interchangeably (Ryan & Deci, 2001). Consequently, HWB is now most commonly divided into three subcategories when studied (PA, NA, life satisfaction) (Deci & Ryan, 2008). However, it should be mentioned that there are scientists disagreeing with including life satisfaction in HWB (see Sumner, 1996).

Henceforth the focus will be narrowed to eudaimonia. This is done in part because of previously mentioned majority of research on hedonia (Deci & Ryan, 2008) and more attention to eudaimonia is needed to resolve the existing challenges regarding definitions, conceptualizations and operationalizations (Huta & Waterman, 2013).

Eudaimonia

The division between hedonia and eudaimonia was first made by Aristotele (4th century B.C.E/1925), as he distinguished between pleasure (hedonia) and living *the good life* (eudaimonia) (Kashdan et al., 2008). Aristotle's philosophical underpinnings of eudimonia can be traced to his book *Nicomachean Ethics* (4th century B.C.E/1925) and his view is grounded in ideals of nature-fulfilment, thus called nature fulfilment theories (Huta & Waterman, 2013). In Aristotle's (4th century B.C.E/1925) book he states that the highest

condition that can be brought about by human action is eudaimonia. Eudaimonia is said to be lived by focusing on engagement in virtuous activities closely related to the human soul, coupled with striving to find and develop the best within us. Namely, humans are thought to flourish by fulfilling their true nature. In addition, eudaimonia is also said to be consisting of a sense of meaning, purpose and positive engagement and the focus should be on the way of living, rather than reaching a certain state. When we live in line with eudaimonic notions, Aristotle meant humans are fully functioning. And, by being fully functioning and living in accordance with ones true nature, positive subjective experiences is said to come automatically. Yet, it should be noted that eudaimonia is not about feeling good or satisfying appetites as a primary objective, rather, PA is something that comes as a by-product when we are living the good life (Aristotle, 4th century B.C.E/1925).

Eudaimonia – An ambiguous concept. Even though eudaimonia is regularly understood as happiness, debate has been raised surrounding the accuracy of this translation (Ryff, 1989a). As interpreters of hedonia too use the term happiness in their translations, this has caused difficulties in separating the approaches and hampers the possibility of following the original descriptions of the two views as separate (Waterman, 1984). Different interpretations of EWB further add to the confusion when referencing authors reference each other. One example concerns life satisfaction, by most scientists regarded as being part of HWB such as Deci and Ryan (2008) and Ryan and Deci (2001), but not by e.g Sumner (1996). To exemplify; in a review article by Berridge and Kringelbach (2011) they state that life satisfaction is a part of EWB when they refer to a study by Kuppens, Realo and Diener (2008). Yet, Kuppens et al. (2008) only measure the three components most commonly used to assess HWB; PA, NA and life satisfaction, as their view of HWB comprise. Berridge and Kringelbach (2011) draw the conclusion that HWB and EWB is conceptually different, concluding that life satisfaction is a cognitive component of WB, stating it to be EWB. With

this, it is in Berridge and Kringelbach's (2011) article claimed that HWB and EWB is conceptually different but correlated concepts, with high occurrence of one component relating to high occurrence in the other. This example do not demonstrate that Berridge and Kringelbach (2011) necessarily have made a mistake as their view of EWB might differ, nevertheless, it causes ambiguity. Furthermore, the common operationalization of eudaiomonia as happiness has in some cases led to being translated into frequency of PA and NA, and is something Ryff (1989a) claim to be one reason for the field of WB research to have this definition problem. In addition, eudaimonia is a broad concept under which many topics has been gathered from several fields such as psychology, philosophy, ethichs and spirituality, making it hard to define, operationalize and manipulate in research (Huta, 2013). Thus, further questions concerning how broad the concept can be without stop being informative have been put fourth (Huta & Waterman, 2013). And finally, Waterman (1984) argue that if eudaimonia had been understood as the realization of one's potential instead of happiness, the research on WB might had looked very different for the last decades, and many of the original descriptions of eudaimonia might not have been neglected (Deci & Ryan, 2008). In essence, the controversy in the field of WB research is ongoing, more evidently in the field of EWB than HWB research. This controversy have led to Huta and Waterman (2013) further highlighting the problems regarding the different operationalizations, strengthening the reasons for being cautious when interpreting studies made on EWB.

Due to mentioned difficulties, there is a complexity in finding a common terminology in reserach on eudaimonia (Huta & Waterman, 2013; Kashdan et al., 2008). In a relatively new area of research, diversity can be beneficial as a questioning phase may contribute to thoughtful operationalizations (Huta & Waterman, 2013). Yet, the existing multiplicity has now become one of the field's biggest challenges, and as stated, various interpretations of

Aristotle's (4th century B.C.E/1925) original descriptions have emerged (Archontaki, Lewis & Bates, 2013; Huta & Waterman, 2013). To discuss all suggestions, operational definitions and conceptualizations made to date is far too broad the fit in the scope of this paper, hence only some of the most recognized approaches to EWB will be presented (for more extensive reviews see Huta & Waterman, 2013; Kashdan, et al., 2008; Ryan & Huta, 2009; Ryff & Singer, 1998). The coming views of EWB are brought forth as a way of pointing out that various opinions and interpretations of eudaimonia exist. Namely, the notion of EWB as PWB, which later will be the main focus of this thesis, is not the only interpretation of the concept.

Different views of eudaimonia. A first approach is proposed by Waterman (2011), called the eudimonic identity theory. In this theory, self-realization is considered be a core element, along with exploring and living in accord with ones potentials, having feelings of expressiveness and living in harmony with one's inner nature. In addition, authenticity, having a meaning and purpose in life and pursuing excellence is central (Waterman, 2011). Waterman has developed two instruments measuring EWB, the Personally Expressive Activities Questionnaire (Waterman, 1993) and the Questionnire for Eudaimonic Well-Being (Waterman et al., 2010).

A second approach is formulated by Fowers (2012) stating that eudaimonia constitutes of activities that are meaningful in themselves and go in line with one's values. Here eudaimonia involves trait like qualities such as justice, belonging and knowledge. These qualities should be explored and employed with excellence, meaning that one should strive and try to attain them, to subsequently employ the qualities within relationships. This usage should in turn lead to a meaningful life, in which positive relationships, personal development and purpose is present (Fowers, 2012). Fowers uses parts of several instruments to measure EWB, such as the Constitute Goal Orientation subscale of the Goal Orientations

Scales (Fowers, Mollica & Procacci, 2010), the Integrity subscale of the Project Matrix (Palys & Little, 1983), the Personal Expressive subscale from the Personally Expressive Activities Questionnaire (Waterman, 1993) and three of the subscales from Scales of Psychological Well-Being (positive relations with others, purpose in life and personal growth) (Ryff, 1989a).

A third view is presented by Ryan and Deci (2001) suggesting eudaimonia is formed on the underlying conceptions of the self-determination theory; relatedness, autonomy and competence. More specifically including the pursuit of intrinsic goals, personal growth, relations, contributing to something larger, having good physical health and being mindful, all of which satisfy the needs in the self-determination theory (Ryan, Huta & Deci, 2008). In Ryan and Deci's (2001) studies they have used various scales to assess EWB, for example the General Causality Orientations Scale (Deci & Ryan, 1985), the Mindful Attention and Awareness Scale (Brown & Ryan, 2003) and the Basic Psychological Needs Scale (Gagné, 2003).

A fourth suggestion has come from Seligman (2002). He emphasises having meaning and purpose in life along with identification and development of character strengths, particularly to contribute to the world outside of oneself. He has used one subscale from the Orientations of Happiness Scale called the Life of Meaning (Peterson, Park & Seligman, 2005) to assess EWB.

A fifth interpretation defines eudaimonia as striving towards being the best possible self by developing individual inner potential in line with one's values, shaped by Huta & Ryan (2010). In this approach the Hedonic and Eudaimonic Motives For Activities Scale has been used (Huta & Ryan, 2010).

The sixth approach is suggested by Delle Fave proposing eudaimonia to be constituted of two parts; flow and meaning (Delle Fave, Massimini & Bassi, 2011). In this

approach the notion of flow is adopted from Csikszentmihalyi (1975) and is described as an optimal experience, deep engagement, a balance between challenge and skill, leading to personal growth. Meaning is conceptualized as developing a purposeful daily environment, with activities related to optimal individual functioning (Delle Fave, Massimini et al., 2011). The assessment of EWB has been made by using a renewed version of the Flow Questionnaire (Delle Fave & Massimini, 1988) and an interview method called Eudaimonic and Hedonic Happiness Investigation (Delle Fave, Brdar et al., 2011).

The last view is put forth by Ryff (1989a), in which she labels her interpretation of EWB as *psychological well-being* (PWB) as measured by her scale *Six Factor Scales of Psychological Well-Being* (SPWB). This view will be the basis in this thesis and will be presented in more detail in later sections.

The six factor scales of psychological well-being – A common denominator of eudaimonia. As the aim of this paper is to present neuroscientific- and additional biological research on PWB and subsequently suggest a biological and psychological profile of eudaimonia as high PWB, the availability of neuroscientific research on EWB was critical. The choice of limiting the scope to studies that have included the SPWB is because that the majority of existing research addressing EWB in the field of neuroscience that has used this instrument (Ryff, 2014). Equally, it is the most frequently employed measure in research on EWB overall (Archontaki et al., 2012; Huta, 2013; Huta & Waterman, 2013; Lewis, Kanai, Rees & Bates, 2013; Ryff, 2014; Ryff & Singer, 2006). Furthermore, SPWB has been translated into 30 languages and applied in over 350 published articles spanning over various scientific fields such as; humanistic psychology, personality correlates, adult development in later life, work engagements, health, experiences in family life, clinical intervention studies and biological risk (Ryff, 2014). Beyond this, other factors have had impact on this choice, such as that the Aristotelian notion of WB is the most common approaches to study EWB

(Ryan & Deci, 2001). Another argument concerns the problem of definitions and equivalent results and the advantage of making this distinction is that the results will be comparable.

And as stated, efforts aiming to find a clearer terminology and conceptualization of eudaimonia is ongoing, but far from established. In the previously presented article regarding the attempt to create an initial coherent classification system of WB, Huta and Waterman (2013) have additionally reviewed operational definitions and conceptualizations of EWB. Huta and Waterman (2013) examined 11 practiced approaches among recognized researchers with established research programs (Alan Waterman, Carol Ryff, Corey Keyes, Blaine Fowers, Richard Ryan and Edward Deci, Martin Seligman, Joar Vittersø, Jack Bauer, Michael Steger, Veronika Huta and Antonella Della Fave) (for details, see Huta & Waterman, 2013), and found that the majority of included researchers have accepted and incorporated all or some of the features integrated in the SPWB in their separate views, which further adds to the present selection.

Eudaimonia as Psychological Well-Being

As mentioned, WB has mainly been studied in the notion of the hedonistic view (Waterman, 2008). In order to approach this imbalance between HWB and EWB and be able to study and measure Aristotele's (4th century B.C.E/1925) idea of eudaimonia empirically, substantial effort has been made trying to quantify and develop assessment instruments (Ryff, 2014). Within this process Ryff (1989a) carried out a study aimed at defining core elements of EWB and incorporate previously neglected aspects of psychology such as positive functioning, optimal development, individuation and self-actualization (Deci & Ryan, 2008; Ryff, 1989a). She combined features from various theoretical domains and integrated them into a common view (Ryff, 1989a). Consequently, SPWB is basically built on the Aristotelian view on eudaimonia, with influences from literature including; Buhler's (1935) basic life tendencies, Erikson's (1959) psychosocial stages and Neugarthen's (1973) study of

personality changes in later life, all founded in developmental psychology. Moreover, the basic structures of SPWB were also influenced by the work of clinical psychologists such as Jung (1933), Maslow (1968), Allport (1961) and Rogers (1961). Input from mental health literature has also been taken into consideration, for instance, Birren and Renner (1980) and Jahoda (1958). From mentioned influences, Ryff formed her alternative understanding of EWB as PWB, resulting in the multidimensional SPWB (Ryff, 1989a, see Appendix for SPWB scale and subscale-items). Six common and recurrent features were found and constitute the six subscales of SPWB; autonomy (AU), environmental mastery (EM), positive relations with others (PRWO), purpose in life (PL), personal growth (PG) and self-acceptance (SA), which together form an overall PWB-factor (Ryff & Singer, 2006). The subscales will be described in more detail in the following paragraphs and are suggested to represent six sub dimensions of a fully functioning person (Ryff, 1989b).

AU includes being able to resist social pressures and evaluating oneself according to own standards (from Maslow, 1968). AU is also signified by self-determination and living independently, resulting in a regulation of ones behaviour from within (from Jahoda, 1958) as well as being free from outer norm based strains (Ryff, 1989b). In essence, AU is centred around feelings of self-determination (Ryff & Keyes, 1995). High AU means independence, successfully handling social pressures, standing by one's own convictions and living in accordance. Low AU is characterized by worrying about social evaluation, tend to conform to others and not standing up for oneself (Ryff & Keyes, 1995).

EM refers to the ability to manage one's life and surroundings successfully (Ryff & Keyes, 1995). From Neugarthen (1973) Ryff (1989b) has included features of being able to master and control the environment and being competent. Buhler (1935) influenced the aspect of using creative physical and mental activities to reach goals (Ryff, 1989b). Also emphasised is Birren and Renner's (1980) notion of acting on opportunities in different

contexts and Jahoda's (1958) idea of the capacity to form or match environments to one's personality (Ryff, 1989b). High EM implies mastering one's life and external activities, seeking and acting on opportunities, and successfully approach environments that fulfil personal needs. Low EM is signified by feeling unable to manage and control the surrounding context to ones favour and difficulties in handling everyday life (Ryff & Keyes, 1995).

PRWO includes having trusting and warm interpersonal relations. It is central to have empathic and affectionate feelings towards others, and feel connected. Essential is also to be capable to love and nurture friendships (Ryff, 1989b). Additionally, the ability to be compassionate, respectful, appreciative and intimate towards and with others is underscored. High PRWO is signified by a caring personality, having trusting relationships and the ability of conveying empathy and love. Indicators of low PRWO include having weak and few relationships and difficulties of keeping them and problems of being affectionate (Ryff & Keyes, 1995).

PL refers to the belief that life is meaningful and has purpose. It involves growth processes with emphasis on having productive goals (Ryff, 1989b). PL also comprise of Buhler's (1935) notion of being able to manage one's world creatively and having the capacity to hold up one's internal structure. Importance is also put on living in the moment (from Rogers, 1961) and having an integrated philosophy of life (from Allport, 1961) serving as a foundation for seeing life as purposeful, balanced and having a unified understanding of the self (from Jahoda, 1958). High PL is signified by a targeted personality in combination with experiencing life as worthwhile. A central aim is to reach goals (Ryff, 1989b). Low PL score tend to indicate an aimless life with a lack of meaning (Ryff & Keyes, 1995).

PG refers to continuous development and growth throughout life in addition to exploring one's potentials (Ryff, 1989b). PL includes being able to adapt to a changing environment and as Rogers (1961) particularly emphasises, being open to new experiences.

Both Rogers (1961) and Maslow (1968) underscore that personal development should be a continuous process and not an achievable state that marks that you are fully developed and functioning. Likewise, Jahoda (1958), Allport (1961) and Erikson (1959) put further emphasis on lifelong growth. High PL indicates strong feelings of continued progress throughout life. To realize potentials, have self-knowledge and constantly trying to improve oneself is central. Low PG implies a lack of interest in life and finding it pointless to engage in positive changes (Ryff & Keyes, 1995).

Ryff (1989b) describes SA as the most recurrent feature in reviewed literature on positive functioning. SA is here being built on Maslow's (1968) notion of self-actualization, consisting of a general acceptance of oneself, others and the nature as a whole. From Rogers (1961) an emphasis on self-worth has been included, and from Allport (1961) the aspect of emotional security. Additionally, general acceptance, holding a positive attitude towards oneself and an acknowledgment of past life successes as well as disappointments are included (Ryff, 1989b). High SA refers to a positive attitude and evaluation of oneself, accepting multiple aspects of one's personality and thinking brightly on the life passed. Low SA is characterized by disappointment and dissatisfaction with the self, one's accomplishments and past life (Ryff & Keyes, 1995).

Psychometric Properties

The SPWB has until 2014 been evaluated on its psychometric properties in more than 25 articles. The focus in these studies has mostly been investigating if the SPWB do measure six distinct dimensions or not (Ryff, 2014) and support for the six-factor model has been provided from several sources and from applications in different cultural contexts (see Gallagher, Lopez & Preacher, 2009; Ryff & Singer, 2006).

In the initial verification study by Ryff (1989a) an 120-item version of SPWB was employed (n=321). This version had a six-point scale with both positively and negatively

formulated items. Respondents ranged themselves on each item from *strongly agree* to *strongly disagree*. An overall PWB score is acquired by adding the scores from each subscale into a total score (Heller et al., 2013). In Ryff's (1989a) study the SPWB had internal consistency coefficients for each of the sub-dimensions as follows: AU, .86; EM, .90; PRWO, .91; PL, .90; PG .87 and SA, .93. Moreover, the test-retest reliability coefficients over six weeks were: AU, .88; EM, .81; PRWO, .83; PL, .82; PG, .81and SA, .85. A stability of 95% over a 10-year period using the reliable-change index has also been provided in a later study by Heller et al. (2013).

The first version of the SPWB included 120 items (20 per dimension) but has later been modified and is now available in different lengths including; 84 items (14 per dimension), 54 items (9 per dimension), 42 items (7 per dimension) and 18 items (3 per dimension) (Abbot et al. 2006). It has been suggested that versions containing more items (at least 42) are more reliable than the later revised models including fewer original questions. This suggests that the basic theoretical model is reliable, but as versions shortens, the psychometric properties decline (Gallagher et al., 2009), which has been one of the criticisms the SPWB has received. Yet, the most frequent criticism regards the that the six subscales in some cases overlap, suggesting the SPWB measure fewer than six dimensions of PWB (Ryff, 2014). This overlap was first found in Ryff's (1989a) own validation study where the intercorrelations between the subscales ranged from .32 to .76. The largest correlation was found between SA and EM (r= .76) followed by SA and PL (r=.72), PL and PG (r=.72) and PL and EM (r=.66). The problem with overlapping subscales has been further addressed by Springer, Hauser and Freese (2006), as they have further analysed studies where Ryff has used the SPWB (e.g. Ryff & Keyes, 1995). In their analysis they found that some subscales tend to have high correlations, adding to the suggestion that SPWB measure less than the six stated dimensions (for further discussions see Abbott, Ploubidis, Huppert, Kuh & Croudace,

2010; Springer & Hauser, 2006; Springer, Hauser & Freese, 2006).

The Biology of Eudaimonia as Psychological Well-Being

To be able to uncover the biology of EWB, and subsequently the psychological profile of an individual with high PWB, it is essential to identify the underlying biopsychological interplay. In order to uncover this interplay, sciences are investigating the biological profiles of individuals with high WB (Ryff, Singer & Love, 2004). Yet, the field investigating the biology of EWB is still in its infancy, especially within the field of neuroscience where comparable results are scarce (Friedman, Hayney, Love, Singer & Ryff, 2007; Heller et al., 2013; Kringelbach & Berridge, 2009; Ryff et al., 2006; Urry et al., 2004). Therefore it is important to support this process by shedding light on existing, equivalent results.

To avoid adding to further confusion regarding the terminology of eudaimonia, the term PWBc will be added in this thesis. PWBc will be employed when the purpose is to express a generalized understanding of PWB, meaning either *some of the subscales jointly* or *PWB and some (or all) of the subscales together*. The term PWB will be used when authors have computed an overall PWB score, hence referring to PWB as a coherent construct. When subscales are specified, they will be stated respectively.

Psychological Well-Being and Neuroscientific Measures

As stated, the concept of WB has been widely studied in the field of psychology in the last decades (Deci & Ryan, 2008). However, WB research is a new subject within the field of neuroscience (Kringelbach & Berridge, 2009) and until 2004 no published articles had directly investigated the neural correlates of WB (Urry et al., 2004). But in the last decade the focus have been broadened within the neuroscientific research as well, and have now begun to explore the neurological features of a fully functioning person (Kringelbach & Berridge, 2009).

Within neuroscience, PWBc has been investigated with the brain measurements electroencephalography (EEG), magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI). EEG measures coherent electrical potentials produced by large populations of neurons that results in a continuous recording of overall brain activity, called an electroencephalogram. This measure is enabled through electrodes placed on the scalp, recording electrical currents generated by synaptic activity. In a MRI scanning, a magnetic field and radio waves are produced and used to create detailed image of the brain. An advancement of the MRI scan is the fMRI imaging technique. With fMRI one can detect metabolic signals in blood flow while a subject perform cognitive tasks (Gazzaniga, Ivry & Mangun, 2009). In the neuroscientific area to date, conducted research has primarily been focused on how PWBc is associated with asymmetric prefrontal cortex (PFC) activation, PFC functioning, GM volume and reward circuitry. Results from these areas are presented next.

Asymmetrical prefrontal cortex activation. A substantial number of investigations have explored the function of asymmetrical PFC activation, but Urry et al. (2004) was the first research group to carry out research on the neurobiology of WB. In previous studies where greater left than right prefrontal activation has been found, this specific activity has been especially frequent in individuals who regularly experience more dispositional PA than NA (Tomarken, Davidson, Wheeler & Doss, 1992). In addition, greater left than right activation is closely related to approach oriented behaviours (Harmon-Jones & Allen, 1997), a well developed ability to recover from negative emotional challenges (Jackson et al., 2003) and capability to suppress unwanted emotions (Jackson, Burghy, Hanna, Larson & Davidson, 2000).

In Urry et als. (2004) study they measured HWB and PWBc, to relate the results to resting EEG activation. HWB was measured with the Satisfaction With Life Scale (Diener, Emmons, Larsen & Griffin, 1985) and the Positive and Negative Affect Schedule (Watson,

Clark &Tellegen, 1988), and PWBc was assessed with SPWB (84-items) (*n*=84). It was found that having more activation at the left frontocentral lead at baseline compared to the right was positively correlated to high scores on the subscales SA (*r*=.39), PL (*r*=.34), PRWO (*r*=.36) and EM (*r*=.26), as well as HWB. Yet, in the hemisphere-specific analysis it was noted that frontal EEG asymmetry explained the variation in PWBc in individuals outside the accounted variation due to approach-oriented PA. In addition, the hemisphere-specific analysis further demonstrated the greater left than right activation had a stronger relation to PWBc than HWB, even after the variance linked with PA was isolated. Namely, the variation in approach-oriented PA contributing to WB was only evident for PWBc and not for HWB (Urry et al., 2004).

In sum, the results from Urry et als. (2004) study indicate that a higher left to right anterior cortical activity at baseline is a predictor SA, PL, PRWO and EM. The relation between PWBc and asymmetrical PFC activation was stronger than with HWB in the sense that goal directed approach tendencies not accounted for by PA might be more essential for high PWBc than HWB.

Prefrontal cortex functioning. Previous studies linked to PFC functioning have detected activation in amygdala and PFC when engaging in emotional and social behaviour, therefore believed to be involved in individual differences in emotional reactivity (Davidson, 2000). Influenced by such results, van Reekum et al. (2007) investigated individual differences in amygdala activation in response to negative relative to neutral stimuli using fMRI. Here the evaluation time of the stimuli were included and related to differences in medial PFC functioning and further linked to PWBc (SPWB: 84-items). All participants (*n*=29) were exposed to unpleasant arousing pictures and neutral non-arousing pictures. Instructions were to evaluate the picture as negative or neutral as soon as possible by pressing a button. Results indicated a significant correlation between individuals reporting higher

PWB and slowness in identifying unpleasant arousing- relative to neutral non-arousing pictures (r=.43). In addition, high PWB was found to be strongly positively correlated with higher activation in a part of the ventromedial PFC, the ventral anterior cingulate cortex (ACC), when viewing the unpleasant arousing- relative to the neutral non-arousing pictures (r=.67). As previous studies have found that emotional regulation may be initiated by ACC activation and down-regulating amygdala functioning when facing potentially aversive information, ACC activation may lead to interpreting the information as less threatening which may reduce the stress response (Davidson, 2004). In this context it could mean that high PWB may be contributing to successfully down-regulating strong unwanted emotions (Davidson, 2004). Thus, van Reekum et al. (2007) propose that individual differences in response to negative events is a part of PWB, and that ACC activation can predict evaluation speed and PWB.

Furthermore, van Reekum et al. (2007) also found that slower reaction time to unpleasant arousing pictures was linked to amygdala activation, especially, the subscale PL was found to be negatively associated with activity in the left amygdala activity (r=.-45) and positively and significantly correlated with judgement time (r=.63). This finding indicates that high PL is a predictor for lower amygdala activation in response to unpleasant arousing stimuli. Yet, van Reekum et al. (2007) suggest this discovery to show that the amygdala is less significantly involved in contributing to PWB. Namely, it is the ACC activation that is the primary cause for the amygdala activation to decrease, implying that ACC is more likely to contribute to high PWB than the amygdala.

In sum, the higher PWB, the more activation in the ventral ACC and the higher PL, the lower activity in amygdala is to expect in response to unpleasant arousing stimuli (van Reekum et al., 2007).

Grey matter volume. The grey-coloured matter in the brain containing cell bodies of

neurons and glial cells is called grey matter (GM). GM volume can increase as we learn or adapt to new behaviours. This volume increases as the synaptic connectivity in a certain area strengthens (Gazzaniga et al., 2009).

In 2014, Lazar conducted a study with the aim of investigating a possible link between GM volume and PWBc using MRI. This was done by using an eight-week Mindfulness-Based Stress Reduction (MBSR) course to induce possible changes in GM quantity, as has been seen in a study by Hölzel et al. (2011). In Hölzel et als. (2011) study they found GM changes in the pontine tegmentum, nucleus raphe pontis, locus couruleus and the sensory trigeminal nucleus bilaterally. These areas are known to be involved in arousal-regulation and mood and can all be found in the brainstem (Lazar, 2014). Based on Hölzel et als. (2011) findings, Lazar (2014) conducted a study hypothesizing that this region in the brainstem could be involved in PWBc. Thus, the pons/raphe/locus coeruleus area in the brainstem was compared to SPWB (54-items) results (Lazar, 2014). Participants (n=14) took part in the eight-week MBSR course and SPWB was measured before and after. Results showed that PWB increased significantly from Pre- to Post- intervention and changes in GM volume were found in the pontine tegmentum, locus coeruleus, nucleus raphe pontis, and the sensory trigeminal nucleus bilaterally. Additionally, the degree of improvement in PWB corresponded to the increase in GM volume. Namely, the more the individual's PWB increased over the eight-week course, the more GM volume enlargement could be observed. Accordingly, strong positive correlations for change in the left (r=.72) as well as in right (r=.76) brainstem cluster was observed (Lazar, 2014).

The pontine tegmentum are part of the cholinergic system that is involved in learning, motor function, sleep, wakefulness, reward and attention (Kobayashi & Okada, 2007). The region's nuclei, pendunculopontine nucleus and the dorsolateral tegmental nucleus, are in turn involved in dopamine generation as they send axons to dopamine-holding areas such as

substantia nigra, lateral hypothalamus, thalamus and basal ganglia, areas included in control over reward and learning (Steiniger & Kretschmer, 2003). The locus coeruleus synthesizes noradrenaline so that the individual properly can adjust to environmental demands (Aston-Jones & Cohen, 2005) and be attentive (Olson, 2007). Moreover, this region has also been found to have less GM density in people with depression, compared to healthy individuals (Arango, Underwood & Mann, 1996). The nucleus raphe pontis is a region holding numerous neurons distributing serotonin (Michelsen, Schmitz & Steinbusch, 2007), a hormone involved in mood, sleep patterns (Lazar, 2014), pain relief, hunger, emotions and sexuality (Olson, 2007). And the sensory trigeminal nucleus is too involved in mood and arousal-regulation (Aston-Jones & Cohen, 2005)

Thus, brain regions investigated here are all shown to be involved in factors contributing to PWBc such as learning (PG), adjustment to environmental demands (EM) and to various components of cognitive functioning and survival. In brief, results indicate that an eight-week MBSR course can increase PWB. Moreover, possible brain regions involved in PWBc have been identified, as an improvement in PWB showed a parallel increase GM volume in the pons/raphe/locus coeruleus regions of the brainstem (Lazar, 2014).

Furthermore, the first study *exclusively* aimed at investigating the structural brain correlates of PWBc with MRI, was published in 2013 by Lewis et al. In this study they examined if GM volume could be associated with PWBc. The participants (n=70) were assessed for differences in regional brain structure and the SPWB (42-item) was applied. PWB was found to be significantly and positively correlated with GM volume of the right insular cortex (r=.46) as well as the subscales PG (r=.48) and PL (r=.46). PRWO (right: r=.51, left: r=.50) and PG (right: r=48, left: r=.45) had positive correlations with insular cortex volume on both the right and the left side.

As previously stated, the neuroscientific investigation of PWB is young and the

significance of these results are hard to interpret at this point. Yet, positive correlations between reduced insular (GM) volume and depression has been found (Bechdolf et al., 2012) which might have significance in this context (Lewis et al., 2013). Furthermore, positive correlations have been established between insula and personal agency (Waterman 1993), agentic control (Lee & Reeve, 2013) and active guidance of behaviour (Menon & Uddin, 2010). These three abilities are closely linked to Ryff's (1989a, 1989b) descriptions of PWBc and can therefore be connected to PWB through GM volume in the insula (Lewis et al., 2013). However, further research is needed to ensure such an establishment.

Briefly, Lewis et al. (2013) noted a positive connection between PWB and PL and GM volume in the right insular cortex, as well as positive correlations between insular volume on both sides with PRWO and PG. These results might indicate a link between PWBc and positive psychological resources.

The reward circuitry and stress. Reward is an essential aspect for motivation, developing goal-directed behaviours and learning to respond suitable to our milieu (Haber & Knutson, 2009). Reward is produced by the reward circuit that comprises of brain regions involved in reward processing. Within this circuit the cortical-basal ganglia is central and among the key structures we can find the ACC, the orbitofrontal cortex and the ventral striatum. Other areas important for reward regulation include the amygdala, raphe nucleus and the dorsal PFC. The connections between these (and additional regions in the reward circuitry) create a multifaceted neural network mediating features of the reward process (Haber & Knutson, 2009).

Brain regions of the reward circuitry have been investigated together with measurements of PWBc by Heller et al. (2013). In their study the focus was on finding a relation between PWBc, stress and individual differences in sustained engagement of reward circuits in response to affective stimuli. In particular, if the individual differences can be

coupled with higher levels of PWBc, and protective against stress. This study built on previous research by (Heller et al., 2009), where the results indicated that individuals with depression was unable to continually engage the reward circuit in a sustained manner while exposed to both negative and positive events (affective arousing pictures) in a intermixed mode over time. Brain regions was explored with fMRI and stress was measured with assessment of salivary cortisol four times a day for four days (Heller et al., 2013).

Cortisol is an endogenous stress hormone released when hypothalamic-pituitary-adrenal (HPA) axis is activated when we experience physical or psychological stress (Gazzaniga et al., 2009). The hormone is produced by the adrenal cortex in the adrenal glands. Cortisol is essential for survival as is facilitates stress responses, but continuous exposure to high levels have been found to correlate with several negative conditions such as impaired immunity, insulin resistance (McEwen, 1998), and hippocampal atrophy (Davidson, 2004) which can lead to deficient episodic memory (Gazzaniga et al., 2009; Lupien et al., 2005). Finally, which may be of most interest here, having strong psychological resources influence the activation of the HPA axis. This leading to individuals with stronger psychological resources coping better with stress as they do not perceive as many situations as threats, hence can handle them more effectively (Taylor et al., 2008).

In the study by Heller et al. (2013) participants (n=72) were assessed for PWBc (no specified version) and cortisol at 3.5 and 1.5 years respectively, prior to the fMRI scanning session. The affective stimuli comprised of an imaging task where participants were shown positively arousing, negatively arousing and neutral non-arousing pictures (for four seconds each) in a randomized manner during fMRI scanning. It was found that sustained striatal activity in the ventral striatum and dorsolateral PFC when viewing the positively arousing stimuli predicted lower cortisol output and higher PWB. Moreover, the activity in the dorsolateral PFC mediated the correlation between PWB and cortisol. In turn, the activity in

the ventral striatum was shown to be mediating the relationship between sustained dorsolateral PFC activity and PWB (Heller et al., 2013).

In short, the results indicate that sustained striatal activity in the ventral striatum and dorsolateral PFC in response to positively arousing stimuli could be a biologically protective factor as it reduces daily cortisol output and is related to higher PWB. This finding also led to a proposal that sustained activity in ventral striatum and dorsolateral PFC in response to positive affective stimuli may be the neurobiological mechanism through which PWB influences health as this particular sustained activity mediated the relationship between daily cortisol output and PWB (Heller et al., 2013).

Additional Biological Research on Psychological Well-Being

To broaden the view to other significant areas within the biological research, supplementary biological studies from additional fields will now be added.

In biological investigations of PWB outside neuroscience, measurements of biomarkers are commonly used. These measures are done due to suggestions that people with high WB has specific patterns of biomarkers (Lewis et al., 2013). A biomarker is a measurable, physical, objective and medical sign indicating a certain medical condition (Strimbu & Tavel, 2010). In essence, it can be any measurable substance, process or structure that can be assessed in the body able to predict or induce a state of disease (World Health Organisation, 2001). Biomarker measures coupled to PWBc have mainly been conducted on the neuroendocrine, cardiovascular and immune systems and on physical disabilities and disease. Studies investigating the biology linked to PWBc often include measures from various physiological aspects as little is known of the underlying biology (Ryff et al., 2004). Results from neuroendocrinal-, immunological- and cardiovascular research are presented next, followed by studies on physical malfunction and disease.

Neuroendocrine measures. The neuroendocrine system (NS) is made up by the

nervous system and the endocrine system (Di Comite, Grazia Sabbadini, Corti, Rovere-Querini & Manfredi, 2007). The NS includes endocrine cells and specific neurons controlled by the central nervous system (CNS). Through the NS, various body functions are controlled by the communication between the brain, nervous system and endocrine glands. The CNS releases neurotransmitters through the hypothalamus that in turn regulate the anterior pituitary gland, leading to control over endocrine glands all over the body. These glands release hormones that control blood pressure, reproduction, metabolism, mood, thermoregulation, body fluids and electrolyte homeostasis, sleep and stress (Di Comite et al., 2007). The neuroendocrine functions have also been linked to psychological and social factors (Ryff et al., 2004) adding to the interest of including these measures in this context. Typical measures from the NS linked to PWBc include cortisol and cathecolamines.

Within the neuroendocrial research the relation between stress and health (PWBc) has been investigated by Lindfors and Lundberg (2002) (n = 26). Stress was measured by salivary cortisol output seven times a day for two days and the SPWB (18-items) was used. Results indicated that individuals with high levels of PWB had considerably lower levels of morning cortisol and total cortisol output during the two days. In addition, the subscale EM showed the strongest negative correlation to total cortisol (r=-.56) and morning cortisol (r=-.64). This finding demonstrating that high EM scores are linked to lower levels of cortisol secretion and higher cortisol output in EM low-scorers (Lindfors & Lundberg, 2002) A possible cause for these results builds on previous research by Taylor et al. (2008) as they found that the distress EM low-scorers experience doubting their capability to manage daily activities might produce the higher levels of cortisol.

In another study Ryff et al. (2004) explored whether PWBc could be correlated with reduced biological risk (n=135, SPWB=84-items), as indicated by lower levels of salivary cortisol (measured three times a day for four days). They found that higher PL and PG are

predictive of lower levels of daily salivary cortisol. Namely, they noted that individuals with higher scores on PL and PG on average had lower levels of salivary cortisol in the morning and also had flatter slopes of cortisol throughout the day, compared to those with lower scores on these subscales. In brief, high-scorers on PL and PG had better neuroendocrine regulation.

Moreover, within research on PWBc and neuroendocrine function, PWBc have been linked to a class of neurotransmitters called catecholamines, namely, noradrenalin and adrenalin. These neurotransmitters are involved in behaviours related to arousal-regulation and attention (Gazzaniga et al., 2009).

Furthermore, in the same study by Ryff et al. (2004) they found the subscale AU to correlate positively to higher levels of noradrenalin (r=.21) as measured by overnight urinary samples. The level of noradrenalin was significantly higher in participants with high scores of AU, than those having lower AU scores. Noradrenalin is a neurotransmitter usually coupled with emotional expressions, such as too low levels is related to depression and too high levels linked to stress (Nyberg, 2009). Additionally, adrenalin, a synthesized version of noradrenalin, has too been positively correlated with having higher scores on PRWO (r=.21), as measured in urine (Ryff et al., 2006).

Briefly, PWB, EM, PG and PL have been linked to lower levels of cortisol (Lindfors & Lundberg, 2002; Ryff et al., 2004), indicating that these features of PWBc might have a biologically protective function. AU has been positively correlated with noradrenalin (Ryff et al., 2004) and PRWO to the synthesized form adrenalin (Ryff et al., 2006), two neurotransmitters involved in arousal, attention (Gazzaniga et al., 2009), emotion, depression and stress (Nyberg, 2009).

Immunological measures. The immune system protects the body from harmful bacteria, substances and viruses by identifying their antigens and activating a defending

response. It consists of cells, tissues and extracellular effector molecules involved in the immunological reactions (Haug, Sand & Sjaastad, 1993). Measures in studies linking PWBc to the immune system have mostly been on the pleinotropic cytocine interleukin-6 (IL-6). IL-6 is a pro-inflammatory protein involved in the activation of inflammatory responses leading to negative health outcomes (Papanicolaou, Wilder, Manolagas & Chrousos, 1998).

Most research investigating the effects of IL-6 have focused on negative psychological states and less attention have been given to investigating the opposite, if positive psychological states may influence IL-6 levels (Friedman et al., 2007). However, existing evidence suggests there are links between positive psychological states and health, such as in reduced risk of inflammation (Steptoe, Dockray & Wardle, 2009). Built on such findings, Friedman et al. (2007) investigated if high PWBc could be associated with lower levels of IL-6 (n=135). Measures of PWBc (SPWB: 84-items) were completed 3-4 weeks before the assessments of IL-6 of and soulable IL-6 receptor concentrations in blood plasma. The plasma levels of soulable IL-6 receptors was measured as this cytocine receptor, unlike others, amplifies the inflammatory potential of IL-6. Hence, soulable IL-6 receptors are as well considered as pro-inflammatory factors (Jones, Horiuchi, Topley, Yamamoto & Fuller, 2001). Results showed that plasma levels of soulable IL-6 receptors were negatively correlated to PL and EM. Additionally, the subscale PRWO was negatively correlated with plasma IL-6 levels. These results indicating that higher PL, EM and PRWO scores may influence lower levels of circulating IL-6 in peripheral blood (Friedman et al., 2007).

Moreover, in a study by Friedman and Ryff (2012) the subscale PL (from SPWB 42-items) has separately been applied in a biopsychosocial study. Here they investigated if psychological correlates in age-related chronic conditions could have protective functions and reducing biological risk. Primarily looking into PL could influence positively coping with medical comorbidity, and if this could lead to less circulating inflammatory proteins

such as IL-6 (*n*=998). IL-6 has previously been linked to age-related disorders such as AD, osteoporosis, cardiovascular disease (Papanicolaou et al., 1998) and other negative health outcomes such as type II diabetes and insulin resistance (Black, 2003). IL-6 was measured from fasting blood samples and results indicated that high PL indicated lower levels of IL-6 (*r*=-.07) (Friedman & Ryff, 2012). This result adds to prior findings by Ryff et al. (2004) where it was shown that high PL related positively to better neuroendocrine regulation and fewer inflammatory markers than participants with lower PL. These results taken together indicate that comorbid participants with higher PL had lower IL-6 levels than comorbid participants with lower PL. Furthermore, as inflammatory proteins have been found to be involved in negative age-related health outcomes, having high PL may have a biologically protective function. In brief, the results suggest that people with medical comorbidities maintaining high levels of PL have reduced risk of inflammation (Friedman & Ryff, 2012).

To sum up, high PL and EM was negatively correlated to soulable IL-6 receptors (Friedman et al., 2007), and in Friedman and Ryff's (2012) study they also found a negative correlation between high PL and IL-6. These results indicating that high PL and EM might be protective against inflammation, AD, osteoporosis, cardiovascular disease (Papanicolaou et al., 1998), type II diabetes and insulin resistance (Black, 2003).

Cardiovascular measures. The cardiovascular system consists of the heart and the circulatory system which together supply organs and tissues with nutrients and oxygen through blood. This system also remove waste products such as carbon dioxide, transport hormones from endocrine glands to their receptors aiding the physical communication, assist in maintenance of proper body temperature and provide protection from infections (Haug et al., 1993). Common measures from this system employed in research on PWBc have included glycosylated hemoglobin (HbA1c) and cholesterol. HbA1c is an objective parameter to assess blood glucose level in blood (Alam, Weintraub & Weinreb, 2006) and cholesterol is

a lipid also found in blood (Freeman & Junge, 2005).

In one study by Tsenkova, Love, Singer and Ryff (2007) the aim was to investigate the links between PWBc, income and HbA1c (*n*=115, SPWB: 84-items). HbA1c level is regularly coupled with negative health conditions such as diabetes. However, an increasing amount of research emphasize a relation between HbA1c levels and health in individuals without diabetes, in example in relation to coronary heart disease, cardiovascular disease and mortality (Tsenkova et al., 2007). In an attempt to supplement such findings, Tsenkova et al. (2007) hypothesised that people with higher socioeconomic status (years of education and income) would have lower levels of HbA1c and also that PWBc independently would contribute to lower levels of the HbA1c. Results showed no such indication; yet, the subscales PL and PG were found to be moderators of relation between HbA1c and income. This moderating factor between HbA1c and income amplified the adverse affects in low-income participants, as they already had higher HbA1c levels compared to people with higher incomes. Namely, having low income combined with low scores on PL and PG strengthened the negative effects resulting in even higher levels of HbA1c. This finding underscores the importance of examining combinations of factors that might better predict individual differences of HbA1c. In sum, support for an interplay between PL, PG and income in moderating HbA1c levels has been found (Tsenkova et al., 2007).

Furthermore, other studies have also investigated the possible relationship between PWBc and HbA1c. In one study by Ryff et al. (2004) (*n*=135, SPWB: 84-items) they found that the subscales PRWO (*r*=.21), EM (*r*=.20) and SA (*r*=.19) are linked to lower levels of HbA1c. This result indicating that having high scores on PRWO, EM and SA may contribute to reduced biological risk (Ryff et al., 2004).

Another biomarker that has been of interest in PWB research is cholesterol. As mentioned, cholesterol is a central component for our body to function well. It is important

because it supplies the structure of cell walls, helps the body to produce vitamin D, enable production of certain hormones and aids in food digestion. The two main types of cholesterol are low-density lipoproteins (LDL) and high-density proteins (HDL). The LDL cholesterol is often referred to as the "bad" cholesterol as too much is possibly related to negative health outcomes such as atherosclerosis, heart disease, stroke, and other major health problems. The HDL cholesterol is known as the "good" cholesteol as some support has been found for it to reduce LDL levels in the body, having a protective effect (Freeman & Junge, 2005). In addition, it has been suggested that it is an inverse, independent predictor of cardiovascular disease (Curb et al, 2004).

In one study from 2004, Ryff et al. investigated if a linkage between PWBc and HDL and LDL cholesterol could be found (n=135, SPWB: 84-items). Positive correlations with HDL cholesterol for both PL (r=.22) and PG (r=.17) was obtained. PG was also negatively correlated with total cholesterol (r=-.16). These results indicate that having high PL and PG is related to reduced cardiovascular risk (Ryff et al., 2004) as HDL cholesterol is believed to be a protective factor for cardiovascular diseases (Curb et al., 2004).

In sum, results from research on PWBc and HbA1c have found PL and PG to mediate the relationship between HbA1c level and income (Tsenkova et al., 2007). In this context meaning that having low income combined with low scores on PL and PG results in higher levels of HbA1c. Complementing results have found negative correlations between PRWO, EM and SA, and HbA1c (Ryff et al., 2004). Regarding research on PWBc and cholesterol, positive correlations with HDL cholesterol have been found for both PL and PG. PG have also been negatively correlated with total cholesterol (Ryff et al., 2004), indicating PWBc might protect against cardiovascular-related diseases.

Physical malfunction and disease. Another field of interest have been associations between PWBc and different kinds of physical malfunctions and diseases including general

negative physical symptoms, musculoskeletal symptoms, AD and mortality.

In one study from 2002, Lindfors investigated the relationship between PWBc and physical symptoms (*n*=91, SPWB: 18-items). It was found that physical- (nausea, stomach-ache, colds, head-ache) and musculoskeletal (pain in back, neck or wrists) symptoms correlated negatively with PWB. Similar results were obtained in another study by Lindfors and Lundberg (2002), in which the same version of the SPWB was used. This study found people with high PWB to have significantly fewer musculoskeletal- as well as physical symptoms than people with lower PWB (Lindfors & Lundberg, 2002).

The association of PL and risk for AD has been investigated by Boyle, Buchman, Barnes and Bennett (2010). AD is an illness in which memory and cognitive abilities are disturbed due to the malfunction of the neurotransmitter acetylcholine (Olson, 2007). Here they examined the risk of incident AD (*n*=951, SPWB: 10-items) in a longitudinal design. In a seven-year period with continuous follow-ups, results showed that PL was related to a considerably reduced risk of developing AD. More specifically, a person within the 90th percentile of higher PL, had a 2.4 reduced risk of getting AD, compared to an individual with a lower score (Boyle et al., 2010). In addition, PL have also been shown reduce the risk of stroke in older adults (Kim, Sun, Park & Peterson, 2013).

In another study by Boyle, Barnes, Buchman and Bennett (2009) investigated whether PL could be a predictor of mortality (*n*=1238, SPWB: 10-items). In a five-year follow-up the researchers found participants with higher PL having a significantly reduced risk of dying compared to individuals with lower PL (hazard ratio=.60) (Boyle et al., 2009).

In brief, people with higher scores PWB have shown less physical symptoms as well as musculoskeletal symptoms (Lindfors, 2002; Lindfors & Lundberg, 2002). Having a higher score on the subscale PL has been associated with lower risks of falling ill of AD (Boyle et al., 2010), dying (Boyle et al., 2009) and having a stroke (Kim et al., 2013).

Discussion

The aim of this paper has been to present neuroscientific- and additional biological research on PWBc to subsequently be able to suggest a biological and psychological profile of eudaimonia as high PWBc. The reviewed neuroscientifc- and additional biological has included the SPWB developed by Ryff (1989a). The neuroscientific- and additional biological research will in later sections be used to present a proposal of a biological and psychological profile of an individual with high PWBc.

The thesis has been presented along with a background of WB and the philosophical underpinnings of the chosen view built of Aristotle's (4th century B.C.E/1925) notions of eudaimonia. The delimitation to only focus on PWBc using the specific SPWB measure has been partly chosen based upon the current state of difficulties in defining EWB. It can be concluded that the field of EWB research have one basic challenge before results can be interpreted with some certainty and comparability (Delle Fave, Brdar et al., 2011), and that is to find a common way of classifying and operationalizing EWB (Huta & Waterman, 2013). The literature investigating the biology of PWBc is currently growing in multiple scientific disciplines. This is due to the improving scientific measures addressing the matter along with a growing interest in human functioning. Ongoing advancement in the understanding of human WB is in process, as well as linking PWBc to scientific fields such as health, biology and neuroscience (Ryff, 2014). Yet, the field of research on PWBc in relation to biology and neuroscience is still novel and tentative.

The central findings in this paper have been regarding brain activity linked to PWBc in various manners. Beyond this, neuroendocrinal, immunological and cardiovascular measures have been included as a supplement, and links between physical malfunctioning and disease have been presented.

Starting with the neursocientific research on PWBc, it can be concluded that very few

exist in general, and those addressing PWBc with neurocientific measures obtain diverse results. For example, no findings to date have found associations between the same brain regions and PWBc, making the interpretation of results complicated. Adding to the complexity, some research designs have a third variable connected to the result (e.g. Lazar, 2014). With these difficulties in mind, the general findings from the neuroscientific research will be presented.

Urry et al. (2004) found a positive correlation between the subscales SA, PL, PRWO and EM having more activation at the left frontocentral leads compared to the right (Urry et al. 2004). This finding adds another dimension to previous studies of asymmetrical prefrontal activation in which high and stable left prefrontal activation have been seen in individuals who regularly experience more dispositional PA than NA, significant for high HWB (Tomarken et al., 1992). Furthermore, van Reekum et al. (2007) have found high PWB to be strongly correlated with activation in the ventral ACC in response to negative stimuli. ACC activation is known for down-regulating amygdala functioning when facing potentially aversive information (Davidson, 2004). Consequently, van Reekum et al., (2007) found that amygdalar activation was lower in response to the unpleasant arousing stimuli in people with a higher PL score, suggesting high PWB and PL being predictors for lower amygdalar activation in response to unpleasant arousing stimuli (van Reekum et al., 2007). In another study Lazar (2014) identified a positive correlation between increased PWB and GM volume in the pontine tegmentum, locus coeruleus, nucleus raphe pontis, and the sensory trigeminal nucleus bilaterally following an eight-week MBSR course. Further correlations between GM volume and PWB have been found by Lewis et al. (2013) as they saw a positive correlation between PWB, PG, PRWO and PL and GM volume in the right insular cortex. In addition, PRWO and PG had positive correlations with insular GM volume on the left side as well (Lewis et al., 2013).

Furthermore, to be able to interpret the results from both the neuroscientific- and the additional biological research, they will first be coupled with each subscale. This will be done to more specifically see which neuroscientific- and additional biological findings each specific subscale are linked to. And, the division of the subscales will additionally be made as no other study have done this, to the author's knowledge. Consequently, the distribution of the subscales and their specific biology, might add clarity and an enhanced understanding of each subscale's individual contribution to PWBc. The neuroscientific- and additional biological findings that have been linked to PWBc will then be used as a basis for further speculation on how biology contributes to high PWBc. The discussion will end with a total combined proposal of what biological and psychological features an individual with high PWBc might have.

AU, meaning being able to manage one's life and one's surroundings successfully has been positively linked to noradrenalin (Ryff et al., 2004). AU is the subscale with least existing results tied to it in this thesis.

Central features of EM are to be able to manage ones life and surroundings successfully. EM has been positively correlated to greater activation in the left frontocortal site compared to the left (Urry et al., 2004). Outside of the neuroscientific research, EM has been negatively correlated with lower levels of HbA1c (Ryff et al., 2004). In another study including inflammatory biomarkers, EM has been found to correlate negatively to plasma soulable IL-6 receptors (Friedman et al., 2007). Moreover, a negative link between cortisol and EM was found by Lindfors och Lundberg (2002).

PRWO involve being able to have empathic and affectionate feelings and being capable to love, nurture friendships and feel connected to others (Ryff, 1989b). PRWO have been positively correlated to insular cortex GM volume on both the right and the left side (Lewis et al., 2013) as well as to greater activation in the left frontocortal site compared to the

left (Urry et al., 2004), adrenalin (Ryff et al., 2006) and lower levels of HbA1c (Ryff et al., 2004). Furthermore, high PRWO have been positively linked to lower plasma IL-6 (Friedman et al., 2007).

PL include having a belief that life is meaningful and has purpose, being involved in growth processes and having goals that include being productive (Ryff, 1989b). PL has been found to have a negative correlation to left amygdala acitivty in response to unpleasant arousing stimuli (van Reekum et al., 2007). A positive correlation has been found between PL and greater activation in the left frontocortal site compared to the left (Urry et al., 2004) and right insular cortex GM volume (Lewis et al., 2013). Results from research on PWBc and HbA1c have found PL to mediate the relationship between HbA1c level and income, meaning that having low income combined with low scores on PL results in higher levels of HbA1c (Tsenkova et al., 2007). A positive correlation with HDL cholesterol and PL was found by Ryff et al. (2004), as well as between PL and lower levels of cortisol (Ryff et al., 2004). PL has also a negative correlation to plasma levels of soulable IL-6 receptors (Friedman et al., 2007) and IL-6 (Friedman & Ryff, 2012). And finally, PL has particularly been shown to reduce the risk of developing AD (Boyle et al., 2010), having a stroke (Kim et al., 2013) or dying (Boyle et al., 2009).

The subscale SA comprises of central features such as having a general acceptance of oneself, others and the nature as a whole (Ryff, 1989a). SA has been positively correlated with greater activation in the left frontocortal site compared to the left (Urry et al., 2004). Moreover, SA has been linked to lower levels of HbA1c (Ryff et al., 2004).

PG includes exploration of one's potentials and growing as a person throughout life. PG has been positively correlated with both right and left insular cortex GM volume (Lewis et al., 2013), HDL cholesterol and total cholesterol (Ryff et al., 2004). PG has also been found to mediate the relationship between HbA1c and income (Tsenkova et al., 2007). In

addition, PG has been linked to lower levels of daily cortisol output (Ryff et al., 2004).

And finally the linkages to PWB. In the study by van Reekum et al. (2007) they detected a positive correlation between PWB and ventral ACC when viewing unpleasant and arousing pictures. Furthermore, GM volume of the pons/raphe/locus coeruleus area in the brainstem has also been positively related to PWB (Lazar, 2014). In another study, a positive linkage between PWB and right insular cortex GM volume was found (Lewis et al., 2013). Heller et al. (2013) identified people with high PWB having stronger sustained striatal activity in the ventral striatum and dorsolateral PFC in response to positively arousing affective stimuli, in turn leading to lower cortisol output. A similar result was found by Lindfors and Lundberg (2002) as they discovered PWB to be negatively linked to cortisol. And last, a negative correlation between both physical- (nausea, stomach-ache, colds, head-ache) and musculoskeletal (pain in back, neck, wrists) symptoms and PWB was found by Lindfors (2002) and Lindfors and Lundberg (2002).

With all findings considered, an initial biological profile of a fully functioning person is starting to be formed. Now we go further to integrate the biological profile as a basis for proposing the psychological profile of a person with high PWBc. Even as it is speculative and caution must be taken when interpreting results, we can see some points of convergence in the research.

The most recurrent feature in the research relates to stress, in which negative correlations have been found to PG, PL, EM and PWB in repeated results. The stress-generating hormone cortisol (Gazzaniga et al., 2009) is the only marker that has been specifically measured in both the neuroscientific- (Heller et al., 2013) and in the additional biological research (Lindfors & Lundberg, 2002; Ryff et al., 2004). In all included studies lower level of cortisol was linked to higher level of PWBc (Heller et al, 2013; Lindfors & Lundberg, 2002; Ryff et al., 2004). As cortisol is related to stress (Gazzaniga et al., 2009) an

additional related findig by van Reekum et al. (2007) can be discussed in this context. In van Reekum et als. (2007) neuroscientific study where they did not directly measure cortisol, but amygdala activity, they found high PL being linked to lower activity in the amygdala when individuals viewed unpleasant arousing pictures. As activity in the amygdala is involved in initiating the stress response, hence releasing cortisol (Davidson, 2004) van Reekum et als. (2007) result regarding PWB and the positive correlation to ventral ACC activation might be of interest in this context. Namely, the relevance of van Reekum et als. (2007) finding is due to that activation in the ventral ACC when viewing unpleasant arousing stimuli initiate a lower activity in the amygdala, which may reduce the stress response, and subsequently the cortisol level (Davidson, 2004). In essence, as high PWB increased the activation in the ventral ACC and PL was positively correlated with lower amygdala activity, this result might indicate that PWBc can be protective against stress. Additionally, in the study by Lazar (2014) they employed a MBSR course to influence the level of PWBc. As stress was reduced, the PWB increased, suggesting that less stress may increase PWB. This result add to van Reekum et als. (2007) finding, further strengthening the indication that PWBc might be involved in reducing stress. Furthermore, individuals with chronic stress have shown to have smaller hippocampal volume, which might lead to impaired episodic episodic memory (Davidson, 2004; Gazzaniga et a., 2009; Lupien et al., 2005), indicating that PWBc can help maintaining an intact memory. In addition, the hippocampus is also involved in feedback regulation of the HPA axis, thus suggested to be important for emotion regulation. Hence, an impaired hippocampal function could lead to deficient emotional control (Davidson, 2004; Olson, 2007). With this linkage to the hippocampus, one might also infer that PWBc aid in facilitation of emotional control (Olson, 2007). Furthermore, high cortisol influence many negative health outcomes such as impaired immunity and insulin resistance (McEwen, 1998), indicating PWBc also having protective functions against these deficiencies. Furthermore,

knowing that higher levels of cortisol produces stress (Gazzaniga et al., 2009), we can find further convergence in the findings from the additional biological research. First, from the immunological research it was found that higher PWBc (Friedman et al., 2007; Friedman & Ryff, 2012) is linked to lower levels of IL-6. High IL-6 is in turn positively associated with stress (Black, 2003), leading to a stronger indication that PWBc might be protective against stress. And second, as having strong psychological resources have been positively linked to coping better with stress (Taylor et al., 2008), it might be possible that high PWBc is influenced by having psychological abilities such as learning, attention, and motivation (Haber & Knutsson, 2009). This can be inferred as PWBc have been positively associated to parts of the reward circuitry that facilitates mentioned psychological abilities (Haber & Knutsson, 2009). Furthermore, high cortisol is also related to several forms of cancer, multiple sclerosis, post-traumatic stress disorder (Sapse, 1984), major depression and asthma (Gazzaniga et al., 2009), meaning that with the lowering effect PWBc has on cortisol, PWBc can also have a protective function against these diseases. Yet, one single measure has indicated a negative relation to stress from a health-promotion perspective, and that is that PRWO has been positively correlated to adrenalin (Ryff et al., 2006). Adrenalin might increase stress if it becomes too high (Olson, 2007), which might be counterproductive if the other positive, seen from a health promotion view, results are being taken in to consideration. Finally, with all results related to cortisol are being summed up, we can find an indication that a person with high PWBc might be biologically and psychologically protected against stress and cortisol-related diseases. A person of high PWBc might therefore be characterized by the opposite of being stressed, perhaps having a peaceful and calm personality.

The strongest link to a psychological feature a person with high PWBc probably would have, is goal directed behaviour. This inference is made as goal directed behaviour have been linked to six of the brain regions that have been found to have a positive link to

PWBc. Namely; the insula (from Lewis et al., 2013) (Haber & Knutson, 2009), ventral striatum and the dorsolateral PFC (from Heller et al., 2013) (Menon & Uddin, 2010), asymmetrical prefrontal activation (from Urry et al., 2004) (Harmon-Jones & Allen, 1997), and ACC (from van Reekum et al., 2007) (Miller, Cohen & Ritchey, 2002). Strengthening this inference, the closely related abilities approach-oriented behaviour and active guidance of behaviour has been linked to brain regions positively correlated to high PWBc, namely, greater left than right PFC activity (Harmon-Jones & Allen, 1997) and insular cortex GM volume (Menon & Uddin, 2010) respectively.

A further recurrent finding regards greater left frontocortal site activity than right which have been found in high EM, PRWO, PL and SA. Greater left frontocortal site activity has been linked to being able to recover from negative emotional challenges (Jackson et al., 2003) and being able to suppress negative unwanted emotions (Jackson et al., 2000). Subsequently, a person with high PWBc might therefore have such abilities to be able to produce features central features of EM, PRWO, PL and SA, such as mastering ones life (EM), ability to care for others (PRWO) having capacity to hold up one's internal structure (PL), seeing one self as valuable and holding a positive attitude towards oneself (SA).

Another point of convergence in was found in insular cortex GM volume which has been found in positive relation to PRWO, PL, PG and PWB. The insula is involved in psychological resources such as agentic control (Lee & Reeve, 2012) personal agency (Waterman, 1993) and emotional regulation (Olson, 2007). This suggests that agentic control, personal agency and emotional regulation are abilities which might generate maintenance of strong quality relationships and being able to love central notions of (PRWO), seeing life as meaningful and having productive goals (PL) and exploration of ones potentials (PG), which are important features of PWBc.

Next coherent result regard the inflammatory protein IL-6, which have been

negatively linked to PWBc in two included studies (Friedman et al., 2007; Friedman & Ryff, 2012). As IL-6 has inflammatory properties (Jones et al., 2001) higher levels might increase the risk for AD, osteoporosis, cardiovascular disease (Papanicolaou et al., 1998). Additionally, higher IL-6 have also been positively linked to days sick in a year, health problems interfering with daily activities, depression in older adults (Pennix et al., 2003) and stress (Black, 2003). Consequently, PWBc might have protective functions to inflammatory related diseases, less risk of being in poor health and experience stress, meaning that an individual with high PWBc would have good physical health with no inflammation.

Moreover, PWBc tend to have recurrent a negative correlations to HbA1c (Ryff et al., 2004) which might imply that PWBc has a protective biological function against diabetes (Tsenkova et al., 2007).

Another discovery during this process has been that PWB and depression seem to have opposite neural correlations. The first area is the locus coreleus, an area known to indicate depression as the GM density may shrink in individuals with depression (Arango et al., 1996). This area was positively correlated with PWB in Lazar's (2014) study, where the GM volume was increased when participants improved their PWB. The second area is the insula, which have been negatively linked to depression (Bechdolf et al., 2012) and positively correlated to PWB, PRWO, PG and PL (Lewis et al., 2013). These results indicate that PWBc and depression share a biological link and it could be proposed that PWBc and depression have a mirrored neural correlate.

The mentioned convergence points such as stress, cortisol, goal directed behaviour, activation of the reward circuitry, insular cortex volume, greater left frontocortal site activity than right, IL-6, HbA1c and depression, are the findings with the most strength as they have related to multiple features of PWBc. But a few other interesting results are also notable.

The first is that PWB has been positively linked to the ventral ACC (van Reekum et

al., 2007) which is involved in cognitive control (Miller et al., 2002). As ventral ACC is coupled with cognitive control it might be an indication that people with good cognitive contol may have higher PWBc, suggesting that cognitive control might be important for PWBc. Furthermore, positive linkages between PWB and GM volume in areas in the brainstem (the pontine tegmentum, locus coeruleus, raphe pontis and sensory trigeminal nucleus) has been found by Lazar (2014). The pontine tegmentum facilitates behaviours such as learning, wakefulness and attention, but is also involved in reward (Kobayashi & Okada, 2007). The locus coeruleus have been shown to be concerned with modulating behaviour and adjusting it to environmental demands (Aston-Jones & Cohen, 2005). The locus coeruleus is also significant for emotional expressions as it projects noradrenaline throughout the brain (Nyberg, 2009). The nucleus raphe pontis facilitates cognitive functions as well as being involved in emotions (Olsen, 2007), and the sensory trigeminal nucleus is involved in mood and arousal-regulation (Aston-Jones & Cohen, 2005). As these brainstem areas are connected to mentioned abilities such as learning, wakefulness, attention and modulation of behaviour to environmental demands, the suggestion is that these abilities might be important for facilitation of high PWBc. Moreover, PL and PG has been positively correlated with HDL cholesterol and negatively to total cholesterol (Ryff et al., 2004). As HDL might have a protective biological function, and total cholesterol reduces that protection, this finding indicates that PWBc may reduce risk for cardiovascular illnesses such as heart disease (Freeman & Junge, 2005). In addition, PL has been shown to reduce the risk for dying (Boyle et al., 2009), stroke (Kim et al., 2013) and AD (Boyle, 2010). PWBc has also been negatively correlated with less physical (nausea, stomach-ache, colds, head-ache) and musculoskeletal (pain in back, neck, wrists) symptoms (Lindfors, 2002; Lindfors & Lundberg, 2002), indicating that PWBc might influence physical comfort. And finally, a positive correlation between AU and noradrenalin has been detected (Ryff et al., 2004). Higher noradrenalin is

linked to excitement (Gazzaniga et al., 2009), attention (Olson, 2007) and increased PA and NA (Harmer, Shelley, Cowen & Goodwin, 2004). This linkage might implicate that the psychological abilities significant for AU such as independence, handling social pressures well, standing by one's own convictions (Ryff & Keyes, 1995) may require the excitatory (Gazzaniga et al., 2009) and attention strengthening (Olson, 2007) effect of noradrenalin.

With all results taken together we have an initial insight to the biological and psychological profile of a person with high PWBc. All results are difficult to interpret at this initial stage and suggestions of what might influence high PWBc are somewhat speculative and should be done with caution. Yet, a proposal of what a biological and psychological profile of a fully functioning person may comprise will now be provided.

The first suggestion regards the biological profile of high PWBc. This biological profile is suggested to be composed of features such as; greater left than right frontocentral activity, greater GM insular cortex volume, less amygdala activity in the face of threat, greater GM volume in the pontine tegmentum, locus coeruleus, raphe pontis and sensory trigeminal nucleus in the brainstem, greater ventral ACC activation when facing threat, an active reward circuit, sustained striatal activity in the dorsolateral PFC and ventral striatum in response to positive events, lower levels of HbA1c, cortisol and IL-6, and higher levels of HDL cholesterol and noradrenalin. With this proposed biological profile the individual would have reduced biological risk in general. Yet, one might more specifically be protected against neuroendocrinal, inflammatory and cardiovascular-related conditions, especially AD, stroke, diabetes and stress. In addition, the individual would also have fewer negative physical and musculoskeletal symptoms, and a reduced risk of cancer, depression and dying.

Moreover, the proposal of a psychological profile of an individual with high PWBc primary includes; a general goal directed behaviour and being calm and peaceful as central features. In addition, being able to regulate ones emotions and suppress unwanted feelings,

having more PA than NA, being able to actively guide one's behaviour, having personal agency, being able to learn, being attentive and being able to adjust one's behaviour to environmental demands are also suggested to be important for having and maintaining high PWBc.

Limitations and Future Directions

The limitations of this thesis have mostly been regarding the restricted amount of studies on overall biological research on eudaimonia and the ambiguity of EWB in general. Due to these constraints there are few comparable results, hence the choice of limiting this paper to one measurement, the SPWB. Especially, the small quantity of investigations within the field of neuroscience makes it hard to generalize results. In addition, the majority of the included studies have included participants from the West, making the proposed biological and psychological profiles mainly applicable to the Western view of WB. A thought for the future would be to carry out more studies on PWBc in other countries outside the West, especially the neuroscientific research in which the currently available research is overrepresented by the Western individualistic approach. In addition, the sample sizes in the neuroscientific research are small, adding to the difficulty of generalizability. A further limitation is that there are only correlational studies, so it might be interesting to use other research designs, and replicate studies to strengthen the credibility of results. Regarding the problem with definitions, conceptualizations and operationalizations of EWB, there are existing suggestions coming from Huta and Waterman (2013) for how to make the field of EWB research more understandable. The suggestions include recommendations of specifying the core definitional elements of EWB and being clearer when stating categories of analysis and levels of measurements, both in own studies and when referring to others. But as the classification system is recently published, it has have not yet received any response, hence not been accepted or implemented in studies. But even if the classification system will be

accepted and implemented, there still are, and will be, different opinions about what EWB comprise. Yet, with a collective effort to clarify understandings of EWB in investigations and literature, it would make a better ground for comprehending the different approaches and being able to recognize the different interpretations in a more coherent way, possibly leading to more comparable results. A further note for being cautious when interpreting the suggestions in this thesis is that even if the scope has been limited to measure EWB as PWB with SPWB, there are still different lengths of the instrument adding to further variations in validity and reliability. Nevertheless, the presented results from various researchers, and the proposal of a biological and a psychological profile included here, will hopefully serve as an inspiration for further efforts in the process of finding a sufficient explanation for the psychology and biology of a fully functioning person. In addition, this small contribution might also inspire fields such as health promotion as the biological and psychological underpinnings of PWBc may add to knowledge on how to prevent stress, reduce biological risk and being able to improve individual-, as well as societal health.

Conclusion

The underlying psychology of well-being has been a theme of great philosophical interest for centuries (Linley et al., 2009). Despite this long history, no coherent understanding of the concept exist and the field of well-being research is signified by its ambiguity (Huta & Waterman, 2013). Yet, the most common understanding of the concept is the Aristotelian division of well-being in research as hedonic well-being and eudaimonic well-being (Deci & Ryan, 2008; Ryan & Deci, 2001). In this thesis Ryff's (1989a) interpretation of the Aristotelian notion of eudaimona as psychological well-being has been reviewed. Ryff's (1989a) understanding of the concept has generated the measure Six Factor Scales of Psychologial Well-Being, which has been used as a foundation for exploring the biology and psychology of eudaimonia. With the young history of biological research on

well-being and the problems of defining EWB in mind, all inferences regarding the underlying biology must be done with caution (Waterman, 2008). Nevertheless, this thesis has generated a proposal for a biological and a psychological profile of an individual with high PWBc. The biological profile has included greater GM volume in the insular cortex and the pons/raphe/locus coeruleus area in the brainstem, asymmetrical prefrontal activation, sustained striatal activity in the dorsolateral PFC and ventral striatum, greater ventral ACC activation, an active reward circuit, lower amygdala activity, higher levels of noradrenalin and HDL cholesterol and lower levels of HbA1c, cortisol, IL-6 and total cholesterol. An individual with this biological profile would have a reduced biological risk in general, but specifically be less likely of having neuroendocrinal, inflammatory and cardiovascular-related conditions as well as negative physical symptoms. An additional protective factor would relate to a reduced risk of AD, diabetes, stress, cancer, depression and dying. In addition, an exploratory psychological profile of high PWBc has been suggested. In this psychological profile it has been emphasised that being goal oriented and calm might contribute the most to high PWBc. But further suggestions also include having a developed emotional regulation including being able to suppress unwanted emotions. In addition, having more PA than NA, being attentive, being able to learn, having personal agentic control and able to navigate in one's environment successfully are all abilities that are proposed to influence high PWBc. As stated, even though the proposed biological and psychological profiles are tentative, they might hopefully serve as an inspiration for further investigation of the biological and psychological contours of human well-being.

Finally, in Aristotle's (4th century B.C.E/1925) original notions of eudaimonia he spoke of engagement in virtuous activities closely related to the human soul, development of the best within us, fulfilment of our true nature and having a sense of meaning, purpose and positive engagement in life as essential for being fully functioning. Equally, in the current

thesis, a proposal of a biological profile has generated a basis for describing the psychological profile of a fully functioning person (i.e. high PWBc). The psychological profile's central qualities has included being goal directed, have good emotional and cognitive control, and being peaceful. However, if this proposed tentative psychological profile of high PWBc generates Aristotle's (4th century B.C.E/1925) true idea of a fully functioning person remains an unsolved query left for future investigation.

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Appendix

Six Factor Scales of Psychological Well-Being (84-items)

The following set of questions deals with how you feel about yourself and your life. Please remember that there are no right or wrong answers.

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
1. Most people see me as loving and affectionate.	1	2	3	4	5	6
2. Sometimes I change the way I act or think to be more like those around me.	1	2	3	4	5	6
3. In general, I feel I am in charge of the situation in which I live.	1	2	3	4	5	6
4. I am not interested in activities that will expand my horizons.	1	2	3	4	5	6
5. I feel good when I think of what I've done in the past and what I hope to do in the future.	1	2	3	4	5	6
6. When I look at the story of my life, I am pleased with how things have turned out.	1	2	3	4	5	6
7. Maintaining close relationships has been difficult and frustrating for me.	1	2	3	4	5	6
8. I am not afraid to voice my opinions, even when they are in opposition to the opinions of most people.	1	2	3	4	5	6

9. The demands of everyday life often get me down.	1	2	3	4	5	6
10. In general, I feel that I continue to learn more about myself as time goes by.	1	2	3	4	5	6
11. I live life one day at a time and don't really think about the future.	1	2	3	4	5	6
12. In general, I feel confident and positive about myself.	1	2	3	4	5	6
13. I often feel lonely because I have few close friends with whom to share my concerns.	1	2	3	4	5	6
14. My decisions are not usually influenced by what everyone else is doing.	1	2	3	4	5	6
15. I do not fit very well with the people and the community around me.	1	2	3	4	5	6
16. I am the kind of person who likes to give new things a try.	1	2	3	4	5	6
17. I tend to focus on the present, because the future nearly always brings me problems.	1	2	3	4	5	6
18. I feel like many of the people I know have gotten more out of life than I have.	1	2	3	4	5	6
19. I enjoy personal and mutual conversations with family members or friends.	1	2	3	4	5	6
20. I tend to worry about what	1	2	3	4	5	6

other people think of me.						
21. I am quite good at managing the many responsibilities of my daily life.	1	2	3	4	5	6
22. I don't want to try new ways of doing things - my life is fine the way it is.	1	2	3	4	5	6
23. I have a sense of direction and purpose in life.	1	2	3	4	5	6
24. Given the opportunity, there are many things about myself that I would change.	1	2	3	4	5	6
25. It is important to me to be a good listener when close friends talk to me about their problems.	1	2	3	4	5	6
26. Being happy with myself is more important to me than having others approve of me.	1	2	3	4	5	6
27. I often feel overwhelmed by my responsibilities.	1	2	3	4	5	6
28. I think it is important to have new experiences that challenge how you think about yourself and the world.	1	2	3	4	5	6
29. My daily activities often seem trivial and unimportant to me.	1	2	3	4	5	6
30. I like most aspects of my personality.	1	2	3	4	5	6
31. I don't have many people who want to listen when I need to talk.	1	2	3	4	5	6

32. I tend to be influenced by people with strong opinions.	1	2	3	4	5	6
33. If I were unhappy with my living situation, I would take effective steps to change it.	1	2	3	4	5	6
34. When I think about it, I haven't really improved much as a person over the years.	1	2	3	4	5	6
35. I don't have a good sense of what it is I'm trying to accomplish in life.	1	2	3	4	5	6
36. I made some mistakes in the past, but I feel that all in all everything has worked out for the best.	1	2	3	4	5	6
37. I feel like I get a lot out of my friendships.	1	2	3	4	5	6
38. People rarely talk to me into doing things I don't want to do.	1	2	3	4	5	6
39. I generally do a good job of taking care of my personal finances and affairs.	1	2	3	4	5	6
40. In my view, people of every age are able to continue growing and developing.	1	2	3	4	5	6
41. I used to set goals for myself, but that now seems like a waste of time.	1	2	3	4	5	6
42. In many ways, I feel disappointed about my achievements in life.	1	2	3	4	5	6
43. It seems to me that most other						

people have more friends than I do.	1	2	3	4	5	6
44. It is more important to me to "fit in" with others than to stand alone on my principles.	1	2	3	4	5	6
45. I find it stressful that I can't keep up with all of the things I have to do each day.	1	2	3	4	5	6
46. With time, I have gained a lot of insight about life that has made me a stronger, more capable person.	1	2	3	4	5	6
47. I enjoy making plans for the future and working to make them a reality.	1	2	3	4	5	6
48. For the most part, I am proud of who I am and the life I lead.	1	2	3	4	5	6
49. People would describe me as a giving person, willing to share my time with others.	1	2	3	4	5	6
50. I have confidence in my opinions, even if they are contrary to the general consensus.	1	2	3	4	5	6
51. I am good at juggling my time so that I can fit everything in that needs to be done.	1	2	3	4	5	6
52. I have a sense that I have developed a lot as a person over time.	1	2	3	4	5	6
53. I am an active person in						

carrying out the plans I set for myself.	1	2	3	4	5	6
54. I envy many people for the lives they lead.	1	2	3	4	5	6
55. I have not experienced many warm and trusting relationships with others.	1	2	3	4	5	6
56. It's difficult for me to voice my own opinions on controversial matters.	1	2	3	4	5	6
57. My daily life is busy, but I derive a sense of satisfaction from keeping up with everything.	1	2	3	4	5	6
58. I do not enjoy being in new situations that require me to change my old familiar ways of doing things.	1	2	3	4	5	6
59. Some people wander aimlessly through life, but I am not one of them.	1	2	3	4	5	6
60. My attitude about myself is probably not as positive as most people feel about themselves.	1	2	3	4	5	6
61. I often feel as if I'm on the outside looking in when it comes to friendships.	1	2	3	4	5	6
62. I often change my mind about decisions if my friends or family disagree.	1	2	3	4	5	6
63. I get frustrated when trying to plan my daily activities because I never accomplish the things I set out to do.	1	2	3	4	5	6

64. For me, life has been a continuous process of learning, changing, and growth.	1	2	3	4	5	6

65. I sometimes feel as if I've done all there is to do in life.	1	2	3	4	5	6
66. Many days I wake up feeling discouraged about how I have lived my life.	1	2	3	4	5	6
67. I know that I can trust my friends, and they know they can trust me.	1	2	3	4	5	6
68. I am not the kind of person who gives in to social pressures to think or act in certain ways.	1	2	3	4	5	6
69. My efforts to find the kinds of activities and relationships that I need have been quite successful.	1	2	3	4	5	6
70. I enjoy seeing how my views have changed and matured over the years.	1	2	3	4	5	6
71. My aims in life have been more a source of satisfaction than frustration to me.	1	2	3	4	5	6
72. The past had its ups and downs, but in general, I wouldn't want to change it.	1	2	3	4	5	6
73. I find it difficult to really open up when I talk with others.	1	2	3	4	5	6
74. I am concerned about how other people evaluate the choices I have made in my life.	1	2	3	4	5	6

75. I have difficulty arranging my life in a way that is satisfying to me.	1	2	3	4	5	6
76. I gave up trying to make big improvements or changes in my life a long time ago.	1	2	3	4	5	6
77. I find it satisfying to think about what I have accomplished in life.	1	2	3	4	5	6
78. When I compare myself to friends and acquaintances, it makes me feel good about who I am.	1	2	3	4	5	6
79. My friends and I sympathize with each other's problems.	1	2	3	4	5	6
80. I judge myself by what I think is important, not by the values of what others think is important.	1	2	3	4	5	6

81. I have been able to build a home and a lifestyle for myself that is much to my liking.	1	2	3	4	5	6
82. There is truth to the saying that you can't teach an old dog new tricks.	1	2	3	4	5	6
83. In the final analysis, I'm not so sure that my life adds up to much.	1	2	3	4	5	6
84. Everyone has their weaknesses, but I seem to have more than my share.	1	2	3	4	5	6

Scoring Instructions

(+) indicates positively scored items

(-) indicates negatively scored items

AUTONOMY

(-) 1. Sometimes I change the way I act or think to be more like those around me.

(+) 2. I am not afraid to voice my opinions, even when they are in opposition to the opinions of most people.

(+) 3. My decisions are not usually influenced by what everyone else is doing.

(-) 4. I tend to worry about what other people think of me.

(+) 5. Being happy with myself is more important to me than having others approve of me.

(-) 6. I tend to be influenced by people with strong opinions.

(+) 7. People rarely talk me into doing things I don't want to do.

(-) 8. It is more important to me to "fit in" with others than to stand alone on my principles.

(+) 9. I have confidence in my opinions, even if they are contrary to the general consensus.

(-) 10. It's difficult for me to voice my own opinions on controversial matters.

(-) 11. I often change my mind about decisions if my friends or family disagree.

(+) 12. I am not the kind of person who gives in to social pressures to think or act in certain ways.

(-) 13. I am concerned about how other people evaluate the choices I have made in my life.

(+) 14. I judge myself by what I think is important, not by the values of what others think is important.

ENVIRONMENTAL MASTERY

(+) 1. In general, I feel I am in charge of the situation in which I live.

(-) 2. The demands of everyday life often get me down.

(-) 3. I do not fit very well with the people and the community around me.

(+) 4. I am quite good at managing the many responsibilities of my daily life.

(-) 5. I often feel overwhelmed by my responsibilities.

(+) 6. If I were unhappy with my living situation, I would take effective steps to change it.

(+) 7. I generally do a good job of taking care of my personal finances and affairs.

(-) 8. I find it stressful that I can't keep up with all of the things I have to do each day.

(+) 9. I am good at juggling my time so that I can fit everything in that needs to get done.

(+) 10. My daily life is busy, but I derive a sense of satisfaction from keeping up with everything.

(-) 11. I get frustrated when trying to plan my daily activities because I never accomplish the things I set out to do.

(+) 12. My efforts to find the kinds of activities and relationships that I need have been quite successful.

(-) 13. I have difficulty arranging my life in a way that is satisfying to me.

(+) 14. I have been able to build a home and a lifestyle for myself that is much to my liking.

PERSONAL GROWTH

(-) 1. I am not interested in activities that will expand my horizons.

(+) 2. In general, I feel that I continue to learn more about myself as time goes by.

(+) 3. I am the kind of person who likes to give new things a try.

(-) 4. I don't want to try new ways of doing things--my life is fine the way it is.

(+) 5. I think it is important to have new experiences that challenge how you think about yourself and the world.

(-) 6. When I think about it, I haven't really improved much as a person over the years.

(+) 7. In my view, people of every age are able to continue growing and developing.

(+) 8. With time, I have gained a lot of insight about life that has made me a stronger, more capable person.

(+) 9. I have the sense that I have developed a lot as a person over time.

(-) 10. I do not enjoy being in new situations that require me to change my old familiar ways of doing things.

(+) 11. For me, life has been a continuous process of learning, changing, and growth.

(+) 12. I enjoy seeing how my views have changed and matured over the years.

(-) 13. I gave up trying to make big improvements or changes in my life a long time ago.

(-) 14. There is truth to the saying you can't teach an old dog new tricks.

POSITIVE RELATIONS WITH OTHERS

(+) 1. Most people see me as loving and affectionate.

(-) 2. Maintaining close relationships has been difficult and frustrating for me

(-) 3. I often feel lonely because I have few close friends with whom to share my concerns

(+) 4. I enjoy personal and mutual conversations with family members or friends.

(+) 5. It is important to me to be a good listener when close friends talk to me about their problems.

(-) 6. I don't have many people who want to listen when I need to talk.

(+) 7. I feel like I get a lot out of my friendships.

(-) 8. It seems to me that most other people have more friends than I do.

(+) 9. People would describe me as a giving person, willing to share my time with others.

(-) 10. I have not experienced many warm and trusting relationships with others.

(-) 11. I often feel like I'm on the outside looking in when it comes to friendships.

(+) 12. I know that I can trust my friends, and they know they can trust me.

(-) 13. I find it difficult to really open up when I talk with others.

(+) 14. My friends and I sympathize with each other's problems.

PURPOSE IN LIFE

(+) 1. I feel good when I think of what I've done in the past and what I hope to do in the future.

(-) 2. I live life one day at a time and don't really think about the future.

(-) 3. I tend to focus on the present, because the future nearly always brings me problems.

(+) 4. I have a sense of direction and purpose in life.

(-) 5. My daily activities often seem trivial and unimportant to me.

(-) 6. I don't have a good sense of what it is I'm trying to accomplish in life.

(-) 7. I used to set goals for myself, but that now seems like a waste of time.

(+) 8. I enjoy making plans for the future and working to make them a reality.

(+) 9. I am an active person in carrying out the plans I set for myself.

(+) 10. Some people wander aimlessly through life, but I am not one of them.

(-) 11. I sometimes feel as if I've done all there is to do in life.

(+) 12. My aims in life have been more a source of satisfaction than frustration to me.

(+) 13. I find it satisfying to think about what I have accomplished in life.

(-) 14. In the final analysis, I'm not so sure that my life adds up to much.

SELF-ACCEPTANCE

(+) 1. When I look at the story of my life, I am pleased with how things have turned out.

(+) 2. In general, I feel confident and positive about myself.

(-) 3. I feel like many of the people I know have gotten more out of life than I have.

(-) 4. Given the opportunity, there are many things about myself that I would change.

(+) 5. I like most aspects of my personality.

(+) 6. I made some mistakes in the past, but I feel that all in all everything has worked out for the best.

(-) 7. In many ways, I feel disappointed about my achievements in life.

(+) 8. For the most part, I am proud of who I am and the life I lead.

(-) 9. I envy many people for the lives they lead.

(-) 10. My attitude about myself is probably not as positive as most people feel about themselves.

(-) 11. Many days I wake up feeling discouraged about how I have lived my life.

(+) 12. The past had its ups and downs, but in general, I wouldn't want to change it.

(+) 13. When I compare myself to friends and acquaintances, it makes me feel good about who I am.

(-) 14. Everyone has their weaknesses, but I seem to have more than my share.