CHAPTER 2

Positive Psychophysiology

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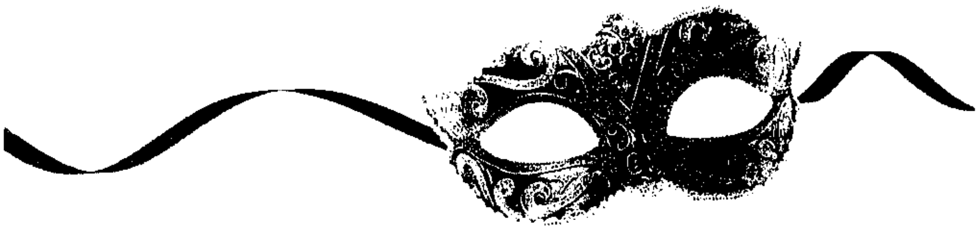

Learning Objectives

What exactly is our body made of and how do the mind and body work together to increase psychological and physical flourishing? This chapter will set the scene in order to understand the influence of our psychological processes on our body and vice versa. The body systems as well as tools used in psychophysiology will be detailed with a particular emphasis on the role of cortisol in wellbeing.

Topics include

- Definition of psychophysiology
- Measurement tools in psychophysiology
- Anatomy 101
- Positive psychophysiology
- The role of cortisol and melatonin in optimal functioning
- The role of glucose in optimal functioning
- Heart rate variability
- Facial feedback hypothesis

MOCK ESSAY QUESTIONS

1 Critically discuss the role of cortisol within physical and psychological flourishing.

2 What do positive psychology researchers stand to gain by including more objective physiological markers within their research?

Introduction

The term 'positive psychophysiology' was first used by Segerstrom et al. (2011) in their chapter within the Biological Perspectives Section on positive psychology (Sheldon et al., 2011). The study of the body, how it is affected by thoughts and emotions and how this can influence flourishing and health, is of upmost importance to those interested in the discipline. Positive psychophysiology seeks to use objective biological markers of the positive effects of wellbeing. We are now able to provide supportive research that 'positive psychological states are reflected in biological processes, objective physical health and mortality' (Low et al., 2011: 41).

Psychophysiology is 'the study of relations between psychological manipulations and resulting physiological responses, measured in the living organism to promote understanding of the relation between mental and bodily process' (Andreassi, 2007: 2). The behavioural links between the mind and the body in which psychophysiologists are most interested include: 'sleep, reactions to stress, problem solving, learning, memory, information processing, and perception' (p. 1).

Within the area of psychophysiology, researchers study areas of the body (e.g. brain, eyes, heart, skin, body fluids) to assess responses to changes in psychological state. The strategies available to provide this 'window' to the mind range from the non-invasive to more invasive procedures (e.g. PET) (see Table 2.1 for a review of measures).

Toughness theory

Richard Dienstbier was one of the original researchers to propose a physiological model of wellbeing (Dienstbier, 1989; Dienstbier and Pytlik Zillig, 2009). Toughness is a purely somatopsychic theory, focused on how the body influences the mind to enable resilience in the face of challenge. Toughness is defined as 'having a greater capacity for arousal and energy when needed' (p. 537) and is purported to spill over into enhanced emotional coping and stability. Toughness theory posits that we can train our neuroendocrine system, which can then have an effect on our personality, health and performance. There are four main principles that underlie toughness theory:

1 'All major physiological systems within an organism interact, so that the state of one system (e.g. the major muscles) will influence most others (e.g. the endocrine and neural systems).

Psychophysiology measures	Acronym	Uses
Positron emission tomography	PET	Similar to the fMRI, this measurement shows the anatomy and physiology of the brain. PET uses radioactive substances, delivered by an injection into the bloodstream, to examine their localization in the brain, e.g. oxygen and glucose usage (p. 15).
Functional magnetic resonance imaging	fMRI	Similar to the PET, fMRI shows the anatomy and physiology of the brain. It is less invasive than PET (as it does not require an injection) but still requires complex and expensive technology as well as the participant to stay very still during testing.
Magnetoencephalography	MEG	This measurement tool assesses the changes in the brain's magnetic fields (below the surface cortical area). It is less expensive to operate than PET and fMRI and provides accurate assessment of changes in brain activity over short periods of time (p. 14).
Electroencephalogram	EEG	This measurement tool assesses brain wave activity. It can study basal patterns of brain activity as well as responses to stimuli, called evoked potentials.
Event-related brain potential	ERP	This measure averages the output of the EEG responses to stimuli. It is useful to determine the time course of such responses (p. 14).
Electromyogram	EMG	This is used to measure muscle activity, e.g. in the face, to assess changes in expression, or skeletal muscles to assess postural changes.
Pupillometry	N/A	The measurement of variations in the diameter of the pupillary aperture of the eye, which is an indicator of autonomic nervous system activity (p. 289).
Electrooculography	EOG	This tool is used to measure electrical activity produced by eye movement.
Electrodermal activity	EDA	This tool assesses changes in electrical conductance at the surface of the skin and is an indication of sympathetic nervous system activity.
Neuroendocrine system		Products of the neuroendocrine system can be measured in body fluids, e.g. the hormone cortisol can be measured in blood, urine or saliva samples.
Electrocardiography	ECG	This can be used to assess electrical activity generated from the beating of the heart. It provides an indication of autonomic nervous system activity.

TABLE 2.1 Common psychophysiological measurement tools (Andreassi, 2007)

2 In order to maintain general health, physical systems should be stimulated and used in ways that maintain them near the midpoints of their genetically determined operating potentials.
3 The body must be exposed to environments it was designed to experience, and
4 The organism must behave in ways that correspond with the ways that it was designed to behave' (Dienstbier and Zillig, 2009: 537–8).

Toughness theory is more aligned to enabling individuals to stand 'tough' in the face of challenges (rather than used as coping mechanism after a negative event). At present, toughness-enhancing manipulations have generally been delivered in the laboratory setting, or through lifestyles and training programmes (e.g. aerobic exercise, cold weather). Overall, the activity must a) push the individual; b) be determined via the individuals starting levels of toughness; and c) have repetition with sufficient rest periods in between. The researchers argue that by going through this process, the body will build up resistance and toughness.

Toughness can be linked to the theory of salutogenesis which reflects optimal physical functioning (salutogenetic versus pathogenic) (Cassel and Suedfeld, 2006). The major issue with this model is that it is primarily based on animal research (rats, mice and dogs). With the advancement of modern technology, we will soon be able to understand the links between toughness and wellbeing. The next section will review what we know about the mind/body interactions, with a specific focus on cortisol in optimal human functioning.

Anatomy 101 (Tortora and Derrickson, 2009)

We humans are incredibly put together machines that function on a biological level, consisting of several co-existing systems, each with their own important functions and influences for optimal human functioning.

System	Components	Responsible for
Skeletal	The human skeletal system contains 206 (mostly paired) bones. Adult skeletons consist of two divisions: axial (80) and appendicular (126)	The skeleton acts as a 'framework' for the body, aiding movement and posture and providing protection of internal organs for survival
Digestive	The digestive system is a tubular system that extends from the mouth through to the anus (5–7 metres long). There are two groups of organs in the digestive system: gastrointestinal tract and accessory digestive organs (teeth, tongue, salivary glands, liver, gallbladder, pancreas) (p. 968)	Involved in the breakdown of food and completes six processes: ingestion, secretion, mixing and propulsion, digestion, absorption and defecation (pp. 968–9)

System	Components	Responsible for
Muscular	Contains 700 individual muscles which produce movement in the body and stabilize bones	The muscular system is responsible for mediating homeostasis within the body system, including movement regulating organ volume, moving substances within the body and producing heat (p. 366)
Lymphatic	Consists of a fluid called lymph and vessels (called lymphatic vessels)	The lymphatic system's main responsibility is providing defence against disease and illness and protecting immunity. Also linked to digestive and cardiovascular systems
Endocrine	Consists of the pituitary gland, thyroid and parathyroid, adrenal gland, pancreas, ovaries and testes	Together with the nervous system, the endocrine system works to coordinate all bodily systems ('a super system', p. 681). The endocrine on its own works through the release of hormones to regulate cells in other parts of the body
Adrenal glands	Part of the bigger endocrine system, these paired glands are small in size (3.5–5 grams) and separated into adrenal cortex (80–90 per cent) and adrenal medulla	Secretes steroid hormones, which are essential for survival. The adrenal medulla is responsible for the production of norepinephrine, epinephrine and small amounts of dopamine whilst the adrenal cortex secretes cortisol and DHEA (p. 703)
Nervous	Only weighing 2 kg, this is the most complex of the body systems. Contains two systems: central nervous system (CNS) and peripheral nervous system (PNS). The CNS is comprised of the brain and spinal cord whilst the PNS is comprised of all nervous tissue outside the CNS (p. 448). The PNS is divided into the somatic nervous system (SNS), autonomic nervous system (ANS) and enteric nervous system (ENS)	The CNS is responsible for deciphering sensory information and is the source of thoughts, emotions and memories (p. 448). The CNS is also responsible for muscle contraction and gland secretion. The PNS monitors changes in the internal and external environment. Overall the nervous system functions on three levels: sensory (input), integrative (process) and motor (output) (p. 448)
Cardiovascular	Comprises of blood, the heart and blood vessels	Blood is one of the major transporters of substances throughout the body and helps regulate the body and protect against disease. The heart is the pump that circulates blood throughout the body through blood vessels

Did you know?

We take 10 000 blinks, 20 000 breaths and 100 000 heart beats a day.

Psychoneuroimmunology (PNI)

The area of PNI focuses on the 'interactions among behavioural, neuroendocrine and immunological processes of adaptation' (Taylor, 2012: 244). Optimal functioning of the immune system is vital to our ability to ward off illness and disease, allergens and infections. The immune system is in a constant battle between deciphering what is 'self' and what is 'foreign' and trying to rid the body of harmful foreign invaders (Taylor, 2012: 344). Traditionally, the majority of studies have focused on biomarkers of dysfunction and predictors of stress and negative health (e.g. dysfunctional HPA axis and inflammatory activity). Contemporary research now embraces positive psychological processes linked to increased 'heart rate variability and anabolic hormones' (e.g. DHEA; Low et al., 2011: 46). However, we need further interaction and prospective research to advance the area of positive PNI.

The immune system

The immune system is divided into two types of immunity that work together: the natural immunity which is involved in the defence against numerous pathogens and specific immunity which revolves around the slow protection process against one type of pathogen. Our immune system has been attributed to both natural (e.g. derived from breastfeeding, in response to exposure to pathogens and illness) and artificial (in response to vaccinations) processes (Taylor, 2012).

There are several ways in which the body can protect against illness and disease. Phagocytosis is one such route and occurs when white blood cells (phagocytes) ingest microbes (foreign bodies such as infection).

B-lymphocytes are responsible for protection against bacteria toxins and prevention of re-infection (humoral immunity) and do so by the production of antibodies and their release into the blood stream. T-lymphocytes (Cytotoxic – Tc cells) and Helper (Th cells) are found in cell-mediated immunity. These are cells that help fight against viral infections that have infiltrated the system, such as cancer or parasites.

Physiological systems and their role in wellbeing

What are the mechanisms by which how you feel affects your health? The major systems which link the brain with the body include:

The nervous system (direct control of bodily organs by nerves)

The autonomic nervous system is the focus of most positive psychophysiology (Andreassi, 2007) and controls the bodily function within the 'digestive system, body temperature, blood pressure and many aspects of emotional behaviour' (p. 64). Although these processes usually function without our awareness, through the use of biofeedback and training techniques, researchers have been able to show that we can, when consciously trying, manipulate some of these functions in order to optimally function.

The sympathetic nervous system (SNS) is the reactive, integrated system that responds during periods of activation, such as feelings of fear, anticipation and excitement. Activation of the SNS induces physiological changes such as increased heart rate, secretion of adrenaline, sweating and pupil constriction. The parasympathetic nervous system (PNS), on the other hand, 'is the system of rest, repair and enjoyment' (p. 67). Balance between these two branches of the autonomic nervous system is essential for optimal functioning. The propensity for one of these systems to dominate over the other under certain circumstances, thereby producing appropriate physical responses, is a fundamental requirement for flourishing. If one system tends to dominate (typically the SNS, thereby inhibiting appropriate activation of the PNS) then the balance between these two branches of the nervous system is compromised and optimal functioning is compromised. In order to assess this balance, psychophysiologists can study heart rate variability (HRV) (Segerstrom et al., 2011).

The hypothalamic pituitary adrenal axis and the role of cortisol

When we are scared or frightened, the brain immediately reacts, sending signals to the hypothalamic pituitary adrenal (HPA) axis, which secretes the hormone cortisol from the adrenal cortex. This process ensures that increased levels of cortisol are passed through the entire system in less than 15 minutes (Clow, 2013). Cortisol is a steroid hormone and essential for many functions within the body system (see Figure 2.1). Cortisol's primary function is to regulate all these processes around a 24-hour cycle. Basal levels of cortisol are controlled by the body clock (the suprachiasmatic nucleus located in the hypothalamus of the brain) and informed by light/dark cycles. For optimal functioning, levels should be low during sleep, produce a peak in the first 30–45 minutes after awakening and gradually decline over the day. However, cortisol is also the body's primary stress-response hormone.

The issue is that in our society today stress is ever present as threat is usually psychosocial in origin, and not physical as it was during evolution. For us humans, environments that induce novelty, lack of control, unpredictable events, anticipation,

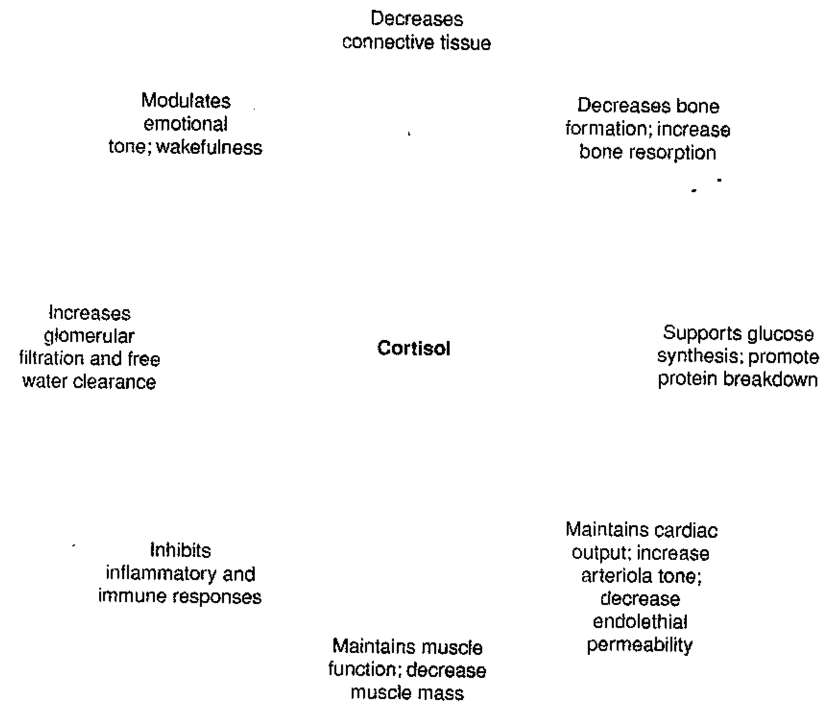

FIGURE 2.1 The role of cortisol within the system (created by Angela Clow)

threats to self-esteem and physical illness can all increase the secretion of cortisol. The problem is that exposure to excessive stress can dysregulate the HPA axis such that its primary role as conductor of 24-hour cycles becomes compromised and when this happens, illness can result.

Types of cortisol

Cortisol (MW: 362) circulates in the blood in two main components: bound or unbound. Approximately 85–90 per cent of circulating cortisol is bound and only 10–15 per cent is unbound. Bound cortisol is biologically inactive as it is bound to cortisol binding proteins, albumin and erythocytes. Bound cortisol is only blood borne as it does not pass into the saliva. Unbound cortisol on the other hand, is biologically active and found in all bodily fluids. Cortisol that is found in saliva accurately reflects the unbound fraction in blood (correlation $r > .90$). There is a moderate to high correlation with blood levels of 'total' cortisol ($r = .50–90$). As such, salivary cortisol measures provide the ideal measure of bioavailable cortisol.

The testing of unbound cortisol in saliva lends itself to non-invasive, easy and quick sampling, taking about a minute per sample to collect; it is also independent of saliva flow rate (which means that precise timing of sampling is not necessary). Saliva samples can be stored at ambient temperatures for up to one week (enabling postage if necessary) and are stable when frozen at −20°C for long periods of time. This type of sampling is ideal for ambulatory assessment within the domestic setting, which provides ecological validity, and is also suitable for use with children. Participants can be informed of the procedures, supplied with the necessary collection devices and make the collections on their own. The only issue that needs careful consideration is the time of day at which the sample is collected. This is important as the secretion of cortisol changes more than 20-fold over the day such that 'normal' morning levels are much higher than 'normal' evening levels. Consequently, the time of day (and preferably the time of awakening) must be recorded for each saliva sample collected for determination of cortisol concentrations. Due to the ease of cortisol data collection from saliva sampling, since the late 1990s there has been a huge spike in publication rates featuring saliva and cortisol. These studies have done much to aid our understanding of the links between mind and body.

Environmental factors on stress responses

The extent to which we respond to stressors can determine our resilience to negative life events. There are many factors that can influence this and they can impact across the life course. For example, Wüst et al. (2005) found that there were potential early developmental influences, such as birth weight at term. From a sample of 106 adult males, researchers found that higher birth weight at term participants showed smaller cortisol responses to a standard stressor than lower birth weight participants. This data is consistent with a broad range of research that indicates a role for the pre-natal environment in 'setting' our stress neuroendocrine axis and consequently our resilience to negative life events. The larger birth weight of the participants in the Wüst study is assumed to be indicative of a more favourable in utero environment.

Our social status is also thought to influence our vulnerabilities and resilience. For example using a large birth cohort (n = 6,335) Li et al. (2007) studied the mean daily levels of cortisol secretion in relation to social economic status. Adult males and females with a lower lifetime SES had higher mean cortisol levels than those with higher SES; they also had more dysregulated daily cycles of cortisol secretion (i.e. flatter 24 hour cycles rather than the optimal dynamic of change over the day). Associations between social functioning and cortisol secretion are apparent from a very young age. For example, Gunnar et al. (2003) looked at the cortisol secretion associated with social status in 4-year-old children at a nursery. Children who were less socially competent and socially rejected showed higher cortisol levels than those that were deemed average or popular.

These studies presented snapshots of HPA axis function at any one time point and showed social and environmental disadvantage to be associated with aberrant levels and patterns of cortisol secretion. In another study, Chen et al. (2009) reviewed the cortisol trajectories over two years for children with low and high SES aged 13 years at the start of the study. The saliva was collected four times per day for two days every six months. Each day, saliva was collected at 1, 4, 9 and 11 hours after wakening. In total, there were five assessments across the two years (0, 6, 12, 18 and 24 months). They found that cortisol output rose 40 per cent more over two years in low SES children (mean age 13) compared with high SES children. As cortisol plays a role in psychiatric and physical illnesses the authors interpreted these findings as a way of explaining why low SES children may be more vulnerable to developing these conditions later in life.

Cortisol and sleep

As mentioned earlier, cortisol is more than just a stress hormone; its primary role is to tell other body systems when it's night and day, so that they can function appropriately and in a synchronized fashion. Cortisol works in partnership with its night-time counterpart melatonin, a hormone secreted from the pineal in response to darkness. Cortisol and melatonin are counter-regulatory, thus if cortisol is high at night, it will inhibit melatonin secretion during sleep. Healthy cortisol secretion has a marked daily rhythm. Waking and light at dawn promote the early morning rise in cortisol, known as the cortisol awakening response (CAR) (Edwards et al., 2001). The CAR is a much used biomarker of healthy functioning as it is thought to prepare the body for the day ahead. However, examination of the entire daily pattern of cortisol secretion can be very informative. By measuring cortisol from saliva samples over the course of the day (typically collecting saliva samples at awakening, 15, 30 and 45 minutes after awakening for determination of the CAR and daytime samples at 3, 6, 9 and 12 hours after awakening) researchers have found that the brain exerts a marked circadian (24-hour) cycle on cortisol secretion. This is regulated by the suprachiasmatic nucleus (SCN) (the body clock located in the hypothalamus of the brain) and synchronized by the light/dark cycle. Whilst we are sleeping, healthy cortisol levels are low, peaking about 30 minutes following awakening and then gradually declining over the course of the day until we are ready for bed again. The issue for modern society is that this predictable light/dark cycle competes with unpredictable life events or stressors, which both affect cortisol secretion from the adrenal cortex. Repeated exposure to stress consequently affects the basal levels or the circadian pattern of cortisol secretion as a result of 'wear and tear' changes in feedback regulation. The result is that the systems that rely upon cortisol for their regulation (e.g. the immune, cardiovascular and metabolic systems) become dysfunctional and fail to operate adequately, thus ill health can follow. Depending upon underlying vulnerabilities determined from genetics, developmental factors and lifestyle, we may manifest different patterns of ill health. Stress and dysregulation of the HPA axis can expose these vulnerabilities rather than cause them in the first place.

The importance of sleep

We spend a significant amount of our life sleeping and yet we are only just discovering what actually goes on in the brain during this time of consciousness. Ultimately, sleep is not a passive process, with evidence showing the brain to be as active during sleep as it is awake in some cases (Toates, 2011).

Using more sophisticated methods of apparatus, we have been able to ascertain that sleep cycles run in four distinct phases. The first stage is the lightest form of sleep (marked by theta waves, Taylor, 2012: 108). This is where we start to attempt to block out noise; however, we are easily startled in this phase. The second stage is where our body temperature begins to drop, our heart rate and our breathing start to even out and our brain switches between two types of waves – sleep spindles and K-complex (Taylor, 2012: 108). The third and fourth stage is one of the deepest, where the brain is marked by delta waves. The last two phases are imperative for regeneration of cells, release of growth hormones and restoring energy lost throughout our day (Taylor, 2012). Rapid eye movement (REM) occurs approximately 90 minutes after we have entered sleep. Our breathing, eyes and heart rate can 'flutter' during this phase. REM is the deepest form of sleep, where we tend to engage in dreaming (marked by beta waves). Across the lifespan, we spend less and less time in REM.

An individual phases in and out of REM and NonREM sleep throughout the night cycle with phases of REM lasting 5–30 minutes every 60–90 minutes (Toates, 2011). There are severe repercussions to not getting enough sleep, including tiredness, vulnerability to depression, hallucinations and reduced productivity (Taylor, 2012). Sleep enables our bodies to repair nerves and muscles and carry out overall recovery. It is estimated that we need approximately seven to eight hours sleep with a small percentage of the population needing less (5 per cent can live on less than four hours a night) (Wells, 2012).

Ideal cortisol day profiles

The hormone cortisol is essential for life but levels need to be carefully regulated across the 24-hour day. When the circadian pattern of cortisol secretion starts to go awry then that is the start of more permanent problems for physical and mental health. For example, Hsiao et al. (2010) studied the daily salivary cortisol profiles of individuals who also filled out the Beck depression inventory. They found that the least depressed individuals were those that demonstrated the steepest cortisol patterns in contrast to the most depressed participants that had the flattest cortisol profile. There have been fewer studies of HPA axis function and positive wellbeing but Steptoe and Wardle (2005) examined happiness and levels of cortisol over the day. They found that happier people had lower levels of cortisol and that this was inversely related to happiness.

In a very influential study Sephton et al. (2000) looked at the cortisol profiles of two groups of breast cancer survivors after treatment. Half exhibited a steeply declining healthy cortisol profile (n = 52) and half exhibited a flat diurnal cortisol slope (n = 52). The research followed the patients over several years and found a significant association between cortisol profiles and survival rates (21 vs. 12 survivors at seven years follow up for the steep vs. flat cortisol profiles respectively).

Think about it...

What is your sleep routine? Are you someone who likes to watch TV, talk on the phone, check emails before bed? One major interference with sleep is light, thus experts recommend turning off phones, tablets, laptops and anything with a screen 30–60 minutes before sleep as the light can trigger optic nerves, shutting off melatonin and stopping you getting into that needed REM sleep (Wells, 2012a).

Cortisol and self-esteem

Psychophysiologists can examine individual differences in response to stress by use of a standardized laboratory stressor. The 'gold standard' laboratory stressor is the Trier Social Stress Test (TSST), which is a 10 minute stressor involving public speaking and mental arithmetic in front of an unsympathetic panel of two to three experts. Exposure to such a standardized stressor reliably induces increased cortisol secretion (Pruessner et al., 1999). The most marked cortisol responses are observed in subjects with low self-esteem in response to failure. In addition, those with low self-esteem continue to respond to the stressor, day after day, failing to show habituation to the same events. In contrast, individuals with high self-esteem habituate more rapidly (Kirschbaum et al., 1995). These data can be interpreted as indicating that high self-esteem is a powerful resilience factor as it lessens the perceptions of threat in psychosocial situations.

Interventions for decreasing stress

One's stress reactivity can be modulated by a range of factors and interventions. For example, Hammerfald et al. (2006) assigned participants to either a cognitive behavioural stress management (CBSM) group or a control group. After four months of CBSM participants showed significantly reduced stress responding, as determined by lower cortisol increases, compared to the controls. Similarly Khalfa et al. (2003) utilized music as an intervention to reduce stress responses. They found that individuals who were assigned to the music group had significantly lower stress responses compared to the silence groups. In a way similar to the CBSM programme discussed above, weekly, one-hour relaxation training sessions have been found to significantly reduce evening basal cortisol levels versus control groups over a five week period (Bullen et al., 2006).

However, interventions don't have to be several weeks and take a lot of investment. In 2006, Clow and Fredhoi conducted a surprising study on the effects a 35-minute art gallery visit on basal cortisol secretion. They found that individuals in the intervention group significantly dropped cortisol levels from pre-intervention status. Just taking a short time out to relax and enjoy the environment was enough to lower cortisol levels back to healthy levels for that time of day.

Think about it...

Do you live in an urban area? Do you think this adds to your stress levels? Researchers looked at UK residents with high versus low green space in neighbourhoods. They found that there was a steeper profile for those in high green spaces than low green spaces, whose profile was flat (Thompson et al., 2012).

Self-regulation, glucose and the brain

If you were put into a room with a tray of fresh baked chocolate chip cookies and a bowl of radishes, and made to sit and resist the temptation of the cookies, how well do you think you would do on a subsequent concentration/perseverance test? Evidence shows that the answer is not so good. In a groundbreaking experiment into the role of willpower (also known as self-regulation: SR), Baumeister et al. (1998) found (and have replicated over and over again) that when we exert energy into resisting something, we deplete levels of mental energy caused in regulating the self and our behaviour/emotions. This depletion has been coined 'ego-depletion'.

Self-regulation is defined as 'control over one's emotions, thoughts and behaviour' (Segerstrom et al., 2011: 25). When individuals are not capable of controlling these impulses, it can lead to issues with eating, alcohol and drug use, overspending, sexual promiscuity and inter-violence (Baumeister and Vohs, 2004). Segerstrom et al. (2011) argue that not only is SR important for suppressing negative behaviour, but also for regulating individuals' optimal functioning, for example: attending to positive stimuli, reflecting and savouring positive experiences, controlling stress and coping processes during difficult times, as well as enhancing social interaction (e.g. helping others, adhering to social etiquette).

In the anterior cingulated cortex of the brain, 'the error detection system' (Baumeister and Tierney, 2011: 28), once depleted, slows down, thereby increasing the likelihood of mistakes and lowered self-control. Overall, individuals who are experiencing this depletion also have a heighted intensity of emotions and cravings (Baumeister and Tierney, 2011).

We appear to have a reserved amount of 'self-regulation' and when this is used, it is gone. Segerstrom et al. (2011) argue that the capacity to self-regulate is 'embodied' and that blood glucose and heart rate play a significant role in self regulating ourselves. The main physiological parameters that have been thus far studied and linked to SR (Segerstrom et al., 2011: 26) include:

metabolic (blood glucose and glucose regulation);
neuroendocrine (cortisol);
cardiovascular – heart rate variability.

I will discuss these in relation to glucose and SR, supporting the role of the body in optimal functioning.

The role of glucose

Research has shown that the body, and more specifically the brain, relies on glucose for fuel (Baumeister and Tierney, 2011; Segerstrom et al., 2011) as seen from studies that use individuals with differing glucose productivity (hypoglycemic, euglycemic, hyperglycemic) as well as individuals with diabetes.

Did you know?

Although the brain takes up only 2 per cent of our entire body mass, it uses up to 21 per cent of the blood's glucose (Elia, 1992 as cited in Segerstrom et al., 2011).

There is great controversy between the direct relationship between high levels of glucose and better self-regulation and performance (Segerstrom et al., 2011). Gailliot et al. (2007) claim that researchers can identify those who will be able to self-regulate based on higher blood glucose levels. Research manipulated the blood glucose of several participants with diabetes into euglycemic (normal levels of insulin) and hypoglycemic states. Those in the hypoglycemic state experienced more heightened intrusive and negative repetitive thought than the normal states (McAulay et al., 2006).

In relation to emotions, research has shown some supportive evidence that drops in glucose levels trigger negative emotions as well as increased tension (Wredling et al., 1992). Reasons for this link between negative emotions and low levels of glucose have been explored in relation to the effects of glucose on cortisol functioning.

Overall, Segerstrom et al. (2011) point to several issues regarding a clear association between blood glucose levels and their beneficial effects on cognitive functioning, emotion regulation and affect. One major reason is the fact that glucose regulation in the brain is different from that within the body with brain glucose transporters (GLUT3) being non-insulin regulated as opposed to the peripheral glucose transporters (GLUT4) and are less saturable. The second issue regards the difficulty in assessing the direction of causation from glucose production: 'although blood glucose may be a good marker, it is entirely possible that the effects on self regulatory ability are not due to blood glucose per se, but to the indirect effects of blood glucose on neuro-hormonal responses, to its ability to index qualities of glucose metabolisms and regulation, or both' (Segerstrom et al., 2011: 29).

Heart rate variability

The small 10-ounce heart is one of the major drivers of our body system. When we breathe it sends fresh oxygen into the blood supply for use throughout the body. Inhalation triggers the acceleration of heart rate whereas exhalation kicks the parasympathetic system into action. Heart rate variability (HRV) is the commonly used index of this parasympathetic/sympathetic nervous system balance (Segerstrom et al., 2011: 27). HRV is an index of the flexibility of the beating heart. If the rate of beating is very fixed from minute to minute, hour to hour then this is an indication of SNS overdrive and inadequate input from the PNS. Marked variation in the interval between heart beats is an index of adequate PNS input to the cardiovascular system and advantageous to health. Chronic stress is associated with reduced HRV and increased SNS input to the heart. HRV is linked to polyvagal theory (discussed in Chapter 5). Neurovisceral integration relates to polyvagal theory in that both identify structures within the brain (ventral vagus complex) which is involved in the regulation of the PNS which in turn affects emotions and behaviours. This theory relates to HRV as when the nerve to the heart is functioning well, our heart rates tend to show higher rates of variability (more on the vagus nerve in Chapter 3) (Segerstrom et al., 2011).

Research has shown that higher HRV is positive and linked to increases in self-regulatory processing on emotions, thoughts and behaviours (Compton and Hoffman, 2012) such that individuals with high HRV report more positive emotions and report higher levels of social connectivity (Kok and Frederickson, 2010). Individuals can increase HRV via several physical manipulative exercises such as physical activity, yoga and meditation (Segerstrom et al., 2011; Compton and Hoffman, 2012).

Did you know?

If you store up the power from all the heartbeats from one person in a day, it could lift a car 30 feet into the air.

The psychophysiology of the face

The next section will review the interesting research into the well known facial feedback hypothesis which suggests that, 'muscular manipulations that result in more positive facial expression may lead to more positive emotional states in affected individuals' (Alam et al., 2008, p. 106; Strack et al., 1988).

Anatomy of the face

The face is made up of scalp, mouth, neck, orbit and eyebrow muscles that play a role in the outward expression of emotion. The research pertaining to the face within positive psychology surrounds the two main types of smiles (Duchenne and Pan American). Duchenne smiling is what we would consider 'authentic' (smiling with your eyes as well as your mouth) and involves contraction of both the zygomatic major muscle (raises corner of mouth) and the orbicularis oculi muscle (raises cheeks and forms crows feet). The Pan Am, on the other hand, is what we would call a 'fake smile' and only involves the contraction of zygomatic major muscle. Several pieces of research have found links between 'authentic' (Duchenne smiling) and increases in wellbeing, life satisfaction and even longevity (Harker and Keltner, 2001; Abel and Kruger, 2010). You can't fake this type of smiling, nor necessarily recreate its effect on the brain. Eckman and Davidson (1993) were two of the first researchers to link objective facial expressions of happiness to internal enhanced activation of the left prefrontal cortex in comparison to non-Duchenne smiling or neutral facial expressions.

Muscles used	Function	Expression
Occipitofrontalis	Raises eyebrows and wrinkles forehead	Surprise
Orbicularis oris	Muscles that circles the mouth used in kissing and moving lips when speaking	
Zygomaticus major	Responsible for smiling (moving the angles of the mouth)	Happy
Zygomaticus minor	Responsible for moving the upper lip	
Corrugator supercilii	Responsible for creating frowning by wrinkling of the forehead skin	

TABLE 2.2 Major muscles associated with smiling and frowning (Tortora and Derrickson, 2009: 376–7)

Flow and facial expressions

This section views objective evidence on the existence of flow. Flow[1] is defined as 'the intense experiential involvement in moment-to-moment activity, which can be either physical or mental. Attention is fully invested in the task at hand and the person functions at her or his fullest capacity' (Csikszentmihalyi, 2009: 394). There are several conditions needed to facilitate the flow experience. These include: structured activity with clear goals and immediate feedback; balance of challenges vs. skills; complete concentration (merging of action and awareness); sense of control; transformation of time; and activity for the sake of activity (intrinsic motivation) (Csikszentmihalyi, 1975; 1990; Csikszentmihalyi and Csikszentmihalyi, 1988).

Flow is a well-established phenomenon within positive psychology and has been linked to optimal performance and wellbeing. Individuals who achieve high levels of performance recount their performances as being in flow, thus this subjective state is a highly-sought-after phenomenological way of existing. Research traditionally uses several flow state questionnaires as well as experience sampling methods (ESM) to measure flow. However, recently researchers have started to use psychophysiological tools (*facial electromyography*) in order to understand what is going on in the body during these highly subjective experiences (Thompson and Jaque, 2011; Mansfield et al., 2012). De Manzano et al. (2010) studied expert pianists and the relationship between subjective reports of flow experience and psychophysiological measurements using (ECG) reports. Participants were asked to play several pieces of music, based on whether they liked them or not. The result showed that when individuals played music that they reported being in flow, they began to breathe more deeply and more regularly, their heart rate slowed down, their blood pressure went down and there was increased activity in the zygomaticus major muscle. Kivikangas (2006) also conducted psychophysiological measurements on participants' facial muscles during induced flow states (via computer games). The research found that activity of the corrugator supercilii muscle was negatively correlated with self reported flow.

Botox and facial feedback hypothesis

Interestingly, the research world has explored whether the use of Botox can be utilized with depressed patients in an attempt to freeze the use of negative (frowning) muscles (Finzi and Wasserman, 2006). By reducing the ability to frown (paralyse the upper face dynamic, specifically the corrugator supercilii and the procerus and some of the frontalis), botulin injections can also limit the expression of anger, fear and sadness (Alam et al., 2008). Likewise, however, botulin toxin can limit the Duchenne smile by paralysing the orbicularis oculi, although researchers would argue the effects are less so for positive than negative states (Alam et al., 2008).

Davis et al. (2010) researched the effects of Botox on self-reported emotional experience among two groups (one with Botox and one with restylane, a non-paralytic substance). They found that on their own, the Botox groups showed no changes in emotional responses; however, relative to controls, their strength of emotional experience decreased. Davis et al. (2010) concluded that facial expressions are not necessary but can affect emotional experiences under certain contexts.

It is not just how the person feels subjectively that is important in overall SWB, but how their facial expressions are being perceived as either positive or negative to others, with 'frowners' perceived as expressing more negative emotions than non-frowners (Heckmann et al., 2003). For example, the denervation of the corrugator (frown muscle) via Botox was found to have a profound shift in perception from others. Most notably, individuals were seen to express less anger (−40 per cent), less fear (−49 per cent), less sadness (−10 per cent) but more happiness (+71 per cent).

Research has shown that the manipulation of certain facial expressions has been associated with activation in the limbic system in the brain (e.g. amygdala) (Hennenlotter et al., 2009). In order to assess the physiological mechanism between this potential association, Hennenlotter et al. (2009) administered Botox induced denervation of the frown muscles to individuals who subsequently underwent an fMRI. When imitating angry facial expressions, there was a reduction in feedback and an attenuation of activation of the left amygdale and its 'functional coupling with brain stem regions implicated in autonomic manifestations of emotional states' (p. 537).

The researchers argued that their findings might have implications on the role of social transfer of emotions based on mimicry (Orbach, 2012). Stemming from research into mirror neurons (which help us mirror or mimic the motions and movements of others – see Chapter 3), Neal and Chartrand (2011) have researched the effects of Botox on embodied emotion perception. They have found that Botox can significantly reduce our ability to empathize with others and posit that part of our ability to read others' emotions is by mimicking their facial expressions. These new findings may have implications for the mother/baby early childhood relationship. Stemming from the 30+ years of research on Tronick's (Tronick et al., 1975) 'still face experiment' which encourages mothers to greet their babies with a still face (and maintain for up to three minutes) irrespective of any positive or negative interaction from the child, when confronted with an un-empathetic/non-responsive face, children can become very quickly distressed and withdrawn. Similarly, researchers have warned of the potential dangers of Botox use in mothers (which can create a still face-like or at least reduced expressive appearance) in relation to emotional intelligence development in children (Orbach, 2012).

Summary

Reflecting on the learning objectives you should now understand the components of the body and positive psychophysiology and how they affect wellbeing. More specifically you should know:

- Negative and positive emotions are linked with health outcomes and there is some evidence of direct effects on the neuroendocrine (cortisol) system.
- There are several invasive and non-invasive tools that we can use to assess experiences within the body.
- Toughness theory was one of the first to recognize the influence of the body on resilience.
- The body has several systems that influence physical and psychological functioning.
- Cortisol and diurnal patterns play a significant role in stress and wellbeing.
- Sleep is an overlooked component to optimal functioning with a lack of sleep showing detrimental effects.
- Glucose, HRV and the vagus nerve can all play a role in emotions although more research is needed.
- Manipulation of the face can play a role in emotions and social bonding.

Suggested Resources

http://www.westminster.ac.uk/research/a-z/psychophysiology-and-stress-research-group
This is the link for the psychophysiology and stress research group located at the University of Westminster. You can keep up to date on their newest research and grants as well as find references for follow-up reading.

http://qlrc.cgu.edu/about.htm
To find more updated research on the psychophysiology of flow, please log on to the Quality of Life Research centre at Claremont University.

http://www.lboro.ac.uk/departments/ssehs/research/behavioural-medicine/sleep/index.html
For more information on the importance of sleep, please log on to the Loughborough University Sleep Research Centre with links to publications, current projects and the Clinical Sleep Research Unit.

Note

1 Originally termed *autotelic experience*.