Personality and the Brain
Transcript

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Lay people tend to think of personality as a kind of X-factor that makes them interesting and charismatic. People are described as having “lots of personality” or “lacking it”. In psychology, personality refers to important, enduring temperamental traits along which people vary. It is the study of how people differ one from another, the origins of these differences, and the consequences for their social life and well-being (Eysenck, 1997).

Dimensional analysis of personality reveals certain traits that are especially important. The most widely researched theory is that of H.J. Eysenck (1981), who described three major dimensions of personality: Extraversion (vs Introversion), Neuroticism (vs Emotional stability) and Psychoticism (vs Normality). An extension of this is called the Big Five, which splits P into Conscientiousness, Agreeableness and Openness (McCrae & Costa, 2008). A broader expansion of Eysenck’s system is embodied in the Eysenck Personality Profiler (EPQ; Eysenck et al, 1999), which subdivides each main personality trait into seven subtypes.

Another influential theory of personality is that of J.A. Gray, who identified major brain systems concerned with Reward-seeking (Approach) and Punishment avoidance (Inhibition). People are presumed to vary in the relative strength of these brain systems, yielding primary psychological traits of Impulsivity and Anxiety (Gray, J.A. & McNaughton, 2000). Gray’s theory is rooted in animal research and is often called Reinforcement Sensitivity Theory (Corr, 2008).

Behaviour genetic studies, such as those based on twin comparisons, confirm that around half of the variation in these major personality traits is genetic (Loughlin, 1992; Plomin et al, 1997). This leaves room for significant environmental input, but it is not so much the way our parents treat us that is critical to our development (shared family variance) as haphazard factors like brain damage, exposure to disease and chemicals in utero, and the influence of peer groups (non-shared variance). Many of the “causes” of personality, both genetic and environmental, are now being studied in connection with brain anatomy and functioning.

Which parts of the brain determine personality? A clue is provided by the case of Phineas Gage, who was working on the railway in Vermont in 1848 when an accidental explosion blew a large iron bar through his head. It passed through his left eye, upwards through the front of his brain, and out the top of his head, landing some 80 feet away. Remarkably, Gage survived and even remained conscious while carried away by his workmates. Over the next weeks he staged a considerable recovery but his personality seemed to have changed. Previously well-behaved and responsible, he had become irascible and disinhibited. He “wore his emotions on his sleeve”, crying and laughing inappropriately and with temper outbursts full of uncharacteristic profanities.

Recent reconstruction of the damage to Gage’s brain indicates that around 11% of the white matter in his frontal cortex had been destroyed, including connections with midbrain emotional areas (Van Horn et al, 2012).

What could account for the effects of such brain damage on personality? Eysenck’s theory was that introverts have more self-control than extraverts because their cerebral cortex is generally higher in arousal, keeping in check the emotional areas underneath. Cortical arousal is in turn determined by characteristics of the ascending reticular arousal system (ARAS) which runs up from the brain stem, through the thalamus, and radiates to all parts of the cortex maintaining wakefulness.

Eysenck cited a wealth of experimental observations in support of his arousal theory. Introverts were shown to be more reactive to a standard stimulus (e.g., producing more saliva in response to a standard drop of lemon juice placed on the back of the tongue). They also required more sedative or anaesthesia to have the desired effect. Stimulant drugs make people more introvert (c.f., the use of Ritalin to treat ADHD) while alcohol notoriously shifts people towards extraversion. Skin conductance (a good measure of arousal) is higher in introverts than extraverts throughout the day (Wilson, 1990).

Brain imaging studies are also supportive. Kumari et al (2004) reported negative correlations between E scores and resting fMRI signals in various brain areas ranging from the thalamus to Broca’s and Wernicke’s (speech) areas. Introverts again appear to be characteristically more alert.

Anatomically, introverts seem to have more cortical equipment in the first place. Forsman et al (2012) found that introverts have more white matter than extraverts in areas incorporating upward projections of the reticulo-cortical system. They also have more gray matter in various cortical areas, including the right prefrontal and right temporo-parietal junction (regions involved in behavioural inhibition, introspection and social/emotional processing).

Damage to frontal brain areas concerned with the regulation of behaviour would account for the disinhibited behaviour displayed by Gage following his accident. Consistent with such an interpretation is the finding of Motzkin et al (2011) that clinical psychopaths tend to have damage to the circuits connecting the prefrontal lobes with the emotional mid-brain.
Links between personality and brain anatomy are confirmed by De Young (2010), who used structural MRI to examine the neurological basis of the Big Five. Extraversion covaried with volume of the medial orbitofrontal cortex, a brain region involved in processing reward information. Agreeableness correlated with volume in areas that process information about the intentions and mental states of others (“mind-reading”). Neuroticism went with a variety of brain regions associated with threat, punishment and negative affect, and Conscientiousness was associated with a larger prefrontal cortex (planning and voluntary control of behaviour).

Neuroticism is complicated with respect to brain function. Faced with danger, high N individuals generally show heightened anxiety and vigilance. This can be seen as increased activity in many hypothalamic and limbic (“visceral”) areas of the midbrain, as well as connecting parts of the cortex such as the insula and cingulate gyrus. However, when faced with extreme threat or stimuli that are both disgusting and inescapable (e.g., an impending gruesome operation) high N individuals may “bury their heads”, showing blunted responses in these same brain regions (Wilson, et al, 2000; Kumari et al, 2007; Drabant et al, 2011).

In Gray’s theory, anxiety is associated with circuits in the septo-hippocampal system that are sensitive to punishment, threat and novelty. Impulsivity is linked with reward circuitry in the mid-brain (that activated by stimulant drugs like amphetamine) as well as the motor areas concerned with approach behaviour. Restrained behaviour may therefore be due either to high anxiety (fear of consequences) or an absence of impulsiveness.

Brain wave patterns show links consistent with Gray’s personality system. For example, Shackman et al (2009) showed that behavioural inhibition (anxiety) was associated with higher levels of tonic EEG activity in the right dorsolateral prefrontal area. Similarly, Knyazev (2010) reports that behavioural inhibition (and low sociability) went with higher oscillatory activity in emotional processing areas of the frontal cortex such as the cingulate gyrus. This suggests higher vigilance and emotional tension in anxious and introverted individuals.

Knyazev et al (2003) found that behavioural activation and inhibition scores (measured by the Gray-Wilson Personality Questionnaire; GWPQ; Wilson et al, 1989) were associated with delta and alpha oscillations respectively. To account for these correlations, we proposed an evolutionary theory whereby delta, theta and alpha oscillations reflect activity of three hierarchical phylogenetic brain systems (Knyazev et al 2004). Delta waves arise from the most ancient system, dominant in the reptilian brain. Theta waves predominate in lower mammals, while alpha represents the newest system, featured in adult humans. The three systems operate in parallel and their contribution to behaviour is presumed to differ between individuals. Higher systems function to control lower ones by means of descending inhibition (DI), hence impulsiveness is associated with more slow waves in the EEG relative to high frequency oscillations.

We further proposed that in adults, anxiety is largely cortical in origin (enhanced DI from alpha to delta) whereas in children, behavioural control is associated with DI from theta to delta (resembling the animal mechanism whereby anxiety and fear are mediated mostly by the limbic system). Subsequent research has confirmed this suggestion (Knyazev, 2010).

Is there an addictive personality? People who are prone to alcoholism are more likely to smoke and take drugs as well as being more susceptible to compulsive behaviours like gambling, promiscuous sexual behaviour and uncontrolled shopping. For example, Slutske et al (2005) found that gambling and various types of substance abuse were strongly “co-morbid”, the overlap deriving from a personality profile that included poor self-control, risk-taking, and negative emotionality (anxiety and inability to cope with stress). This sounds like a combination of anxiety and impulsiveness.

Dresler et al (2009) found that Impulsivity relates to fMRI activity in the ventral striatum and orbitofrontal cortex in response to cues indicating reward. These are circuits that use dopamine as a neurotransmitter and it is interesting that dopamine agonists (e.g., medication for Parkinson’s disease) exaggerate addictive/hedonistic tendencies in some patients. However, it not always clear whether such traits are due to excessive dopamine (giving them an extra “high”) or to attempts to compensate for a dopamine deficiency by seeking external rewards (drugs and risk).

Buckholtz et al (2010) measured Impulsivity in healthy volunteers and used PET-scans to see what happened in the brain when they were given amphetamine (an established recreational stimulant that is potentially addictive). Subjects high on Impulsivity showed a greater release of dopamine in the striatum, along with diminished receptor availability in the mid-brain. This could be interpreted as meaning that impulsive people are more addictive both because they get a greater high from a substance and because their brains leave it unbound (in circulation) for longer.

Research such as this supports the idea that some individuals are more reward-dependent (“needy”) and hence more addiction-prone than others. Not everybody who smokes, drinks or takes drugs gets addicted by doing so and genes, dopamine-linked reward circuits in the brain and personality traits like Impulsivity seem to be involved (Sweitzer at al, 2012).

Why should personality variations have evolved when selective forces should perhaps favour similar traits within a species? Some argue that the differences are just random variations around an optimum, with most people gravitating towards the centre. Yet differences along certain traits may provide advantages and disadvantages according to conditions.
An analogy that might help to understand this is that of body weight. When food is abundant, slim people probably do best because they are more agile. In times of deprivation, fat people survive better because they carry higher caloric reserves. Since environments vary in availability of food, genes for both fatness and thinness remain available within the population.

The same applies to traits like Neuroticism and Impulsivity. People prone to fear and anxiety (e.g., highly reactive to threats from snakes, spiders, ghosts and heights) are better placed to avoid danger, while “bravehearts”, who accept more risk, gain rewards seldom achieved by “scaredy cats”. Extraverts meet more sex partners and engage in riskier sexual behaviour, hence spread their genes more widely, but introverts are better adapted to form lasting relationships and support their children. Both strategies have potential survival value according to circumstances and hence remain in the gene pool.

The evolution of psychopathy is an interesting case. Psychopaths typically feign cooperation but then defect. If most of the population is trusting and gullible then cheating may pay off (Mealy, 1995). The psychopath’s short-term, exploitative sexual strategies may be particularly adaptive in mobile, urban environments where they remain under the radar (Wilson, 1995). Psychopathy is therefore an important trait in terms both of its social ramifications and its cost/benefit balance.

Anthropological research has shown that the DRD4 genes associated with novelty-seeking and exploratory behaviour become more common with distance from the African origins of Homo sapiens (Matthews & Butler, 2011). The suggestion is that migrations into new habitats selected for individuals with low reactivity to novel stressors.

Evolutionary approaches thus offer an account of average (usually optimal) personality, as well as the variations favoured by different niches. These niches do not even have to enter the gene pool. For example, birth order positions within the family could provide niches promoting different kinds of behaviour. Sulloway (1996) claims that first-born children are inclined to be conscientious and conforming while later-born children are rebellious and novelty seeking. Although this finding is not reliably replicated, it would make sense if first-borns worked hard to retain parental love in the face later-born usurpers who, “cute” in the eyes of their parents, develop a relative sense of invulnerability. This would be an instance of a personality traits deriving from the between-family (non-shared) environment.

Do men and women differ in personality? Although it is fashionable to view the differences as minimal, recent research reveals them as rather important. Looking at single traits (e.g., Machiavellianism - the tendency to deceive and manipulate people for one’s own ends) the overlap between men and women is considerable. However, when several personality traits are considered simultaneously the “Mars and Venus” gap is substantial, with only about 10% overlap (Weisberg et al, 2011; Giudice et al, 2012). Men are generally more aggressive, assertive and risk-taking, women more emotional, warm and sensitive. Such differences can be attributed to selection pressures favouring promiscuity and status-seeking in men versus social bonding and nurturance in women.

How do we know these differences are genetic rather than acquired through social role learning? For one thing, similar differences are observed in non-human species, where the socialisation alternative is less persuasive. Male monkeys are more aggressive than females even when raised in isolation. Chimpanzees show consolation behaviour, comforting others when they are upset. This is like human empathy and is mostly female (Romero et al, 2010).

Then there is the evidence that sex hormones, both prenatal and activational, affect personality in predictable ways. Digit ratio (2D:4D) is a marker of exposure to prenatal testosterone, short forefingers relative to ring fingers being associated with a great variety of masculine personality traits such as assertiveness, promiscuity and lack of empathy (Wilson, 2010). Administration of testosterone impairs cognitive empathy in women depending on their digit ratio, women with masculinised finger ratios being more affected by testosterone (Van Honk et al, 2011).

The lack of empathy shown by autistic individuals has been traced to deficient exposure to testosterone in utero. Baron-Cohen et al (2005) divide people into systematisers and empathisers. Systematisers relate to things and general principles; empathisers relate to people and examples. Women tend to be empathisers, men systematisers, while autistic and Asperger’s individuals appear as hypermale on these two traits.

There is also direct evidence of brain differences between men and women that relate to femininity of personality. Wood et al (2008) used MRI scans to show that a narrow strip of cortex running along the midline underneath the frontal lobe called the straight gyrus (SG) was proportionally 10% larger in women than men, and regardless of actual gender its volume correlates with feminine traits like interpersonal awareness. This is one of many studies showing that sex differences cannot be ignored in understanding the relationship between personality and neurobiology (Whittle et al, 2011).

Finally, although it is clear that sexual differentiation of the brain is primarily determined by prenatal gonadal hormones, there is increasing evidence that the programming of sex-related behaviour (as well as other aspects of personality) is impacted by epigenetics. This refers to factors, as yet little understood, affecting whether genes are expressed (switched on or off). A variety of “accidental” factors, including maternal diet, toxins, and
early stressors, may be implicated, possibly going back to previous generations (Menger et al, 2010). This is why MZ twins are not always identical and are sometimes even opposite in traits such as handedness and sex orientation. We may expect to see much progress in this field in coming decades.

References


