Moral development and behaviour under the spotlight of the neurobiological sciences

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With the aid of techniques such as functional magnetic resonance imaging (fMRI), neuroscience is providing a new perspective on human behaviour. Many areas of psychology have recognised and embraced the new technologies, methodologies and relevant findings. But how do the tools of neuroscience affect the fields of moral development and moral education? This paper reviews neuroscience research germane to moral development using as an organisational framework, Rest's Four Component Model of moral functioning, which proposes that moral behaviour requires moral sensitivity, moral judgement, moral motivation/focus, and moral action skills. Issues such as the importance of early brain development and attachment are addressed. The authors conclude with a brief description of an integrative theory, Triune Ethics Theory, which provides an example of how moral development and neuroscience can be integrated.

> Morality is as firmly grounded in neurobiology as anything else we do or are.
> (Franz de Waal, 1996, p. 217)

This paper examines research from neurobiology and neuroscience that is relevant to moral development. Much of what we describe comprises recent findings that were not available to Lawrence Kohlberg. Some neurobiological evidence was available at the time regarding the physiological effects of neglectful care giving on a child's potential for sociality (e.g., Bowlby, 1988; Harlow, 1986; Spitz, 1945), but Kohlberg's work was not informed by such findings. His interests lay elsewhere.

An increasing number of moral psychologists, the present authors included, are intrigued by the forays of neuro- and biological science; however, not all are convinced of its relevance. Our interest is fuelled in part by our work with juvenile delinquents who have perhaps irreparable brain damage and corresponding deficient ethics. The mounting evidence for epigenetic and lifelong effects of parenting on brain formation and emotion regulation has become especially salient. The neuro- and biological sciences may help provide explanatory frameworks and guide approaches to intervention and prevention.

Three claims might be made for the role of the neurological sciences in moral development theory and research. First, healthy moral functioning requires proper brain functioning. For instance, some types of brain damage cause moral dysfunction within the context of normal psychological functioning; also, normal brain development is a necessary condition of some aspects of moral functioning, and some care-giving and educational activities promote later moral functioning through their positive effects on brain development and later neural functioning. There may be a range of moral functioning in normal adolescents and adults just because of the brain structure and functioning that was affected by early experience. Second, the claim might be made that brain studies corroborate some, but count against other, traditional concepts of moral functioning. And third, brain function interventions (surgical, electronic, chemical or genetic) can correct and/or enhance some aspects of moral functioning. In this paper we advance and defend the first two of these claims, but not the third. Aside from whether brain interventions would be ethical, the neurosciences are not yet at the point of being able to suggest specific interventions for specific types of repair or enhancement of moral functioning. But we do now know about links between brain damage and moral dysfunction, and we are able to draw some conclusions from brain research about some traditional concepts of moral functioning, such as about the role of emotion. (Please see the additional caveats in the textbox about the use of functional magnetic resonance imaging—fMRI.)

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A note on methodology

In this paper, we describe how findings in the neurosciences are advancing understanding of moral behaviour and development. We focus primarily on work from brain scanning technologies, such as innovative technologies like the fMRI. However, the limitations of the methodology must be noted (Racine, Bar-Ilan & Illes, 2005). Far too often readers assume that fMRI techniques enable researchers to capture 'visual proof' of brain activity, without taking the complexities of acquiring the data and processing the images into account. To ease the task of interpreting and reporting results, neuroimaging studies often highlight responses in specific brain regions; however, these regions are rarely the only ones that produced activity (Olsson & Phelps, 2007). Moreover, every human brain is distinctive, so the fMRI studies look at areas of agreement across brains, which often vary greatly. In fact, each laboratory uses its own techniques to test and analyse the very messy and inconsistent data across participants and trials. Due to limited knowledge, few studies test theories and most are primarily correlational. Moreover, 'correlative approaches, such as human brain imaging and psychophysiology, are not sufficiently robust to adjudicate what is 'basic about basic emotions' because 'autonomic physiology is regulated by generalized sympathetic and parasympathetic controls' which are not measurable through fMRI (Panksepp, 2007, p. 282). Activation can vary for a variety of reasons. Blood glucose levels influence brain activity (Critchley, 2004). Moreover, when comparing novices to experts, the former show much more activation than the latter, as experts automatise responses and use different parts of the brain (e.g., Petersson, Elfgren & Ingvar, 1997). As imaging technology and understanding of human brain functioning evolve, corresponding literature will use terms such as neural *systems* instead of reducing complex behaviour to isolated brain structures (Olsson & Phelps, 2007). Jorge Moll and colleagues do just that, as we discuss below.

We describe studies with other methodologies as well. Neuroendocrine studies examine hormones released, for example, during stress or when comforted. Documentation of brain damage and dysfunction is also a worthwhile approach to studying relations between the brain and moral behaviour. But even there, the brain is so complexly organised that many specifics about internal structural relations are unknown. And again, each brain is different. For a deeper review see Moll *et al.* (2005).

It should also be noted that many of the best findings in science 'challenged consensus and met no perceived need' (Braben, 2008, p. 18). So readers who are sceptical may take comfort in the hope that what they see as questionable now may be key ideas upon which great theories are built.

We hope to demonstrate to readers the potential usefulness and applications of neurobiological and neuroscientific research. Although the examination of physiological processes and mechanisms often draws criticism of reductionism, this paper is not meant to reduce human thought and behaviour to patterns of brain activation. We would argue that humans are complex systems which live within elaborate social networks, demonstrating inclinations, motivations and processes that interact *in situ* with the perceived task, skill, materials, attitudes and social press, among other things, which we can hardly measure in isolation. Much more is to be gained from a holistic approach towards explaining human moral behaviour. Nevertheless, building holistic models requires a study of the fundamentals. Examining the current biological and neuroscientific knowledge about human behaviour is like learning about the soil in which one grows plants. Knowing its composition and the interactions of its component parts helps the gardener work with it to support more flourishing plants. In the same way, learning about the neuro- and biological systems allows moral educators and psychologists alike to understand and work with difficulties and improve outcomes for individuals.

The cognitive and neurosciences illuminate several longstanding debates in moral psychology, including some that Kohlberg took for granted. As Byrnes (2001) points out, the findings of neuroscience help corroborate or refute existing 'models of cognition' and generate 'surprising findings' not predicted by mundane psychology (p. 9). In this paper we address several issues that Kohlberg understood differently: cognition, the roles of emotion, initial conditions, and developmental change.[1, 2]

The nature of cognitive processing

Kohlberg drew upon the assumption held by most scholars and lay persons for centuries: that conscious reasoning directs human decisions and moral reasoning. According to traditional views in moral philosophy human freedom is grounded in rationality, the ability 'to discern options, make decisions, and enact intentions' (Narvaez & Lapsley, 2005, p. 140). Humans are liberated from passions, from external controls, from 'stimulus-response' because of the power of reason. Such a view dominated moral psychology for decades. Kohlberg considered the child to be a 'naïve philosopher' whose thinking develops with experience towards greater philosophical and psychological sophistication (Kohlberg, 1982; 1984). The assumption was that moral problems were approached with conscious deliberation and that the changes in quality of judgement were an appropriate target of inquiry (Colby *et al.*, 1983; Rest, 1979; Turiel, 1983). Kohlberg defined morality according to the 'principle of phenomenalism' (Kohlberg, Levine & Hewer, 1983) which asserts that 'a behavior has no particular moral status *unless it is motivated by an explicit moral judgment';* 'moral behavior is one that is motivated by an explicit recognition of the prescriptive force of moral rules' and 'in the absence of explicit judgements, in the absence of rational deliberation, there can be no distinctly *moral* phenomena in the first place' (Narvaez & Lapsley, 2005, p. 141).

This received view is a fading paradigm. Across the social sciences, the disparity between knowing and doing has instigated a paradigm shift (e.g., Lakoff & Johnson, 1999). The model for human decision making is no longer the rational individual who makes intentional choices through conscious, serial processing: 'Higher mental processes that have traditionally served as quintessential examples of choice and free will --such as goal pursuit, judgment, and interpersonal behavior-- have been shown recently to occur in the absence of conscious choice or guidance' (Bargh & Ferguson, 2000, p. 926). Instead, the emerging view is that human thought processes, decisions and choices are influenced not only by externalities such as the social context processed implicitly; they are also driven by internal multiple unconscious systems operating in parallel, often automatically and without our awareness. It can be helpful to distinguish between the 'deliberative' and the 'intuitive' mind, or implicit System 1 and explicit System 2 (Lapsley & Hill, 2008, p.). According to the new paradigm, implicit processing governs most behaviour, including moral behaviour.

Neuro- and related sciences are underscoring the validity of this paradigm shift. Countless studies demonstrate the ignorance of the individual 'decider' (who can only access what is in the conscious mind) about what implicit systems are doing without conscious control (e.g., Bargh & Chartrand, 1999; Bargh & Ferguson, 2000; Gazzaniga, 1985). For example, Libet (1985) asked participants to indicate when they made a decision by pressing a button at the moment of decision. Their brains were measured for neuronal excitation using an electroencephalogram (EEG). He found that the motor neurons were already active prior to the conscious decision being made, suggesting that unconscious systems were directing action before the person was consciously aware of making a choice.

As another example, political psychologists have discussed political-moral reasoning as 'motivated cognition' (Jost *et al.*, 2003), acknowledging the power of ideology in biasing the processing of information. For example, having a stake in reasoning about conflicting information enlists different parts of the brain than does unmotivated reasoning. Westen and colleagues (2006) scanned committed partisans, presenting them with information that undermined a candidate (from their own party or from the other political party). When considering the statements, brain areas reflecting conscious reasoning were not engaged, but brain areas related to emotions were. Motivated reasoning was evident in both cases; activations were seen in the ventromedial prefrontal cortex, anterior cingulate cortex, posterior cingulate cortex, insular cortex, and lateral orbital cortex. The section normally most associated with reasoning, the dorsolateral prefrontal cortex (DPFC), was quiescent.

Once participants arrived at an emotionally comfortable conclusion (excusing their candidate or condemning the other candidate), the ventral striatum was activated, which is related to reward and pleasure. All this took place without the awareness of the participants. Studies like these show how neurological investigation can corroborate or call into question our assumptions about our own decision-making which have been based on introspection. They make evident that reasoning can be implicitly influenced by one's motivation. One's view of what is true may depend on one's implicit biases of what is good as well as on a desire to protect one's self-image as good (Orizio, 2003).

The importance of the brain for emotion and moral functioning

For centuries, scholars have assumed that emotions are a nuisance to 'rational man' and that morality has more to do with overcoming emotion and thinking logically. James Rest pointed out to his students that Kohlberg avoided using personal dilemmas or 'hot-button' issues as a way to circumvent the contaminating effects of emotion on reason. Neuroscience is illuminating the debate. The example of 'motivated cognition' just discussed is a case in point, and other work in the neurosciences is also relevant.

Damasio and colleagues (Anderson *et al.*, 1999; Damasio, 1999) have shown through the study of brain damaged patients that reason without emotion is deficient and ineffective for general decision making. Depending on the damage, patients are either unable to generate emotional cues or to follow those cues when they arise, for example, in a gambling task. The lack of emotional cue generation or integration of emotion into decisions greatly damages social relations. For example, Anderson *et al.* (1999) examined children whose prefrontal cortex had been damaged before age 16 months. The damage left them unable to acquire social conventions and moral rules throughout life, a syndrome resembling psychopathy. Although normal in language and intelligence, these patients exhibit behaviour perceived as antisocial, such as shoplifting, sexually aggressive behaviour and non-responsiveness to punishment. Thus, moral development appears to be arrested when the ventromedial prefrontal cortex (VMPFC) is damaged at a young age (Eslinger *et al.*, 1992).

Brain areas important for moral sensitivity can also be damaged in adulthood, leading to changes in personality and impulse control. This has been shown most famously in the case of Phinneas Gage, but noted also in other adult patients who demonstrate a lack of impulse control and social appropriateness while exhibiting normal intelligence and language skills (Anderson *et al.*, 1999). Such individuals are unable to respond emotionally to the content of their thoughts, and they often say things that are hurtful and inappropriate. Thus, the VMPFC appears to be linked to social awareness, and its damage leads to social difficulties. This may occur in part because of the inability to suppress fear of others (Morgan, Romanski & LeDoux, 1993) as well as a loss of the ability to process dominance in social relationships (Karafin, Tranel & Adolphs, 2004). Dysfunction in the superior temporal sulcus (STS), critical for social perception, leads to difficulty in attributing intentionality and decreased experience of pride or embarrassment (Iacoboni, *et al.*, 2001; Norris, *et al.*, 2004).

Reason and emotion generally operate together. De Martino and colleagues (2006) found a key role for emotional response (operationalised as amygdala activation) in economic decision making, which was at the same time mediated by more cognitive-rational areas (orbital and medial PFC). Moll *et al.* (2002a) suggest that a cortical–limbic network (including the medial orbital frontal cortex, the medial frontal gyrus and the superior temporal sulcus) gives humans the ability to link emotional experience to moral appraisal.

Neuroscience helps us see that sometimes moral judgement is independent of emotion and sometimes it is not, even though not all findings of neuroscience may correspond with a person's subjective experience. One of the earliest published fMRI studies of moral judgement (Greene *et al.*, 2001) compared appraisal of personal and impersonal dilemmas (where 'personal' refers to the likelihood to cause serious bodily harm to a particular person that is not the result of a deflection of harm onto someone else). Brain activation for impersonal dilemmas was similar to activation for non-moral practical judgements (i.e., working memory: DPFC and parietal) in comparison to personal dilemmas which also activated emotional areas (MFG, posterior cingulate gyrus and bilateral STS). Greene *et al.* (2004) proposed a competitive hypothesis where cognitive and emotional brain systems compete with one another in making moral judgements, resulting in either what they called 'utilitarian' responses when emotions are overridden (reasoning wins) or in so-called 'deontological' responses when emotion dominates (emotion wins). However, in support of the importance of emotion for moral judgement generally, Koenigs and colleagues (2007) found that damage to the prefrontal cortex increased so-called 'utilitarian' moral judgements; missing was the typical aversion to killing one person to save many, an empathic reaction that appears to be innate under normality.

The nature of moral functioning

Although moral judgement has proved to be an area of importance for moral study, it is not the whole picture. James Rest (1983; Narvaez & Rest, 1995) developed an explanatory framework describing psychological processes necessary for moral functioning. His Four Component Model of moral functioning includes not only moral reasoning or judgement but also sensitivity, focus/motivation, and action; all four psychological processes take place in normal moral functioning. Useful for designing educational interventions, the model is also useful for parsing research findings. We organise and review in this section the current literature related to the neurobiology of morality by discussing some of the findings relevant to each component.

Moral sensitivity

Moral sensitivity refers to cognitive and emotional information processing, such as moral perception, moral imagination and empathy. Moral perception involves picking up or apprehending morally-relevant cues in context (Blum, 1994; Narvaez, 1993), which greater expertise facilitates (Narvaez & Gleason, 2007). Moral imagination consists of conceptualising alternative pathways for action as well as possible ramifications from and for those involved (Somerville, 2006). Empathic sensitivity to others in need is frequently the initiator of the other processes that lead to moral action (Hoffman, 2000).

In primates and humans, social sensitivity is evident at the neuronal level when observing behaviour. In fact, primate brains are so sensitive to social stimuli that they react to the action of others as if the observer herself is acting. Brain areas that involve imitative behaviour are called 'mirror neurons' and are involved in observation of others' behaviour (Iacoboni, 2005). Premotor neurons, which are active during action execution, fire when the individual observes an action, suggesting that what an individual observes is what the individual in effect 'practices' doing. Moreover, motor neurons fire when the individual ascribes an intention to another: 'To ascribe an intention is to infer a forthcoming new goal, and this is an operation that the motor system does automatically', suggesting that 'action representation mediates empathy' (Iacoboni *et al*., 2005, p. 0529). The anterior insula is active during observation of another's action but more so when the individual imitates an action. In fact, Critchley (Critchley *et al.*, 2004) found that activity in the right frontal insula was related an individual's ability to detect her own heartbeat as well as to expressions of empathy. They also found that people with higher levels of empathy have more gray matter in the right frontal insula, indicating a greater ability to detect emotions in self and others. Perhaps the neurological evidence will one day provide an important part of the explanation for cultural and individual differences in moral sensitivity.

For humans generally, the rewards for compassion appear to be hardwired in the brain. Harbaugh, Mayr & Burghart (2007) scanned participants as they received or donated money, either voluntarily or in the form of a tax. When the participant chose to donate to the charity, the caudate, nucleus accumbens and insula were active, simulating the reward system that is evoked when eating a tasty dessert or receiving money. When the participant's money was forcibly given to charity outside her control, the same reward network was activated, only slightly less so. Giving was rewarding, whether through 'taxes' or personal charity. This suggests that the normal human brain operates so that the individual is sensitive to the needs of others and activates reward systems when intervening to help.

Moll *et al.* (2002b) tested perceptual sensitivity for moral violations with pictures, contrasting brain activation to scenes evoking disgust and fear with moral violations; only moral stimuli activated the anterior prefrontal cortex (PFC), medial orbital frontal cortex (OFC), and superior temporal sulcus (STS) regions. The researchers proposed that moral sensitivity involves the activation of a network that includes the anterior PFC, OFC, STS and limbic regions.

Not only is there hardwiring for moral sensitivity, early experience is critical for building a brain that can become morally flexible and responsive. Developmental studies indicate that 'experience methodically rewires the brain, and the nature of what it *has* seen dictates what it *can* see' (Lewis, Amini & Lannon, 2000, p. 135). Vital brain circuits that involve memory, emotion, behaviour and relationships are under construction in early life (Schore, 1994). These circuits regulate processes contributing to 'the generation and regulation of emotion, the capacity for "response flexibility" or mindful, reflective behaviour (Siegel, 1999), the autobiographical sense of self and the construction of a "self-narrative", the capacity to understand and care about the minds of others, and the ability to engage in interpersonal communication' (Siegel, 2001, p. 73). Twenty years of longitudinal data have proved that responsive parenting influence the development of these empathy circuits in the brain, conferring apparently permanent personality strengths (Karen, 1994). Securely attached children show earlier conscience development (Kochanska, 2002).

Moral judgement

Moral judgement—reasoning about and judging moral action—is the most well studied aspect of moral psychology since Kohlberg's 1958 dissertation. Some scholars pin moral judgement to innate tendencies; Hauser (2006) has gone so far as to propose an innate, yet-unspecified universal moral grammar for making moral judgements. Even primates appear to have innate dispositions for 'norm-related characteristics', such as prescriptive social rules, rule internalisation, and anticipation of conflict (de Waal, 1996, p. 211).

Neuroscientists have also studied moral judgement. For example, researchers have explored the difference in brain functioning between justice and care decisions (Robertson *et al*., 2007), personal and impersonal dilemmas (Greene *et al*., 2001), and fairness judgements (Knoch, *et al*., 2006). In a review, Moll *et al.* (2005) pointed out the remarkable agreement across clinico-anatomical and functional imaging studies regarding the brain areas involved in moral cognition. The wide variety of stimuli, modalities and moral judgement tasks maintains the same set of active areas, which are the anterior prefrontal cortex (APFC), orbitofrontal cortex (OFC), dorsolateral prefrontal cortex (DPFC), insula, precuneus, superior temporal sulcus (STS), and anterior cingulate cortex (ACC). Examining moral judgement specifically, Moll and colleagues (Moll, Eslinger & de Oliveir-Souza, 2001) found activation in the frontopolar cortex (FPC), medial frontal gyrus (MFG), right anterior temporal cortex, lenticular nucleus and the cerebellum, demonstrating links that exist between evolutionarily older and younger parts of the brain.

Justice vs. care. Examining the contrasts between justice and care issues, Robertson *et al.* (2007) scanned the brains of business students while they read and decided about moral and non-moral concerns in stories. For moral issues (categorised as concerning justice or care), there was increased activation of the dorsal posterior cingulated cortex, posterior superior temporal sulcus (STS), and the polar medial prefrontal cortex. The authors distinguished between care issues (concerning family needs) and justice issues (integrity concerning work decisions and behaviour). Concern for justice issues was correlated with increased activation of the left intraparietal sulcus, whereas concern for care issues was related to increased activation of the thalamus, the ventral posterior cingulated cortex, and the ventromedial and dorsolateral prefrontal cortex.

Moral motivation or focus

Moral motivation addresses several elements that moral psychology is trying to unpack (see Frimer & Walker, 2008, p. ; Narvaez & Lapsley, in press). Generally, moral motivation 'implies that the person gives priority to the moral value above all other values and intends to fulfill it' (Narvaez & Rest, 1995, p. 386). Moral focus relates to the immediate goal of an individual in a particular circumstance, as well as to recurring or chronic goals.

. Moral motivation *in situ* is difficult to study since it is influenced by multiple situational factors, such as environmental affordances (Gibson, 1979), situational press (Zimbardo, 2007), contextual cue quality (Staub, 1978), social influence (Hornstein, 1976), mood and energy (Hornstein *et al.*, 1975; Isen, 1970; Isen & Levin, 1972). Moral motivation has been inferred in the behaviour of many animals. For example, primates show a sense of reciprocity including exchange as well as revenge and aggression against those who violate reciprocity (de Waal, 1996). Rutte and Taborsky (2007) found that female rats who had been helped previously to get food by other rats were more likely to help unfamiliar rats get food, demonstrating generalised reciprocity.

De Quervain *et al.* (2004) scanned brain activation during punishment of those who violated social rules. Although perceived violations of norms were met with costly punishment to the participant, an activated dorsal striatum (reflecting completion of goal-directed action) indicated a sense of reward from justified revenge. 'Psychologically speaking, we punish primarily because we find punishment satisfying (de Quervain *et al.*, 2004), and find unpunished transgressions distinctly un-satisfying (Carlsmith, Darley & Robinson, 2002; Kahneman, Schkade & Sunstein, 1998; Sanfey, *et al*., 2003)' (Greene, 2007, p. 71).

A set of studies examined reciprocity of reward and punishment effects using the Ultimatum Game. In this game, one player has a sum of money that he/she can share with the other player; if the second player accepts the offer, the money is shared accordingly; if the second player rejects the offer, then neither player receives any money. Sanfey *et al.*, (2003) studied the changes in neural activity while players played the Ultimatum Game. In second players, the more unfair an offer, the greater the activity in the anterior insula, an area associated with negative emotions. Strong activity in the anterior insula was correlated with rejecting offers but also to activity in the dorsolateral prefrontal cortex, an area involved in reasoning and planning. The authors suggest that the mixed feelings of second players were reflected in brain activity, showing a competition between a goal to increase wealth and a goal to resist unfairness. Similarly, Knoch and colleagues (Knoch *et al.*, 2006) demonstrate the importance of the dorsal lateral prefrontal cortex (DLPFC) for resisting unfairness. When the DLPFC was disrupted, participants could not refuse unfair offers. Conflicting goals were represented at the neuronal level.

Moral action

Moral action encompasses the abilities and capacities necessary to complete moral actions. These abilities include executive functions such as planning, foresight, selecting action, and starting and stopping action. Moral action is linked to the perception and interpretive skills of moral sensitivity and motivation, which are related to action potentiation and the affordances (action possibilities) apprehended by the moral agent in the particular situation. That is, moral action is dependent on perceptual capabilities (the agent's view of what is occurring and what actions are possible) within the current motivational orientation (what actions fit with current goals). Moral action is most easily studied by comparing either experts with novices or 'normals' with brain damaged individuals with localized disruption to designated brain areas.

Judgement vs. action. The distinction between judgement and action has been documented by Damasio and further examined by Knoch *et al.* (2006). Patients with lesions in the right dorsolateral prefrontal cortex (DLPC) are typically unable to *behave* in socially acceptable ways even though their judgement of appropriate behaviour is intact (Anderson *et al.*, 1999). The right DLPC controls self-interest impulses enabling persons to pursue fairness goals; when Knoch *et al.* disrupted the DLPC in normal participants, selfish behaviours predominated while reciprocal fairness behaviours were diminished (Knoch *et al.*, 2006).

Moral action, like all of the processes involved in moral functioning, is reliant on the prefrontal cortex (PFC). The PFC is involved in the formation of goals and aids in planning to achieve goals. The PFC is used to coordinate plans, applying skills in the correct order. Finally, it helps the agent evaluate success relative to intentions. To do this the PFC accesses a library of associations containing the taxonomy of known categories (the PFC is the associations unit for the frontal lobes, termed the 'action lobes' by Goldberg, 2002). Basing his questions on accumulated data, Goldberg asks: 'Could it then be that…the prefrontal cortex contains the taxonomy of all the *sanctioned moral actions and behaviors*? And could it be that, just as damage or maldevelopment of the posterior association cortex produces *object agnosias*, so does damage or maldevelopment of the prefrontal cortex produce, in some sense, *moral agnosia*?' (2002, p. 142). When the prefrontal lobes are damaged, impulses for anger, lust, and greed can rage out of control. Damage to the PFC, possibly from early neglect, later abuse, or exposure to environmental stress, may result in increased displays of disorganized and impulsive behaviour, poor attention, and impaired behaviour regulation. In patients with damage to the OFC, there is often a disconnection between knowledge and action. Even though they know right from wrong, these patients are unable to regulate their behaviour. Damage to the ACC can lead to 'frontal lobe crime' (Goldberg, 2002, p. 153), where the individual may know the rules of behaviour but does not follow them and instead acts ineptly, with little foresight or precision. Those with 'frontal lobe syndrome' have lost their inner guide to behaviour (ibid, p. 155). Similarly, Blair (1995) proposed that psychopaths lack a 'violence inhibition mechanism' (VIM), a mechanism within the brain that is activated in normal brains when distress cues are exhibited by another, causing behavioural inhibition.

We have used Rest's four components to organise a review of some of the neuroscience relating to moral functioning. Although the research is still preliminary, it thus far corroborates the suggestion that brain damage can lie behind maladaptive behaviour and that socially normative functioning in each component relies on healthy brain functioning. In the next section we review some of the neuroscience literature relating to the importance of early childhood experience to healthy brain functioning.

The importance of initial conditions

Before birth neurons are known to proliferate, migrate, and aggregate as they assemble the 'hardware' of the neonatal brain (DiPietro, 2000); proliferation rates are estimated at 250,000 per minute. In fact, foetal ultrasound measures can disrupt neuronal migration (Ang *et al.*, 2006). Born with 100 million neurons and few synapses connecting them, the human neonate has 25% of the brain size of the adult. Interconnectivity occurs through the synaptogenesis, myelination (the addition of a fatty acid coating to speed up neuronal communication) and selective elimination of existing synapses as a result of experience. At age three, synaptic density reaches its lifetime peak and is 50% greater than in the adult brain. Brain areas develop at different rates, and peak periods are established at different times. For example, the prefrontal cortex, vital for moral functioning, accelerates at 8 months and reaches maximal density at age two at which point cortical development plateaus until early adolescence and is not complete till nearly age thirty. Myelinization continues through midlife (the sixth decade in women).

The impact of many experiences in the life of the infant has often been underestimated. For instance, circumcision was thought once to have no effect on an infant but studies have documented profound effects on bonding (e.g., Denniston, Hodges & Milos, 1999). A child's caregivers play the largest role in determining brain formation both before and after birth. Newer research is indicating that this occurs in ways large and seemingly small. For example, what a mother eats during pregnancy affects food preferences in the toddler (Mennella, Yanina Pepino & Reed, 2005). Depending on when they are used, nicotine, alcohol and illicit drugs have particular detrimental effects on fetal brain formation, disrupting 'the precise interactions of environmental signals with genes that drive cellular differentiation and circuit formation' (Levitt, Reinoso & Jones, 1998, p. 180). Weaver *et al.* (2004) document the importance of maternal nurturance during critical periods for gene expression; for example, high nurturance determines whether a glucocorticoid receptor is turned on or not, influencing stress response throughout the lifespan, a factor implicated in the development of psychopathology and psychosocial functioning. Evidence is converging on how much the brain's systems are co-constructed by the relationship between the caregiver and infant (Lewis, Amini & Lannon, 2000; Schore, 1994).

Attachment. The importance of 'attachment' cannot be overstated. Often discussed as if only a psychological construct, the processes of 'attachment' deeply marks the brain neurobiologically; it would better be called the foundational phase of infant brain development. Evidence for the importance of infancy and early childhood to establish the brain's emotional circuitry has been accumulating since Harlow's (1986) experiments with monkeys. Critical for lifetime brain development and emotion regulation (Gross, 2007), the neurobiological wiring that occurs with secure attachment is also critical for social and moral behaviour. The infant's nervous system is dependent on experience and relies on the caregiver to act as an 'external psychobiological regulator' (Schore, 2001, p. 202) through the social construction of the brain (Eisenberg, 1995). The caregiver plays multiple roles in regulating the physiological and psychological development of the infant. Hofer (1994; Polan & Hofer, 1999) describes how the caregiver's 'hidden' regulation of infant development cuts across sensory systems (e.g., tactile, olfactory) and influences multiple levels of functioning. 'So, for example, maternal tactile stimulation may have the effect of lowering the infant's heart rate during a stressful situation, which may in turn, support a more adaptive behavioural response' (Calkins & Hill, 2007, p. 240). When human mothers and offspring are separated during infancy, the mother's absence causes multiple levels of disruption and disorganization in physical systems. Perhaps this is why mammals never intentionally separate mother from newborn, except for humans.

Early childhood experiences set up the neuroendocrine systems vital for managing stressful situations and bonding to others throughout life (Carter, 1998). Among many systems, it is thought that active peptidergic systems (a type of neuroendocrine system), which involve oxytocin and vasopressin, may inhibit defensive behaviours that are associated with anxiety, stress and fear, which allow for positive social interactions and the development of social bonds (ibid). Oxytocin is related to caring and bonding, inhibiting fight or flight responses and disassociative responses (Perry *et al.,* 1995). The presence of oxytocin is able to counteract the effects of stress by, for example, decreasing blood pressure and reducing activity in the sympathetic autonomic system (Uvnas-Moberg, 1997; 1998). Persistent stress appears to decrease the activity of the oxytocin system and the neurological/emotional ability to bond that accompanies it (Henry & Wang, 1998). In fact in one study, Romanian orphans who did not receive personal care in the first years of life showed depressed levels of oxytocin and vasopressin when in physical contact with adopted parents, unlike comparison children in contact with birth parents, suggesting a critical period for laying down the appropriate neuroendocrine circuitry for social bonding (Wismer Fries *et al.*, 2005).

Neuroendocrine systems play a role in maternal bonding (Nelson & Panksepp, 1998). In fact, bonding is a phenomenon that occurs first in the mother and then in the child, for example, the mother's pertidergic system releases oxytocin which is conveyed to the infant through breast milk.. Nitschke and colleagues (2004) found that the orbitofrontal cortex (OFC) is activated in new mothers when they report a good mood while looking at photos of their babies, suggesting that attachment bonding in the mother may be at least partially mediated by OFC activation. The same neuroendocrine system appears to be involved in bonding to non-kin throughout life (Eisler & Levine, 2002), and trusting others in experimental situations (Kosfeld *et al.*, 2005).

Meaney and colleagues (e.g., Weaver, Szyf & Meaney, 2002) have documented differences in gene expression based on maternal care. Rats with high-caring (i.e., high licking) mothers had more active versions of a gene that encodes a molecule called glucocorticoid receptor protein. Glucocorticoid, a hormone produced in response to stress, needs to be switched off to prevent over-excitation. The receptor protein in the hippocampus dampens further synthesis of the protein, but only in rats with high-caring mothers. Rats with little maternal care have a weaker feedback system, resulting in greater anxiety and heightened responses to stress throughout life. Moreover, there are spiralling generational effects. A low-nurturing mother breeds low-nurturing daughters, compounding the effects of poor bonding and poor brain development over generations. Similarly, 'an absence of positive social interactions early in life, especially those involving physical contact with caregivers, helps set a low threshold for activating the amygdala in response to potential threats that may persist throughout the lifespan' (Ochsner & Gross, 2007, p. 103). Analogous effects are presumed for human caregiving. The high rates of child abuse in the USA suggest extensive bonding problems (Prescott, 1996); the epidemics of depression and anxiety among children and adults in the USA relate to extensive social-relational disruptions (e.g., Siegel, 1999).

Developmental change. The neurobiology of attachment influences many aspects of moral behaviour. For example, secure attachment is associated with early conscience development (Laible and Thompson, 2000). When a caregiver is responsive and attuned to the needs of the infant or child, the child is more likely to be cooperative and conscientious (e.g., Kochanska, 2002). Infants whose mothers are depressed experience less maternal responsiveness and demonstrate persistent cognitive deficits (Murray & Cooper, 1999). It has been consistently well documented that warm, responsive care giving is associated with the child's ability to self-regulate. Punitive parenting, characterised by harsh treatment or lack of warmth, is related to callous and unemotional behaviour (Pardini, Lochman & Powell, 2007). The physical mechanism for this relation appears to be abnormal cortisol levels in neuronal glucocorticoid receptors in the frontal cortex, important for executive functions, due to chronic frustration. Henry and Wang (1998) suggest that chronic frustration in the infant brain results in a disregulated hypothalamic-pituitary-adrenal axis (HPA), leading to a focus on self safety and damaging the ability to relate to others.

Many areas in the brain that are germane to moral functioning appear to be under construction until nearly age 30 (Luna *et al.*, 2001; but see Epstein, 2007). Those final years foster the construction of the prefrontal cortex (PFC), an area vital to moral behaviour. The PFC coordinates initiating and organising action, sustaining attention, inhibiting reactions, shifting from one task to another, regulating emotions and a full working memory. The PFC allows the individual to manage a host of functions, including coordinating internal states with external events. Because the prefrontal cortex is not yet in mature working order in adolescents, researchers argue that decision making takes place primarily through the amygdala's immature system, which focuses on the immediate situation (e.g., Bechara, 2005). So if 'everyone is doing it' in the situation, the adolescent is likely to do it too. In adults the prefrontal cortex functions as quickly as the amygdala system, allowing adults a more tempered decision making style.

The importance of practice

Brain structures and functions are malleable. Even though there appear to be critical periods for brain function development, unless the damage is severe there is the possibility for change. An increasing number of publications are documenting such changes (e.g., Schwartz & Begley, 2003). Changes in aspects related to moral functioning can occur in all four components, throughout life (although it takes considerably more effort in later years; Mahncke, Bronstone & Merzenich, 2007).

For example, experiences throughout the lifetime influence perception and sensitivity. Not only are experts quicker to respond to stimuli in their domain of expertise, but scans show that their brains use less energy to do so (e.g., Solso, 2001). Even the area for initial visual processing is affected by prior experience. Based on repeated experience, neurons in the visual cortex modulate their response in anticipation of reward (Shuler & Bear, 2006), suggesting that even at an early stage of processing, perception is interpretation—expectancies drive what is apprehended. This is perhaps most easily seen in cultural differences, although few brain scanning studies have been done cross culturally. When young and old American citizens were compared with young and old 'East Asians', the Asian elderly were more likely to notice the relationships and the background in a scene. In contrast, American elderly and the young of both countries focused on the person or object of a scene (Goh *et al.*, 2007). Brain activation corresponded to the distinctive response patterns. Such findings suggest that perception is built from culturally mediated experience; sensitivity to stimuli depends on environmental training, whether from everyday unexamined experience which is interpreted and guided by others or from deliberate study. The research thus far suggests that moral development across cultures may differ based on distinctive brain shaping that occurs in each culture.

Moving towards broader integration

Kohlberg's enterprise focused on moral judgement, and clearly that is still important. Yet intentional, deliberative decision making is not sufficient to explain all moral functioning. New findings regarding cognition, emotion and brain development suggest promising directions for a more comprehensive theory. The field of moral psychology yearns to breathe more freely, taking all the domains of psychology into its purview. Neuroscience points to additional insights that can provide a broader footing for theory. Where does current knowledge leave us?

Moll and colleagues (2005) have undertaken a thorough review of the neuroscientific research for what they call a moral cognitive neuroscience. After pointing out the weaknesses in alternative views (e.g., those of Greene, Blair, Damasio), they propose a new framework derived from clinical and imaging evidence: 'moral cognitive phenomena emerge from the integration of content- and context-dependent representations in cortical-limbic networks' (p. 804). There are three components to the framework: *structure event knowledge* which is context-dependent and represented in the prefrontal cortex (e.g., scripts for particular situations), *social perceptual and functional features*, which refers to context-independent knowledge housed in the anterior and posterior temporal cortex (abstractions from an array of information), and *central motive and emotional states,* which are contextually independent activations in limbic and related structures (basic emotions softwired from experience). These three components interact to form 'event-feature-emotion complexes' which guide moral action. The moral psychology theory we describe next elaborates on the 'central motive and emotional states' aspect.

Triune Ethics Theory

Triune Ethics Theory (TET; Narvaez, 2008a) is an attempt to integrate current findings across subfields of the social and neurobiological sciences, addressing the central motive and emotional states identified by Moll *et al.* (2005). TET suggests that three types of affectively-rooted moral orientations emerged from human evolution. Arising out of biological propensities, the three motivational orientations can be significantly shaped by experience. The Ethic of Security is focused on self-preservation through safety and personal or in-group dominance. The Ethic of Engagement is oriented to face-to-face emotional affiliation with others, particularly through caring relationships and social bonds. The Ethic of Imagination coordinates the older parts of the brain, using humanity's fullest reasoning capacities to adapt to ongoing social relationships and to address concerns beyond the immediate. Each 'ethic' has neurobiological roots that are apparent in the structures and circuitry of the human brain. When an individual treats a particular orientation as a normative imperative that trumps other values, it has ethical significance. Each ethic makes normative claims and is primed by the context, in interaction with personality. As a type of motivated cognition, each ethic influences what affordances are salient for action, imbuing ongoing experience with particular moral value (Moll *et al.*, 2002b).

Kohlberg's theory largely ignored the unconscious and the emotions, focusing instead on deliberative reasoning and external, rule-based morality. Although Triune Ethics Theory focuses on emotional motivation, it can link to

Kohlberg's work. Although details still need to be worked out, Kohlberg's stages appear to align developmentally with different TET ethics. The Security Ethic focuses on self-preservation and personal gain (mostly implicitly), much like Kohlberg's preconventional stages. The Security Ethic can easily dominate thought and behaviour under threat, disabling or handicapping other systems for information processing and action governance (MacLean, 1990). Self preservation and in-group survival are reflected in Stage 4 law-and-order thinking, although more implicitly and with greater sophistication, which orients to inflexible rules in order to allay chaos and disorder.

At first glance, the Engagement Ethic appears to correspond to Kohlberg's Stage 3 (be nice and make friends); but it fits better with empathy development (Hoffman, 2000) which crosses species (de Waal, 1996). Not surprisingly, Gilligan's (1982) care ethic can also align with the Engagement Ethic. Although TET theory puts empathy for the non-present, non-familiar other as the most advanced ethical orientation, Gilligan's theory did not address this. Nevertheless, Gilligan's theory provided an initial corrective in emphasising the role of emotions (moral sensitivity) and of the self in context (moral motivation).

The most studied aspect of Kohlberg's theory is postconventional or principled reasoning, Stage 5 and 6. The substance of these stages is deeply rooted in frontal lobe activity and therefore resides in the Imagination Ethic. The Ethic of Imagination is the source of our deliberative reasoning and imagination, which respond to the intuitions and instincts of the other ethics, able to countermand instincts with 'free won't'—stopping our automatic responses, like prejudice, with a more tempered response (Cotterill, 1998). Although humans have evolved to favour face-to-face relationships and have difficulty imagining those not present (such as future generations), the prefrontal lobes provide a means for a sense of community that extends beyond immediate relations.

TET views situations as primes for one or more ethical orientations but within a social-cognitive view of moral personality, which finds dispositional markers in the 'person-by-context' interaction (Lapsley & Narvaez, 2004). That is, particular environments may press individuals to activate one or another ethic (which may take multiple forms). When a particular ethic is primed, it is presumed to influence one's perceptual sensitivities (Neisser, 1976), affective expectancies (Wilson *et al.*, 1989), rhetorical susceptibilities (attractive fallacies), behavioural outcome expectancies and preferred goals (Mischel's 'subjectively valuable outcomes', 1973, p. 270), and perceived affordances (social, physical and action possibilities). In fact, each ethic has its virtues: Security: loyalty, bravery; Engagement: compassion, self-sacrifice; Imagination: open-mindedness, procedural justice. When the security ethic is in control of one's perceptual and response systems, the affordances for behaviour centralise around self-advantageous and in-group-advantageous actions. TET proposes that humans can be at their most moral when both the Engagement and Imagination Ethics are in full function, and the Security Ethic is calm. At the same time, dispositional tendencies towards one ethic or another, canalised from childhood and life experiences, interact with the power of the situation on individual behaviour.

Conclusion

Scholars interested in moral development may find neurobiological research relevant because it sheds light on previously poorly understood factors related to moral behaviour. For example, specific abnormal brain development and brain damage are documented to influence particular deficits in moral cognition and behaviour. Second, brain research sheds light on debates in moral judgement, whether its source is reasoning or emotion, and whether it requires conscious intentionality or operates automatically. Finally, perhaps one of the most interesting areas of research concerns how brain development is influenced by caregiver behaviour, resulting in better or worse equipped brains for the moral life.

Climates and relationships can influence which ethic is active (see Narvaez, 2008b for more detail).[3] Educators can strive to make students feel safe and cared for, monitoring the emotional tone of a classroom and of the teacher-student relationship. Establishing a secure attachment and limbic resonance with children, requires adult attention and emotional awareness. It may be one of the best things educators can do for children.

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Notes

1. Regarding our language use: we speak in the phrases of science, for example, using terms common among neuroscientists—'hardwired' for elements that are not experience dependent, 'softwired' for the experience dependent. Also, we use the terms 'moral' and 'ethical' interchangeably. Both terms refer to aspects of life that impinge on the welfare and well being of individual creatures and groups.
2. Although we only refer to a subset of studies, we encourage the reader to read other helpful reviews of the many neuroscientific studies that have

been done (e.g., Casebeer, 2003; Haidt, 2007; Moll *et al.*, 2005; Robertson *et al.*, 2007).

3. See Narvaez (2008a; 2008b) for applications of Triune Ethics Theory to moral character education.

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