

A Neural Network for Moral Decision Making

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Introduction

Some of the most fundamental psychological questions concerning human relations center on morality and altruism. Reinvigorated by the advent of modern technologies such as magnetic resonance imaging (MRI), these questions have been extended to humans, which has resulted in a recent flurry of empirical studies examining the psychological and neural architecture of moral cognition. The depth of this subject is remarkable, and there is insufficient room here to touch on all facets. As a result, this review will cover two questions central to human moral behavior: How do we arrive at our moral judgments? And what is the neural circuitry that underpins these moral judgments?

How Do We Arrive at Our Moral Judgments? Emotions and the Role of Empathy

An initial theory in moral research proposed that moral judgments were largely the product of applied reasoning (Kohlberg & Hersh, 1977). However, accumulating research illustrates that a confluence of factors – including emotion (Damasio, 1994), reason (Kohlberg, 1969), environmental context (Isen & Levin, 1972), social frameworks (FeldmanHall, Mobbs, Evans, Hiscox, Navardy, & Dalgleish, 2012), empathy and compassion (FeldmanHall, Dalgleish, Evans, & Mobbs, accepted for publication; Preston & De Waal, 2001), sensitivity to harm (Kedia, Berthoz, Wessa, Hilton, & Martinot, 2008), perceived intentions of another (Berthoz, Armony, Blair, & Dolan, 2002), and putative consequences (Borg, Hynes, Van Horn, Grafton, & Sinnott-Armstrong, 2006) – all contribute to guiding our moral judgments. In particular, the proposal that emotion is a fundamental precursor of prosocial behavior (Penner, Dovidio, Piliavin, & Schroeder, 2005) has generated a flourish of research cataloging the putative relationship between emotion and morality. Even with consideration to arguments to the contrary (Hauser, 2006; Huebner, Dwyer, & Hauser, 2009), emotions appear to be central in motivating moral judgments.

Take, for example, the classic trolley dilemma (Foot, 1978): while people are averse to physically pushing a man off a bridge in order to save the lives of five others, they are more willing to contemplate killing five if they only have to flip a switch (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). This particular set of dilemmas suggests that the emotional impact of tactilely shoving another engages emotional processes differentially than the more removed act of flipping a switch. Other research has examined how more specific emotions, like disgust (Hutcherson & Gross, 2011; Ugazio, Lamm, & Singer, 2011; Wheatley & Haidt, 2005), guilt (Finger, Marsh, Kamel, Mitchell, & Blair, 2006; Takahashi et al., 2004), and contempt (Rozin, Lowery, Imada, & Haidt, 1999), can

modify our moral judgments (Eisenberg, 2000; Pizarro & Salovey, 2002; Tangney, Stuewig, & Mashek, 2007). While partaking in immoral behavior can generate guilt or shame, watching others behave immorally incites reactions that give rise to moral appraisals and judgments, like contempt and disgust (Moll et al., 2002a). Each of these distinct moral emotions can promote prosocial behavior. For instance, guilt – a negative evaluation of a behavior that violates moral rules or principles – can motivate people to make amends when they have done something wrong (Chang, Smith, Dufwenberg, & Sanfey, 2011; Giner-Sorolla & Espinosa, 2011). Similarly, exhibiting disgust or contempt (the moral condemnation of others) implements social policing as ultimately, the harming agent is ostracized and morally offensive behavior is minimized (Tangney, Miller, Flicker, & Barlow, 1996).

In the same way that guilt impels people to repair relationships, empathy can be seen as a moral motivator because it 'moves us to partake of the pleasure or pain, the happiness or misery, of others' (Davis, 1900). Empathy, the capacity to have feelings that reflect the emotional dynamics of another's situation (Hoffman, 2000), is a multidimensional psychological concept (Zaki & Ochsner, 2012) composed of distinct, yet related, cognitive and affective processes (Batson, Fultz, & Schoenrade, 1987; Davis, 1983; Penner et al., 2005; Preston & De Waal, 2001). One study in which subjects were trained to become more compassionate and empathic resulted in increased altruistic helping (Leiberg, Klimecki, & Singer, 2011). Similarly, subjects who were part of a group – and thus felt greater positive empathy towards other group members – helped to reduce another member's distress by choosing to endure the physical pain themselves (Hein, Silani, Preuschoff, Batson, & Singer, 2010). Indeed, individuals high in trait levels of empathic concern report greater harm aversion (Crockett, Clark, Hauser, & Robbins, 2010), and this general tendency towards expressing empathic concern for another in distress predicts greater altruistic behavior (FeldmanHall et al., accepted for publication). Together, this work demonstrates how the ability to know, understand, and empathize with what another is feeling can be a strong motivation to help others (Decety, 2011).

Neural Architecture of Moral Cognition

Neuroscientists – predominantly through the use of neuroimaging methods such as functional magnetic resonance imaging (fMRI) and MRI lesion mapping – have identified a set of brain regions that map onto a 'moral circuit.' The earliest imaging experiments contrasted simple written statements containing moral content against statements that contained no moral content (Heekeren, Wartenburger, Schmidt, Schwintowski, & Villringer, 2003; Moll, Eslinger, & Oliveira-Souza, 2001; Moll

et al., 2002b). These studies revealed that moral stimuli preferentially engage the prefrontal cortex (PFC). More recently, research has begun to explore if discrete brain regions support the various psychological parameters known to influence moral cognition (i.e., emotion, reason, and social context). The assumption is that these different psychological parameters can be functionally localized – and dissociated – within the brain. Indeed, moral neuroscientists have found that cognitive load (Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008), semantic content (Takahashi et al., 2004), emotional arousal and regulation (Decety, Michalska, & Kinzler, 2011; Moll & De Oliveira-Souza, 2007), probability (Shenhav & Greene, 2010), intent (Berthoz et al., 2002; Young & Saxe, 2011), and harm (Kedia et al., 2008), to name a few, are associated with distinct activation patterns within the wider moral network.

The Prefrontal Cortex

Through the course of evolution, the capacity for sophisticated reasoning has progressively developed into highly complex and well-tuned cognitive skills. The PFC – which can be subdivided into many subcomponents including the ventromedial PFC (vmPFC), dorsolateral PFC (dlPFC), and orbital frontal cortex (Figure 1) – is considered to underlie higher-order cognition. The cortical expansion of the PFC has permitted humans to engage in more sophisticated capacities, such as abstract reward and punishment contingencies (O’Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001), self-regulation (Raine & Yang, 2006), and top-down control (Mansouri, Tanaka, & Buckley, 2009). By logical extension, it is unsurprising then that moral decision making, which requires the ability to process and integrate highly complex and conflicting stimuli, consistently engages the PFC.

Broadly speaking, the vmPFC and dlPFC demonstrate reciprocal connectivity with different posterior and subcortical regions of the brain, which, in turn, impacts each region’s functionality (Wood & Grafman, 2003). The dlPFC – which receives inputs from temporal and parietal regions and projects to motor regions (Ongur & Price, 2000) – is most closely associated with processes that include cognitive control and deliberative thinking (Mansouri et al., 2009) like executing motivated selfish behavior (FeldmanHall, Dalgleish,

Thompson, Evans, Schweizer and Mobbs, 2012). The dlPFC has also been implicated in processing abstract moral principles (Moll, De Oliveira-Souza, Bramati, & Grafman, 2002) such as sensitivity to unfairness (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). One seminal study showed that when individuals contemplate what they would do during the trolley dilemma (i.e., flipping a switch that reroutes an out of control trolley from a track with five people to a track that only has one person), the dlPFC preferentially engages (Greene et al., 2001). This is a different neural result from when subjects contemplate actively pushing another person onto the tracks to stop the trolley, a more ‘emotional’ response and one that engages the vmPFC.

The vmPFC plays an integral role in social cognition and moral decision making and has shown to be especially crucial for monitoring internal states and motivations (Forbes & Grafman, 2010) like self–other reflection (Van Overwalle, 2009) and perspective taking (Amodio & Frith, 2006). The imaging literature has further emphasized the vmPFC and its role in encoding socioemotional knowledge, such as stereotypes (Gozzi, Raymond, Solomon, Koenigs, & Grafman, 2009) and moral emotions, like pride (Tangney et al., 2007), embarrassment (Zahn et al., 2008), and guilt (Moll et al., 2011). The vmPFC also engages when individuals select the clearly prosocial option in a relatively easy moral dilemma (FeldmanHall, Mobbs, & Dalgleish, 2013) and when they make rapid decisions during emotionally evocative moral challenges (Greene et al., 2001). Similarly, violations of social norms (Berthoz et al., 2002) and adherence to social norms (i.e., greater altruistic behavior) (FeldmanHall, Dalgleish, et al., 2012) preferentially engage the vmPFC. Together, these findings suggest that as individuals navigate through a complex and social world, the vmPFC plays a critical role in evaluating conflicting moral phenomena and assigning moral value (Preston & De Waal, 2011).

Cingulate Cortex and Amygdala

The cingulate cortex and amygdala (Figure 1) – seemingly integral structures for successful moral responding – have extensive connections with one another (Derubeis, Siegle, & Hollon, 2008) and directly project to the anterior portions of

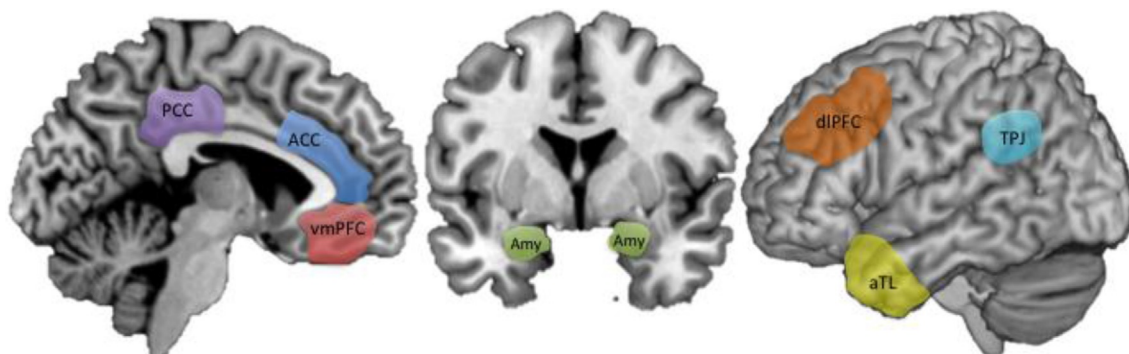


Figure 1 The brain’s ‘moral network’: comprising the prefrontal cortex, which includes the dorsolateral PFC (dlPFC) and ventral medial PFC (vmPFC); the temporal lobes, which includes the anterior temporal lobe (aTL) and temporoparietal junction (TPJ); the cingulate cortex, which is subdivided into the posterior cingulate cortex (PCC) and the anterior cingulate cortex (ACC); and the amygdala (Amy).

the PFC (Van Hoesen, Pandya, & Butters, 1972). The cingulate cortex is divided into the anterior, middle, and posterior cingulate cortices (PCC) and does not exhibit uniform functionality (Devinsky, Morrell, & Vogt, 1995). The anterior cingulate cortex (ACC) has been broadly implicated in a number of cognitive functions that influence moral decision making, including emotional responsiveness (Ochsner & Gross, 2005) and conflict monitoring (Kerns et al., 2004) – especially for difficult moral dilemmas (Greene, Nystrom, Engell, Darley, & Cohen, 2004; Kahane et al., 2011). Research further demonstrates that the ACC engages during evaluations of moral transgressions that involve the self and others (Kedia et al., 2008), possibly indexing the associated feelings of guilt (Shin et al., 2000). The ACC also activates when subjects make moral decisions that result in real outcomes, compared with decisions made in purely hypothetical contexts (FeldmanHall, Dalgleish, et al., 2012). In contrast, the PCC has been more closely linked to reasoning through moral judgments (Greene et al., 2001), hypothetical moral choices (FeldmanHall, Dalgleish, et al., 2012), and simple moral decisions (as opposed to more complex, semantic ones) (Heekeren et al., 2003).

Like the cingulate, the amygdala is anatomically organized into distinct regions that are divided along the basis of evolutionarily newer regions (basolateral) and evolutionarily more primitive areas (corticomедial) (Ledoux, 2007). While the amygdala consistently engages when processing socially relevant stimuli (Adolphs, Tranel, & Damasio, 1998), research has found inconsistent activation of the amygdala for explicit moral phenomena (Raine & Yang, 2006). Some work has illustrated that the amygdala engages for processing the consequences of moral actions (Decety et al., 2011), especially for harmful stimuli like physical and emotional pain. Interestingly, such harmful stimuli – and the moral emotions that arise from situations involving interpersonal harm – do appear to reliably engage the amygdala (Berthoz, Grezes, Armony, Passingham, & Dolan, 2006; Decety & Porges, 2011; Decety et al., 2011; Kedia et al., 2008; Luo et al., 2006). However, the fact that the amygdala is not consistently activated across different types of moral phenomena – especially in contrast to the PFC, which is consistently active across a myriad of moral tasks – suggests that the amygdala may be more sensitive to a particular subset of moral decision-making parameters. For example, imaging studies exploring moral phenomena differ widely in their task requirements (i.e., passive versus active) and emotional engagement. Thus, it is possible that unlike the PFC, the amygdala may only engage when there is salient harm or active engagement during the task (FeldmanHall, Dalgleish, et al., 2012).

The Temporal Lobes

More recently, research has illustrated that the temporal lobes, and in particular the anterior temporal lobe (aTL) and temporoparietal junction (TPJ) (Figure 1), play significant roles in guiding moral cognition. The aTL is thought to encode the understanding of abstract conceptual representations (Moll, De Oliveira-Souza, & Zahn, 2008) – such as ‘honorable’ or ‘brave’ (Zahn et al., 2007) – an ability that allows moral phenomena to be conceptualized across a wide range of

situations (Tse, 2008). That the aTL has been implicated in synthesizing semantic representations and social conceptual information (Lambon Ralph, Pobric, & Jefferies, 2009) dovetails nicely with the evidence that damage to this area can cause inappropriate social behavior (Moll et al., 2008). The TPJ, which is situated posteriorly to the aTL, generally behaves in a similar way; its functions include decoding social cues (i.e., facial expressions and bodily movements) (Saxe & Kanwisher, 2003) and agency and intentionality (i.e., theory of mind) (Moll et al., 2008). This fits with the evidence that disrupting TPJ engagement, through either lesion or transcranial magnetic stimulation, results in the diminished capacity to understand another’s beliefs (Samson, Apperly, Chiavarino, & Humphreys, 2004; Young, Camprodon, Hauser, Pascual-Leone, & Saxe, 2010).

A recent study comparing effortful and cognitively demanding moral decisions (such as suffocating your baby in order to save the rest of your family from being discovered by enemy soldiers) with rapid, easy moral decisions found increased activation in the TPJ (FeldmanHall, Mobbs, & Dalgleish, 2013). This finding accords with the proposal not only that the TPJ is crucial for attending to, shifting between, and weighing up salient and competing stimuli (Mitchell, 2008) but also that the TPJ is integral for understanding another’s intentions (Young, Cushman, Hauser, & Saxe, 2007). Individuals diagnosed with autism, who are known to have difficulty attributing mental states to others, demonstrate abnormal TPJ activity (Baron-Cohen et al., 1999) and even sometimes fail to activate the TPJ altogether (Castelli, Frith, Happe, & Frith, 2002). One recent study found that, the TPJ was relatively deactivated in individuals who have trouble identifying and experiencing emotions (a subclinical personality construct called alexithymia) (Sifneos, 1973) when observing another in distress (FeldmanHall, Dalgleish, & Mobbs, 2013).

A Clinical Perspective

Disturbances in socioemotional responding – observed to varying degrees across multiple clinical populations including psychopaths, alexithymics and frontal lobe patients – can significantly affect social behavior (FeldmanHall, Dalgleish, & Mobbs, 2013). For example, psychopathy is characterized by a profound lack of empathy, guilt, and remorse (Hare, Hart, & Harpur, 1991) – emotions that are critical for dictating how individuals experience interpersonal dynamics. It is thought that a psychopath’s inability to behave morally is related to a lack of empathic concern or a reduced ability to emotionally respond to the observation of distress in others (Blair, Peschardt, Budhani, Mitchell, & Pine, 2006) – abilities that are attributed to the functional integrity of the frontal lobe (Blair, 2007). Early PFC damage, specifically to the anterior PFC, alters the development of social cognition and social emotions, creating deficits in emotional and moral behavior (Eslinger et al., 2009). Research has also found significant reduced PFC gray matter volume in patients diagnosed with psychopathy (Weber, Habel, Amunts, & Schneider, 2008). A recent fMRI study found that the network subserving moral judgment, and in particular the PFC, is relatively underactive in psychopathic individuals when deliberating over moral

dilemmas (Pujol et al., 2011). In addition to the PFC, dysfunction in the amygdala has also been linked to psychopathy (Blair, 2007). Psychopaths exhibiting flagrant immoral behavior without remorse show reduced activity in the amygdala in response to emotional words (Blair, 2007), and another study correlated smaller amygdala volume with increasing degree of psychopathy traits in violent offenders (Blair, 2003).

Evidence from frontal lobe lesions strongly parallels the findings of moral impairment in psychopathy and continues to indicate that robust vmPFC functioning is necessary for effective moral decision making. The earliest and perhaps most famous case comes from Phineas Gage, who in 1848 survived an accident that almost completely obliterated his left frontal lobe, which resulted in somewhat antisocial and morally deficient behavior (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). Other patients with lesions to the vmPFC (Damasio, 1994) commonly illustrate blunted affect, irrational responses to minor provocation, and irritable, angry, and abusive behavior (Koenigs & Tranel, 2007). Research shows that compared with healthy individuals, vmPFC patients judge moral violations as more acceptable (Ciaromelli, Muccioli, Ladavaso, & Di Pellegrino, 2007; Young et al., 2010). One study found that patients with bilateral vmPFC lesions made more utilitarian judgments in high-conflict moral dilemmas (Koenigs et al., 2007) – that is, conflicts where emotional reactions would be likely to motivate a choice incongruent with an ideally ‘rational’ analysis. It is thought that because these patients are unable to harness emotional responsiveness to highly aversive stimuli (e.g., pushing a man in front of a trolley in the trolley dilemma), they make more utilitarian decisions because they have no internal emotional signal indicating that it is aversive to push a man to his death.

Together, the clinical data support the proposal that moral cognition relies on a qualitatively distinct emotional signal. When emotions – which are arguably central to social behavior (Huebner et al., 2009) – fail to develop or cannot be deployed, callous, antisocial behavior can ensue. This could be explained by the theory that a negative emotion can act as an antecedent to a moral decision, alerting the individual to the moral salience of a situation (Decety et al., 2011) and indicating that a certain action should be taken. Without this reflex-like emotional precursor, individuals may have difficulty registering that a relevant event is occurring as they lack the requisite capacity that ‘emotions are, in essence, impulses to act’ (Goleman, 1995).

Conclusions

What has emerged from the growing literature is that moral cognition arises from a complex, diverse, and decentralized neural network that selectively engages distinct brain regions depending on the associated emotions, framework, and context. The vmPFC appears intimately linked with emotional arousal (Harenski & Hamann, 2006; Moll et al., 2007); the TPJ seems to subserve the capacity to think about another’s perspective when deliberating over a moral dilemma (FeldmanHall, Dalgleish, & Mobbs, 2013; Young et al., 2007;

Young & Saxe, 2008; Young, Scholz, & Saxe, 2011); and the amygdala emerged as a region sensitive to salient stimuli and, in particular, harmful actions (Anderson & Phelps, 2001; Berthoz et al., 2006; Blair, 2007; FeldmanHall, Dalgleish, et al., 2012; Finger et al., 2006; Harenski, Harenski, Shane, & Kiehl, 2010; Kedia et al., 2008).

Inevitably, questions remain. Is moral cognition the result of a bottom-up neural process where higher-order rational processes, presumably within the PFC, are modulated by lower-order socioaffective regions (Naqvi, Shiv, & Bechara, 2006)? Or do moral decisions arise from a top-down modulation of subcortical networks (Moll, Zahn, De Oliveira-Souza, Krueger, & Grafman, 2005)? It is also possible that moral cognition is the result of a bidirectional process where a number of specialized neural regions (limbic, prefrontal, and temporal) interact with one another in a reciprocal – and, by extension, influential – manner. To more completely characterize the psychological and neurobiological determinants of moral cognition, future work needs to address these questions.

Issues relating to morality, honesty, integrity, and virtue have been, and will continue to be, relevant throughout humanity’s tenure. This is largely because the issues central to morality revolve around our capacity for successful social living. And as a fundamentally social species, our moral faculty is paramount to our interpersonal experiences. To that end, moral research can inform us about which psychological processes most strongly motivate prosocial behavior, which, in turn, has significant implications for both the legal and clinical domains.

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