A social information processing approach to moral decision-making and moral development: Bridging the gap between developmental psychology and social neuroscience.

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Abstract

In order to bring together developmental psychology and social neuroscience approaches to moral decision-making, several theoretical approaches were integrated, creating the Social Information Processing-Moral Decision-making framework (SIP-MDM).

Initially, a systematic review and meta-analysis of neuroimaging studies of moral decision-making was conducted. The meta-analysis identified brain regions that consistently show increased activation when making moral decisions. Analysis also revealed that making one's own moral response decisions is associated with increased activation in additional brain areas compared to when making moral evaluations.

Secondly, an empirical study using a typically developing sample of eighty 11-18 year olds explored hypotheses generated from the SIP-MDM framework. Moral reasoning, working memory and some social information processing (SIP) skills were found to positively correlate with age, and moral reasoning predicted some steps of the SIP-MDM framework. There was a significant relationship between moral reasoning and working memory but not between moral reasoning and perspective taking, empathy, or emotion recognition, calling largely untested theoretical assumptions into question. There were also no significant relationships between moral reasoning and self or parent reported behavioural difficulties.

A final study used two different instruments to measure and compare the moral reasoning of twenty 11-21 year olds with acquired brain injuries (ABIs) to twenty neurologically healthy (NH) adolescents, matched on age and gender. The Sociomoral Reasoning Measure-Short Form (SRM-SF) and the So-Mature measures had satisfactory psychometric properties for the ABI and NH group. The ABI group showed developmentally immature moral reasoning compared to the NH group for reasoning about moral response decisions, based on scores for the So-Mature, but there were no significant group differences for reasoning about moral values, based on scores for the SRM-SF. So-Mature scores negatively correlated with self-report behavioural difficulties for the ABI group but there were no significant relationships between moral reasoning and behaviour for the NH group.

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List of Abbreviations

ABI	Acquired brain injury
ALE	Activation likelihood estimate analysis
ANOVA	Analysis of variance
BA	Brodmann area
CG	Cingulate gyrus
ERT	Emotion recognition task
FAS-II	Family affluence scale version II
fMRI	Functional magnetic resonance imaging
FSIQ	Full scale intelligence quotient
GCS	Glasgow coma scale
ICC	Intraclass correlation coefficient
INS	Interpersonal Negotiation Strategies
ME	Moral evaluation
MFG	Medial frontal gyrus
MJI	Moral Judgement Interview
MNI	Montreal Neurological Institute
MRD	Moral responses decision
MRI	Magnetic resonance imaging
MTG	Middle temporal gyrus
NH	Neurologically healthy
nTBI	Non-traumatic brain injury
OI	Orthopaedic injury
PANAS	Positive and negative affect scale
PFC	Prefrontal cortex
rTPJ	Right temporoparietal junction
SDQ	Social difficulties questionnaire
SDS-17	Social desirability scale-17
SES	Socioeconomic status
SIP	Social information processing
SIP-MDM	Social information processing-Moral decision-making
SIPT	Social information processing test
SOCIAL	Socio-Cognitive Integration of Abilities Model
So-Moral	Socio-Moral Reasoning Aptitude Level Task
SPSS	Statistical Package for the Social Sciences
SRM-SF	Sociomoral Reasoning Measure Short-Form
STG	Superior temporal gyrus
TBI	Traumatic brain injury
TD	Typically developing
ToM	Theory of mind
TPJ	Temporoparietal junction
vmPFC	Ventromedial prefrontal cortex
WAIS-IV	Weschler Adult Intelligence Scale-version IV
WASI-II	Weschler Abbreviated Scale of Intelligence-version II
WISC-IV	Weschler Intelligence Scale for children-version IV

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Preface

This thesis is submitted to the University of East Anglia for the degree of Doctor of Philosophy. I declare that this thesis presents my original work, that no part has been previously accepted and presented for the award of any degree or diploma from any university, and that, to the best of my knowledge, no material previously published or written by any other person is included, except where due acknowledgement is given.

This thesis is 53,849 words, inclusive of legends and references.

Part of this work has been presented in the following publications:

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Chapter 1: Introduction

1.1 Chapter overview

There is a long and rich tradition of theory and research into moral maturity within developmental psychology, from both a cognitive-developmental and affective perspective (Gibbs, 2013; Haidt, 2001; Hoffman, 2000; Kohlberg, 1984b; Piaget, 1932; Rest, 1984). Developmental psychology research in this area tends to focus on the reasons or justifications given by individuals for their moral decisions, as a measure of moral maturity. In recent years, there has been an increased interest in moral decision-making within social neuroscience, with neuroimaging methods being used to measure the activation of brain regions while individuals are making moral-decisions, or studies measuring moral decision-making in individuals with brain injuries. The disciplines of developmental psychology and social neuroscience have developed mostly in isolation with regards to moral decision-making and development, using different research approaches and informed by separate theories. While social neuroscience focuses on the brain regions and processes involved when making moral decisions, developmental psychology focuses more on how moral decision-making matures over time. Social information processing theory (SIP; Arsenio & Lemerise, 2004; Crick & Dodge, 1994; Lemerise & Arsenio, 2000) theory may offer a suitable framework for integrating aspects from developmental psychology and social neuroscience, providing an explanation of how moral decision-making occurs and typically matures over time, and how moral decision-making and development may be affected following a brain injury.

In this introductory chapter, moral terms will firstly be defined, and the definition and prevalence of acquired brain injuries will be outlined. This will be followed by a review of the main moral theories from developmental psychology and social neuroscience. Differences between these disciplines in terms of theoretical focus and research approaches will be outlined, followed by a discussion of why a new, integrative framework of moral decision-making and development is necessary. SIP theory will be introduced, with a focus on how it could provide the basis for an integrative framework. Selected research into moral decision-making and moral development (including related processes such as perspective taking and working memory) will then be presented. Research discussed will include typical moral decision-making and development, the brain regions thought to underpin moral decision-making and development, and how real-time moral decisions and

moral maturity are affected following a brain injury. This thesis will mainly focus on moral development during adolescence (age 10-19 years; World Health Organisation, 2017) so this introductory chapter will finish with a brief discussion of the importance of adolescence for moral development.

1.2 Defining moral terms

Differences in the research approaches to moral decision-making and development have led to a discrepancy in the definitions and usage of moral terms, which can cause confusion. The terms 'moral judgement', 'moral reasoning', and 'moral cognition' are often used interchangeably, and with differing definitions. The broader term moral decision-making will be used in this thesis, to refer to any decision, including judgements, evaluations, and response choices, made within the 'moral domain' (Smetana, 2006; Turiel, 1983), i.e. decisions regarding moral issues or principles such as justice, harm, fairness and care. A moral decision can be a response decision about how to behave in a real or hypothetical moral dilemma (a situation with moral rules or principles attached, where a response choice is required), or it can be a judgement or evaluation about the moral acceptability of the actions, or moral character of others, including judgements of individuals, groups or institutions. Moral reasoning is one process that can guide moral decisions, but other processes are also involved, and the extent of their involvement can differ depending on the type of decision being made. Moral reasoning differs from other forms of reasoning because it is guided by morally relevant rules, knowledge and understanding, stored in memory as moral schemas. Moral development is the maturation of moral decision-making, including the development of moral reasoning and related processes that increase the capacity for making mature moral decisions.

The moral domain covers the fairly universal principles of harm, justice, fairness and care, though how these principles are set out as rules or laws can differ between societies, cultures and religions, and may change over time. It does not necessarily follow that mature moral decisions based on a deep understanding and appreciation of moral principles will lead to behaviour that conforms to a law of society. For example, an individual with a mature understanding of the moral principle of fairness may feel they cannot obey laws that violate the human rights of a certain group. Furthermore, whether or not a moral decision leads to enactment of a chosen behaviour may depend on other contextual and situational factors. Behaviour which conforms to or follows moral principles (though not necessarily

laws) of society can be referred to as moral or prosocial behaviour, and behaviour which violates a moral principle of society can be referred to as immoral or antisocial behaviour. The major moral principles of a society are generally reflected in the laws of that society, so violating a moral principle can in some cases also be referred to as rule-breaking or offending behaviour. The term moral action has been used by some moral theorists (Gibbs, 2013; Rest, 1983; Rest, Bebeau, & Thoma, 1999) but the broader term behaviour, defined as 'the way in which a person behaves in response to a particular situation or stimulus' (OxfordDictionaries.com, 2017), also covers inaction; a behavioural response to a situation in the moral domain may be to take no action. The term moral behaviour will be used in this thesis to refer to any behaviour (action or inaction) within the moral domain (a situation with moral rules or principle attached), including behaviour in accordance with or in violation with moral principles (moral or prosocial; immoral or antisocial).

1.3 Definition and prevalence of acquired brain injury

An acquired brain injury (ABI) is any injury to the brain that occurs after birth. This can be the result of a traumatic brain injury (TBI; e.g. road traffic accidents and sports injuries) or a non-traumatic brain injury (nTBI; e.g. brain tumours, stroke or infection). An ABI can have physical, emotional, cognitive, social and behavioural effects (Babikian, Merkley, Savage, Giza, & Levin, 2015; Kirkham, 2017). Up- to-date prevalence data for all types of ABI in children and adolescents is scarce. There is some data for hospital admission for ABIs across all ages. For the years 2013-2014, it is estimated that 348,934 people were admitted to hospital with an ABI in the UK, including 162,544 admitted for a head injury and 130,551 admitted for a stroke (Headway, 2015). There is also some data relating to hospital admissions for children and adolescents with TBIs. A population-based study of one hospital in North Staffordshire (UK) found that 280 children a year, out of a population of 100,000, require hospitalisation for 24 hours or more due to a TBI, with 82.7% being for mild TBI (Hawley, Ward, Long, Owen, & Magnay, 2003). An epidemiology study of individuals attending the accident and emergency department at one hospital in Devon (UK) found that head injuries accounted for 3.4% of all cases per year, and attendance rates for moderate and severe injuries was highest for males aged 15-19 years (Yates, Williams, Harris, Round, & Jenkins, 2006).

1.4 Review of moral theories and perspectives

  1.4.1 Cognitive-developmental and affective development theories.
Historically, moral psychology has been dominated by the rationalist, cognitive-developmental theoretical perspective, employing stage theories to explain development. Piaget's (1932) theory, often considered to be the first cognitive-developmental theory of moral development, outlined four stages of logical reasoning and two stages of moral development: heteronomy and autonomy. Children in the heteronomous stage feel an obligation to abide by the external rules set by adults and when they reach the autonomous stage they realise that rules are worthy of respect and are based on mutual consent (Piaget, 1932). Piaget (1932) proposed that logical reasoning develops alongside related cognitive processes such as abstract reasoning, and this paves the way for moral development. At stage four, logical reasoning is defined by the ability to use complex, abstract cognitive skills to solve problems, in turn facilitating more mature moral decisions. Piaget (1932) hypothesised that moral development occurs as a child moves away from egocentrism, which requires the cognitive capacity to differentiate between the ego and social environment, and is facilitated by the maturation of language and imagination. From the age of about six or seven, a child's opportunities for peer co-operation facilitates the development of mutual respect, and so the child moves away from egocentric thought (Duska & Whelan, 1977). Piaget (1932) proposed that children construct their social and moral intelligence through managing their social interactions, and he emphasised peer interactions over parent interactions.

  Kohlberg (1976, 1981, 1984a) expanded Piaget's theory beyond childhood, to encompass adolescence and adulthood, and argued that, "since moral reasoning clearly is reasoning, advanced moral reasoning depends upon advanced logical reasoning. There is a parallel between an individual's logical stage and his or her moral stage" (Kohlberg, 1984b, p. 171). Kohlberg (1976, 1981) proposed six stages of moral judgement, grouped into three levels: pre-conventional, conventional and post-conventional. The pre-conventional level is the level of most children under nine, while most adolescents and adults are at the conventional stage, and the post-conventional level is reached by a minority of adults. Similarly to Piaget (1932), Kohlberg (1976, 1981) emphasised the importance of role-taking (taking another's perspective) in moral development and proposed that a child's social environment provides role-taking opportunities and such participation in role-taking spurs on moral development. Kohlberg saw his six stages as sequential, one must pass

through each in turn. Development to the next stage occurs when cognitive disequilibrium is created, or when a person's perspective is not sufficient to deal with a moral dilemma. This disequilibrium causes a person to think about the inadequacies of their reasoning and to search for more adequate reasons (Duska & Whelan, 1977). There have been some notable criticisms of Kohlberg's theory. Others have commented that his theory is masculine in perspective (Gilligan, 1982), and there is evidence to doubt whether the higher developmental stages are cultural universal (Snarey, 1985).

Rest and colleagues (1999) developed what they called a neo-Kohlbergian approach, moving the field away from stage theory, and argued that rather than one stage at a time, development is a gradual increase of developmentally mature forms of thinking. Rest's componential model of moral developmental (Rest, 1984; Rest et al., 1999) proposed that the four components underlying moral action are moral sensitivity, moral judgement, moral motivation and moral character. Moral sensitivity involves interpreting the situation and an awareness of the relevant moral factors and implications, including how actions would affect others, which requires perspective taking. The moral judgement component involves deliberation over possible courses of action and deciding which would be most morally justifiable. The moral motivation component involves prioritising moral values over other competing values, and moral character refers to skills and strategies that support the moral choice, such as self-control (Rest, 1984; Walker, 2002). This model integrated both cognitive and affective processes and also highlighted that moral action (behaviour), not just moral judgements, requires explanation. Rest and colleagues (1999) also recognised the usefulness of schema theory to moral development, which was further developed by Gibbs (2013).

Cognitive-developmental theories proposed that cognition, and particularly reasoning, is the main driver of moral decisions. Hoffman's theory (2000), on the other hand, is one of affective primacy, and focused on affective empathy as the main driver of moral decisions, rather than cognition, though he did highlight the role of cognition for development and for achieving a "self-other" distinction. He proposed that empathy is congruent with the moral principles of caring and justice, playing an important role in moral decision-making and reasoning. Hoffman's (2000) developmental framework of empathy involved three primitive modes: mimicry, conditioning and direct association, and two mature modes: verbally mediated association and social perspective taking, with language and cognitive development

facilitating the development of the mature modes. He proposed that affective empathy, construed as affect rather than cognition, becomes bonded with moral principles, giving the principles motive force, while empathy could act as a powerful retrieval cue, triggering moral schemas stored in memory. Hoffman (2000) also linked cognition with emotion, as he hypothesised that the attributions people make about the cause of events can affect the level of empathy experienced; empathic distress may be neutralised if a victim is viewed as being responsible for their own plight. He hypothesised that a person's moral structure, made up of empathic affects, cognitive representations and motives is internalised when they accept and abide by its principles without regard to external reward or punishment.

Gibbs (2013) offered an alternative to affective or cognitive primacy theories, and argued that the most plausible position within developmental theory is that moral motivation occurs as a consequence of affective and cognitive *co*primacy; that is, both affect and cognition act as motives for moral action. While Kohlberg proposed six stages, Gibbs, Basinger, and Fuller (1992) and Gibbs (2013) proposed four stages, grouped into immature and mature levels and added more transitional stages. Gibbs (2013) argued that the standard stages of moral development reflect gains in working memory, and hypothesised that attentional abilities are required to develop for the maturation of moral decisions. Increasing attentional abilities allow individuals to attend to more than one feature of a situation, moving away from an egocentric bias, and gains in working memory capacity allow for more than one source of information to be held in mind when making decisions (Gibbs, 2013).

Gibbs (2013) also hypothesised other factors relevant to explaining moral behaviour; he proposed that antisocial behaviour can be explained as a function of a developmental delay in moral judgement, self-serving cognitive distortions (e.g. self-centred, blaming others and minimising biases) and deficiencies in social skills. Gibbs (2013) proposed that the mature stages of moral development are constructed through social perspective taking. He developed Rest and colleagues' (1999) proposition that moral stages should be conceptualised as schemas, proposing that adaptive refinement and reorganisation of schemas enables moral development to take place. Schemas are "general knowledge structures that reside in long-term memory and facilitate information processing" (Walker, 2002, p. 361), with moral schemas being knowledge structures regarding moral events. However, moral decisions do not just mature because they are based on an increased quality and quantity of empirical knowledge; schemas are frameworks, and moral maturity,

or "growing beyond the superficial" requires a deeper understanding of fairness and moral reciprocity (Gibbs, 2013).

While Rest and colleagues (1999) and Gibbs (2013) revised Kohlberg's theory (Kohlberg, 1976, 1981, 1984a, 1984b), retaining the cognitive-developmental perspective, others have criticised Kohlberg's theory and called for a new approach, due to the lack of correlation between moral maturity and behaviour (Krebs & Denton, 2005). It has been argued that the study of morality has been dominated by investigating moral decisions as an end product, whereas in real life, behaviour is the end product (Krebs and Denton, 2005), and moral reasoning does not fully explain behaviour (Blasi, 1983). Rest (1983, 1999) and Gibbs's work (2013) has been crucial for advancing the moral development field towards a co-primacy approach and in conceptualising moral stages as schemas. Both theories focus on moral action as the end point, and go some way to explaining moral motivations and the moral decision-making processes that occur when weighing up different courses of action. These theories could be expanded by also taking into account other, non-moral factors, such as situational factors, that might affect the process from moral decisions to behaviour. Rather than rejecting cognitive-developmental perspectives, an integrative approach incorporating aspects from cognitive-developmental theories with additional aspects from other relevant theories may lead to a theory which predicts moral behaviour more robustly.

1.4.2 Social intuitionist theory and the somatic marker hypothesis.
Through their focus on the development of logical reasoning development, early moral development theorists proposed that moral decisions are *driven* by reasoning, within the cognitive domain. On the other hand, social intuitionist theory (Haidt, 2001) has proposed that moral decisions are driven by emotionally-based intuitions, and that moral reasoning is constructed *after* a decision, to explain a decision that had been made intuitively. Haidt and Bjorklund (2008) argued that moral beliefs and motivations come from a small set of intuitions that have evolved. Support for the theory comes from studies which show 'moral dumbfounding'; people give quick answers to moral dilemmas but then struggle to explain their answers (Haidt & Hersh, 2001). The real difference between rationalist and intuitionist theories is one of emphasis; while rationalists believe that the real action is reasoning, intuitionists believe that the real action is "gut feeling", moral emotions and quick intuition (Haidt & Bjorklund, 2008).

The social intuitionist view of intuitions driving moral decisions is not entirely dissimilar to Damasio's (1994) somatic marker hypothesis, although there are differences with reference to the role of reasoning. Somatic markers are another intuitive, automatic process which may guide some moral decisions. The somatic marker hypothesis (Bechara & Damasio, 2005; Damasio, 1994) recognised the role of emotions in decision-making and proposed that when we think of a bad outcome connected with a given response option that comes to mind, we experience an unpleasant gut feeling, which is a 'somatic marker'. This somatic marker then forces our attention onto the negative outcome and may lead to rejection of this option. Somatic markers can be stored in memory as affect-event links, which further aid future decision-making (Damasio, 1994) as they can guide decision-making by anticipating future events, even when not consciously recognised (Bechara & Damasio, 2005). While somatic markers can operate without coming to consciousness, when they are conscious they can help to narrow down the number of response options and this process occurs before reasoning, increasing the accuracy and efficiency of the decision process (Damasio, 1994). This is in contrast to the social intuitionist view that reasoning is not involved in the decision-making process but is only carried out to explain a decision already made.

Haidt (2001) argued that the important distinction between intuition and reasoning is that intuition occurs quickly, effortlessly and automatically, while reasoning is slow and requires more effort, including attentional resources. Kahnemann (2011) uses the metaphors of System 1 and System 2 to describe fast and slow thinking. System 1 is responsible for intuitive, automatic thinking and operates with little or no effort, while System 2 is responsible for more deliberate thought and reasoning and requires effortful mental activities. Kahneman (2011) argued that System 1 is responsible for more of the decisions we make than System 2, and his view seems to mirror that of the social intuitionists: "If System 1 is involved the conclusion comes first and the arguments follow" (p 45). However, System 2 is needed to monitor and control thoughts and actions suggested by System 1, so deliberate thought and reasoning are needed to confirm, reject or reformulate the automatic suggestions, or intuitions of System 1.

1.4.3 Domain theory. Domain theory, referred to as social-cognitive domain theory or moral domain theory, views morality as one of several strands of the developing social knowledge of children (Smetana, 2006; Turiel, 1983). This theory makes the important distinction between the personal, moral, and social domains

and proposed that these domains follow different developmental trajectories, with knowledge being constructed through reciprocal social interactions. The majority of research based on domain theory has focused on establishing whether children of different ages can distinguish between moral and social conventional acts (Killen & Smetana, 1999; Smetana, 1985; Song, Smetana & Kim, 1987; Tisak & Turiel, 1988). Hypothetical situations used in studies are either in the personal, moral or social domain, yet real-life situations often involve more than one domain. Nucci (2001) argued that in mixed-domain situations there are individual differences in whether the situation is interpreted as being in the social or moral domain.

While domain research has been helpful in highlighting the distinction between domains, the predictions made about how moral decisions develop and mature with age require greater theoretical elaboration. In summarising domain-related research, Smetana (2006) argued that studies with children of different ages confirm understanding within the moral domain develops from a focus on concrete harm in early childhood to an understanding of fairness in later childhood. This is similar to how cognitive-developmental theorists propose that moral reasoning maturity occurs, with the development of an appreciation of fairness and equality, but domain theory does not elaborate on the cognitive or affective processes that allow for this development to occur. A review of domain theory concluded that it should be seen as a complementary rather than alternative to existing accounts of moral development because of its conceptual and methodological flaws (Lourenço, 2014).

1.4.4 Social neuroscience theories and perspectives. There has been an increased interest in moral decision-making amongst social neuroscientists. Some social neuroscience theories of moral decision-making and development have been proposed, but these do not always reference the rich tradition within developmental psychology. The dominant theory within social neuroscience has been the dual-process theory (Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008; Greene, Nystrom, Engell, Darley, & Cohen, 2004; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). This theory proposed that people make moral decisions based either on negative emotional responses elicited by a dilemma, or by engaging in utilitarian moral reasoning. Initial emotional responses can be overridden by moral reasoning but this requires increased cognitive control. Support for this theory comes from studies showing increased activity in the medial prefrontal cortex (emotional responses), dorsolateral prefrontal cortex (cognitive reasoning) and the anterior

cingulate cortex (signals the need for cognitive control) when choosing responses to hypothetical moral dilemmas (Greene, 2009). This theoretical perspective focuses only on explaining utilitarian moral decision-making (i.e. approving harmful actions that maximise good consequences) and while this theory can help in understanding how utilitarian moral decisions are made, it tells us little about how moral maturity occurs.

Other social-neuroscience perspectives have been proposed which are more developmental in focus than the dual-process account. Kagan (2008) presented a developmental theory of morality, drawing on both cognitive-developmental stages and neuroscience, with the inclusion of affective components such as guilt and empathy. He proposed that children follow a universal sequence of stages and each stage involves the emergence of a new cognitive achievement, due to corresponding changes in brain circuitry. Kagan's fifth stage, occurring between ages 5 and 10 years is an understanding of abstract constructs such as fairness and ideals, which is facilitated by profound maturational changes in the brain between ages 5 and 7 years. Similar to Kagan (2008), Baird (2008) linked moral development to brain development within her theory, although she particularly focused on brain development in adolescence and argued that the maturation of the prefrontal cortex (PFC) produces significant improvements in behavioural and emotional control, decision-making and abstract reasoning. Baird (2008) also focused on the integration of emotion and cognition in adolescence, and argued that we have an innate capacity to develop a moral sense. She incorporated ideas from the somatic marker hypothesis (Damasio, 1994) to explain how emotional states can guide future decisions, by proposing that developmental improvements in cognition lead to the development of self-conscious emotions.

Taber-Thomas and Tranel (2012) presented a cognitive neuroscience perspective of social and moral functioning, and argued that there is a functional hierarchy underlying socio-moral functioning, from basic functions such as processing emotion from faces, to higher cognitive processes such as moral cognition. They concluded that social and moral functioning critically depend on a core fronto-limbic network centred on the ventromedial PFC (vmPFC), but acknowledged that this network does not function in isolation and relies on other social functions. As with Baird's theory (2008), their perspective incorporated aspects of the somatic marker hypothesis (Damasio, 1994) and they asserted that the vmPFC is crucial for the anticipation of emotional consequences of behaviour.

There are other social neuroscience theories, which while not specifically moral theories, are of relevance here, as they incorporated moral reasoning and some of the relevant component skills and processes. Anderson and Beauchamp (2012) presented the Socio-Cognitive Integration of Abilities Model (SOCIAL), a theoretical framework of social function, which defined social function/skills as social competence, social interaction and social adjustment. The SOCIAL framework posited that the emergence of social function is shaped by internal factors (e.g. temperament and personality), external factors (e.g. family environment, socioeconomic status (SES) and culture) and brain development and integrity. Brain development and integrity has not yet been explicitly included in any models of moral development. The SOCIAL framework also included higher-order cognitive processes critical for social functioning: attention, executive skills (including attentional control, cognitive flexibility and goal setting), communication and social cognition (including emotion perception, attribution, Theory of Mind (ToM) and moral reasoning) (Anderson & Beauchamp, 2012). While this framework included moral reasoning as a sub-skill of social cognition, this relationship could be reframed to explain how social cognition may impact upon moral reasoning maturity.

Yeates and colleagues (2012) suggested an integrative model of social competence in children with brain disorders, including three main components: SIP, social interaction and social adjustment. The authors defined SIP as a series of problem solving steps, and they referenced the importance of executive functions and ToM to SIP. The three components of the model can impact upon and interact with each other, and factors that can affect the development of these components are parenting style, family function and SES, as well as brain injury related factors such as type and severity of insult and regional brain abnormalities (Yeates et al., 2012). While this is a theory of social competence rather than moral development, social competence can influence interactions with peers, which can in turn impact upon the development of perspective taking, which is proposed to be crucial for moral development (Gibbs, 2013; Hoffman, 2000; Kohlberg, 1976; Piaget, 1932). Components from these social perspectives could be incorporated into a framework of moral development in an attempt to explain how social functioning may affect social interactions, moral decisions and moral behaviour.

1.5 Divides between developmental psychology and social neuroscience approaches to moral decision-making and development

　　1.5.1 Theoretical focus. The theories outlined above differ in their focus. Moral theories within developmental psychology focus on the maturity of moral reasoning, as a process that guides moral decision-making. These theories explain how moral reasoning develops and matures, through processes such as increased role-taking opportunities leading to improvements in perspective taking and a move away from egocentrism. Cognitive-developmental theories focused on the role of reasoning maturity in moral decision-making while Hoffman (2000) focused on the role of affective empathy development (Hoffman, 2000) and Gibbs (2013) suggested a co-primacy approach. Social intuitionist theory (Haidt, 2001) focused on automatic intuitions as a driver for moral decisions but does not propose how moral decision-making matures over time. Similarly, dual-process theory (Greene et al., 2008; Greene et al., 2004; Greene et al., 2001) focused on real-time moral decision-making rather than development of moral maturity, and inferences about which cognitive and affective processes are involved are made based on the extent to which different brain regions are activated. Other social neuroscience approaches are more developmental in focus (Baird, 2008; Kagan, 2008) and focused on how brain development correlates with moral development, through its effect on the emergence of relevant cognitive and affective processes, such as abstract reasoning and emotion recognition.

　　There are strengths and weaknesses of the various theories discussed in this chapter. Piaget's (1932) theory was the first cognitive-developmental theory and highlighted the role of logical reasoning for moral development. While Piaget proposed how moral development can occur (though social interactions), his theory focused on only development in children. Kohlberg (1976, 1981, 1984a) extended this theory beyond childhood, and also proposed how moral development occurs (through role-taking opportunities). However, Kohlberg's theory has received some criticisms that it is masculine in focus and the stages may not be culturally universal. A further weakness of Kohlberg's theory is his proposition that stages are sequential and that higher stages of reasoning replace immature stages. It has been found that individuals are not consistent in their stage of reasoning in response to different hypothetical dilemmas, suggesting that immature stages can co-exist alongside mature stages (Krebs & Denton, 2005). In contrast to Kohlberg's proposition that stages are sequential, Rest and colleagues (1999) and Gibbs (2013) proposed that

development is gradual and can be conceptualised as schemas. Moral schemas, and the extent to which they are activated, may develop over time and be dependent upon situational factors. A further strength of the work of Rest and Gibbs is in their focus on moral behaviour rather than just moral decisions, and they go some way to explaining links between moral decisions and behaviour, though this could be expanded upon. Furthermore, Gibbs's theory is one of co-primacy, which brings together competing viewpoints in the field by proposing that both cognition and affect can act as motives for moral action.

While social intuitionist theory (Haidt, 2001) can help to explain why some moral decisions appear automatic, the theory does not focus on individual differences in the proposed set of evolved moral beliefs or motivations, or how they develop and lead to moral maturity. Domain theory (Smetana, 2006; Turiel, 1983) has been helpful in highlighting the distinction between domains but does not make strong predictions about how moral development occurs. One limitation of moral psychology theories is that they have not explicitly included brain development, and how this can impact on moral development. Social neuroscience theories and perspectives have attempted to link stages of development to corresponding brain circuitry, helping to explain how brain development relates to moral development (Baird, 2008; Kagan, 2008). However, social neuroscience perspectives do not always reference the rich tradition of developmental psychology theory in this area, such as Anderson and Beauchamp (2012) who cite Kohlberg (1984a) in explaining the moral reasoning component of SOCIAL, without reference to criticisms of his theory, or more recent formulations, such as Gibbs (2013).

1.5.2 Differing research approaches. Differences in focus within these moral theories have led to different research priorities. Within developmental psychology, there is a tradition of trying to measure developmental stages of moral reasoning, with a lack of focus on other factors, such as situational factors, which may influence moral decisions and behaviour. Social neuroscience research tends to use either neuroimaging methods while individuals are making moral-decisions, as a measure of which brain regions and related processes are involved, or, measures moral decision-making in individuals with brain injuries. Social neuroscience research typically focuses on the real-time moral decision-making process, without focusing on development, while developmental psychology research focuses on moral maturity rather than other processes involved in

decision-making, with neither research discipline focusing on moral behaviour as the end product.

Instruments used in developmental psychology studies for assessing moral reasoning can be divided into two groups: production and recognition measures. Recognition measures (e.g. The Defining Issues Test; Rest, 1979) involve participants selecting their justification for a decision from a predefined set of moral justifications. Some recognition instruments do not measure younger stages of development, and people with communication difficulties may have difficulties with them (Gibbs et al., 1992; Rest, 1979). Production measures require participants to articulate their own reasons for their moral decisions, which are then scored developmentally, providing a moral maturity score. Lower, or immature levels of moral reasoning are characterised by references to authority, rules and physical consequences, whereas higher, or mature levels are characterised by references to empathic role-taking, interpersonal relations and societal requirements (Dooley, Beauchamp, & Anderson, 2010; Gibbs et al., 1992). Moral reasoning is elicited by "why?" questions in production measures, in response to either moral value judgements, e.g. "In general, how important is it to break the law?" (The Sociomoral Reasoning Measure Short-Form (SRM-SF); Gibbs et al., 1992), or response decisions in hypothetical dilemmas, e.g. if you saw your friend cheat in an exam, do you tell the teacher about it or not? (The So-Mature section of The Socio-Moral Reasoning Aptitude Level Task (So-Moral); Dooley et al., 2010). Moral reasoning measures provide rich detail about developmental level, and an indication of a person's highest capacity for moral reasoning across differing questions or moral dilemmas. However, it has been found that moral reasoning does not always correlate with behaviour (Blasi, 1983) and people do not always use their highest capacity of reasoning for moral decision-making (Krebs & Denton, 1997).

Alternative methods for measuring moral decision-making involve presenting hypothetical dilemmas or stories involving moral transgressions and asking participants to make moral response decisions (e.g. "What would you do?") or moral evaluations (e.g. "Was it OK for X to do that?"). Such instruments are less developmental in focus and so do not provide a moral maturity score. Hypothetical dilemmas are often used in moral neuroscience studies; either asking respondents to choose between two possible actions, judge the appropriateness of possible actions, or judge the permissibility of other people's actions. Many studies use Greene and colleagues' dilemmas (2001), or adapted versions. Such dilemmas are

impersonal, personal or non-moral dilemmas and participants typically choose whether the suggested response is appropriate or not for each dilemma. Personal dilemmas involve expected harm to other people, are more emotionally engaging than impersonal dilemmas, and relate to utilitarian decisions (e.g. stealing one person's organs in order to distribute them to five others), whereas impersonal moral dilemmas are less emotionally engaging and relate to other moral issues (e.g. whether to keep money found in a lost wallet). Dilemmas involving everyday social harm elicit different decisions to life or death dilemmas (Vyas, Jameel, Bellesi, Crawford, & Channon, 2017), so research using utilitarian dilemmas may not be generalisable to everyday moral decision-making involving less extreme outcomes.

1.6 Why is an integrative framework needed?

Taken together, moral theories from developmental psychology and social neuroscience provide a fuller picture of the skills and processes required for moral decision-making, and how these might develop to enable moral maturity. The different component skills and processes proposed to be required for moral development have not yet been integrated into one comprehensive theory of moral development. An integrative framework could include both affective and cognitive processes and also show how both intuitions and reasoning can guide moral decisions. Developmental psychology theories have outlined that the cognitive and affective processes required for mature moral decision-making develop with age, but have not explicitly explained how this occurs as a consequence of brain development. More recent neuroscience perspectives have emphasised the importance of brain development for the maturation of moral reasoning and related skills, but often neglect the moral developmental psychology literature. The field of moral development would benefit from clearer integration of the developmental psychology literature with insights from social neuroscience research.

In a review of the neuroscience of moral cognition, Van Bavel, FeldmanHall, and Mende-Siedlecki (2015) argued that hypothetical scenarios used in neuroscience research usually ignore the influence of social and contextual factors, and they advocated a shift from dual-process theories to a dynamic systems model of moral cognition. Most moral theories and the research focus on moral decisions (judgements, evaluations or response decisions) as the end point, rather than seeking to explain how these moral decisions relate to behaviour. Some theories have sought to explain moral action, including the interpretation of a situation (Rest, 1984), cognitive distortions and social skills (Gibbs, 2013) within theory, but

additional factors may also be relevant. For a dynamic explanation of moral decision-making, development and behaviour, it is necessary to understand (a) how moral decisions are made (including relevant social and contextual factors), (b) what processes are required to develop to enable mature moral decisions, and how these develop over time, and (c) how moral decisions relate to behaviour. Further theory development is needed to answer these questions and provide a predictive model of moral behaviour. An integrative framework incorporating aspects from developmental psychology and social neuroscience could be a first step, to guide future research and theory development in this area.

1.7 Social information processing

1.7.1 Social information processing theory. SIP theory (Crick & Dodge, 1994) was proposed as an explanation of how decisions are made in relation to aggression. Aggression is a behaviour which harms, or is intended to harm another (Anderson & Bushman, 2002). The original SIP model therefore relates to the moral principle of harm, and has the potential to be expanded to explain the processing involved in other behaviours within the moral domain (i.e. justice, fairness and care). SIP theory has previously been integrated with moral domain theory (Arsenio & Lemerise, 2004) but such an integration can be greatly expanded upon, incorporating aspects from other moral theories.

According to SIP theory (Figure 1.1; Crick & Dodge, 1994), children's behavioural responses are a function of the processing of information in a situation. The model consists of six steps: (1) encoding of cues, (2) interpretation of cues, (3) clarification of goals, (4) response access or construction, (5) response decision, and (6) behavioural enactment. The six steps represent a logical order but do not necessarily occur in this order and can co-occur. Children come to a social situation with a set of biologically determined capabilities and a database of memories of past experiences, which can affect how information is processed (Crick & Dodge, 1994). Memories of past events are stored in the database as acquired rules, social schemas and social knowledge. SIP abilities are theorised to develop with age due to a growth in experience with social interactions, developmental shifts in attentional ability, mental capacity or speed of processing, and the organisation and interpretation of social information (Crick & Dodge, 1994). This is similar to how moral development is proposed to occur, according to the various moral development theories, suggesting that moral development could be explained using a SIP framework.

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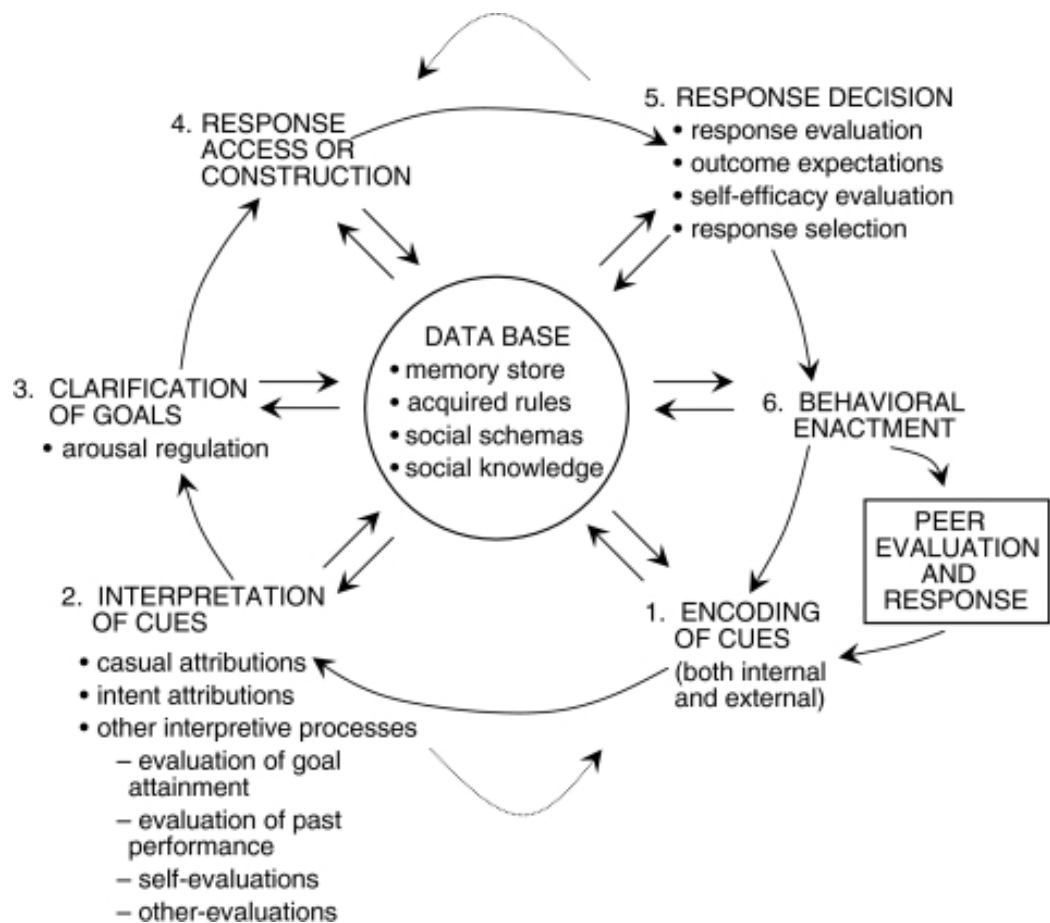
Figure 1.1. Crick and Dodge's (1994) Social information processing model.

From Crick, Nicki, R & Dodge, Kenneth, A. (1994). A review and reformulation of social information-processing mechanisms in children's social adjustment. *Psychological bulletin, 115(1),* 74. Fig. 2: "A reformulated social information-processing model of children's social adjustment", p.76. Copyright 1994 by the American Psychological Association. Reprinted with permission.

Emotional processes were incorporated into the SIP model by Lemerise and Arsenio (2000), suggesting that a SIP approach can be used to address the cognition vs. affect divide within moral psychology. They added emotional processes at certain steps of the SIP model, such as emotion recognition at Step 1 and empathic responsiveness at Step 5. Lemerise and Arsenio (2000) also added affect-event links to the database in the centre of the model, and theorised that memories of past events include affective as well as cognitive components. This is

similar to Hoffman's (2000) proposal that affective empathy can act as a powerful retrieval cue, triggering moral schemas stored in memory, and also similar to Damasio's (1994) proposal that somatic markers can be stored in memory as affect-event links, aiding future decision-making. In addition, Lemerise and Arsenio (2000) added emotional processes to the centre of the SIP model and hypothesised that individual differences in emotionality and emotion regulation can influence each step of SIP. They proposed that children enter a social situation with a level of physiological arousal or mood and differ in their ability to regulate this, partly due to biological predispositions of their emotionality or temperament.

Following their integration of emotional processes into the SIP model, Arsenio and Lemerise (2004) incorporated SIP with moral domain theory, proposing that moral domain theory can be used to expand on the latent mental structures, or the database of the model. They hypothesised that social experiences lead to the generation of latent mental structures that are stored in memory, or the database. Domain knowledge stored in memory must be activated and used in the processing of a situation in order to influence behaviour. If domain knowledge is retrieved early in the process, it can influence other steps of SIP, such as goal clarification (Arsenio & Lemerise, 2004). Social schemas are in the centre of the SIP model, as a component that can influence all steps of processing. Calvete and Orue (2012) found that adolescents who scored higher on a justification for violence schema were more likely to choose an aggressive behaviour in response to a hypothetical ambiguous situation, and a narcissism schema predicted anger and access to aggressive responses. This study also found that aggressive response access predicted aggression, and so response access may play a mediating role between schemas and behaviour (Calvete & Orue, 2012). Moral schemas will be relevant for moral decision-making, but how they relate to moral behaviour, including any potential mediating factors or processes, remains to be explored. The integration of domain theory with SIP theory added moral domain knowledge to the centre of the model, as a component that can affect all steps of processing. However, moral decision-making does not mature based solely on an increase of moral knowledge; it also involves other processes, such as the development of perspective taking and a move away from egocentricity (Gibbs, 2013; Kohlberg, 1976, 1984a, 1984b; Piaget, 1932).

Aspects from other moral theories could be integrated into a SIP framework; Rest's (1984) moral sensitivity component involves interpretation of the situation,

which is similar to Step 2 of the SIP model, and his proposed moral judgement component which involves deliberation could be formulated as Step 5 of a SIP model. Palmer (2003) proposed a model of offending behaviour which incorporated both moral reasoning development and SIP skills, and she theorised that SIP mediates the link between parenting and offending (Palmer, 2000). Palmer (2003) proposed that developmental levels of moral reasoning can affect SIP steps. At Steps 1 and 2, perspective taking and degree of egocentricity, both associated with moral reasoning level, are likely to influence an individual's ability to make accurate attributions about intent and causality (Palmer, 2003). She proposed that immature levels of moral reasoning will be associated with biases in processing, such as a hostile attribution bias. At Step 3, Palmer (2003) theorised that the types of goals chosen are likely to be associated with level of perspective taking and egocentricity, and increasing maturity of moral reasoning will be associated with goals that take the feelings and needs of other people and wider society into account. At Steps 4 and 5, moral reasoning maturity will impact on response generation; different responses will be justifiable depending on moral reasoning maturity, with individuals reasoning at a higher level less likely to perceive physical aggression as justifiable, based on moral concerns for the feelings of others (Palmer, 2003). Components from various moral theories could be added to a SIP framework, to show how moral maturity can affect each step of processing.

1.7.2 Social information processing research. SIP skills are typically measured using hypothetical dilemmas presented as vignettes (videos or drawings) followed by an interview to assess the different steps, such as how much information was encoded, what attributions were made, and the response decision. While SIP skills are hypothesised to develop with age, there is limited research into the typical developmental trajectory of SIP skills, as most research focuses on the relationship between SIP skills and aggressive behaviour, or SIP skills in atypical populations. However, it has been found that SIP skills correlate with age in typically developing (TD) children, including a decrease of endorsing aggressive responses with age (Feldman & Dodge, 1987). Aggressive children display atypical SIP skills, such as making hostile intent attributions in ambiguous situations, and positively evaluating aggressive response options, and SIP problems are predictive of aggressive behaviour (Dodge, Laird, Lochman, & Zelli, 2002; Lansford, Malone, Dodge, Crozier, Pettit, & Bates, 2006; Oostermeijer, Nieuwenhuijzen, van de Ven, Popma, & Jansen, 2016; Ziv & Sorongon, 2011). Not as much research has focused

on the relationship between SIP skills and prosocial behaviour so this relationship remains less clear (Nelson & Crick, 1999; Yagmurlu, 2014).

Atypical patterns of SIP have been found for children with Autism Spectrum Disorders (Embregts & Van Nieuwenhuijzen, 2009; Flood, Julian Hare, & Wallis, 2011; Mazza, Mariano, Peretti, Masedu, Pino, & Valenti, 2017; Ziv, Hadad, & Khateeb, 2014), intellectual disabilities (Embregts & Van Nieuwenhuijzen, 2009; van Nieuwenhuijzen, Vriens, Scheepmaker, Smit, & Porton, 2011) and Fragile X Syndrome (Russo-Ponsaran, Berry-Kravis, McKown, & Lipton, 2014). Some social-cognitive skills such as working memory and perspective taking have been studied alongside SIP steps in children and adolescents (aged 8-12 years) with intellectual disabilities, finding that emotion recognition and interpretation skills are particularly important cognitive skills that predict different steps of SIP (van Nieuwenhuijzen & Vriens, 2012). Relationships between SIP and social-cognitive skills remain to be explored for TD children and adolescents.

There is limited research into SIP steps following a brain injury but there is some research into social problem-solving in children with TBIs. Warschausky, Cohen, Parker, Levendosky, and Okun (1997) found that children with TBIs generated fewer total solutions and fewer positive assertive solutions than a healthy comparison group on a social problem-solving measure. In a study using a virtual reality measure, Cook and colleagues (2013) found that adolescents with TBIs provided significantly fewer long-term consequences for decisions made by actors in hypothetical situations, including situations relating to moral issues (e.g. using a friend's answers to cheat on an exam), suggesting that TBI may affect decision-making through its effect on consequential thinking. Janusz, Kirkwood, Yeates, and Taylor (2002) looked at social problem solving in children and adolescents (aged 9-18 years) with TBIs, using the Interpersonal Negotiation Strategies interview (INS; Yeates, Schultz, & Selman, 1991). The INS asks individuals to identify the problem and how a protagonist feels in a hypothetical dilemma, generate and select response options and evaluate outcomes, so is similar to SIP measures. The TBI group defined the problem and generated strategies to solve the problem at the same developmental level as a comparison group of children with orthopaedic injuries (OIs) but showed lower level strategies for solving problems (Janusz et al., 2002). Although Janusz et al. (2002) found no group differences for defining the problem, a study using a virtual reality version of the INS with adolescents found the strongest group differences between a TBI and uninjured comparison group for

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defining the problem (Hanten et al., 2011). Within this study, the virtual reality dilemma presented the social conflict using naturalistic dialogue between two characters, rather than a text summary as in the original INS; it may be that adolescents with TBI struggle to identify social problems from conversations.

Although SIP has been integrated with moral domain theory (Arsenio & Lemerise, 2004), little research has focused on relationships between SIP and moral variables. Arsenio, Adams, and Gold (2009) measured some SIP skills and moral reasoning, using a moral reasoning measure based on the 'happy victimiser' paradigm (Arsenio & Lover, 1995). This measure presents three stories in which the reader is described as deliberately victimising another person, and then asks the reader how they would feel and why, and how the victim would feel and why, with answers scored according to mentions of moral concerns. Arsenio et al. (2009) found that adolescents who expected to feel happier following acts of unprovoked acts of aggression explained these emotions in terms of material gains, referring less to moral concerns. While some conclusions about relationships between SIP and moral reasoning were made, arguably, stronger conclusions about developmental relationships could be made from research using a moral reasoning measure grounded more firmly in developmental psychology (e.g. SRM-SF; Gibbs et al., 1992).

1.8 Moral decision-making and moral development research

1.8.1 Typical moral decision-making and development. Most research into moral decision-making has focused on moral evaluations or response choices in adults, but there is some research into the development of moral preferences in children and adolescents. Evidence of an understanding of moral rules, as well as showing moral preferences and expectations have been found to be present in children as young as three months, shown by their preference to attend to a prosocial character (Kiley Hamlin, Wynn, & Bloom, 2010). When asked to judge the actions of others, young children weigh up the costs and benefits of harm, as older children and adults do, but children aged 6 years old judge decisions involving harm negatively, regardless of whether it leads to a greater benefit (Powell, Derbyshire, & Guttentag, 2012), suggesting that young children are influenced by outcome when making moral evaluations.

Cognitive-developmental theorists propose that taking situational circumstances, including an actor's intentions into account when reasoning about

moral issues only occurs at the mature level, transition stage 3/4 according to Gibbs and colleagues (1992). In contrast to this proposal, research has found that even young children are able to take intentions into account when making moral judgements. Although influenced by outcome, young children, similarly to adults, are also influenced by an actor's intentions when making moral evaluations; the reliance on intent when making moral decisions, and the ability to distinguish more clearly between ill and well-intentioned actions both develop with age (Cushman, Sheketoff, Wharton, & Carey, 2013; Nobes, Panagiotaki, & Bartholomew, 2016; Nobes, Panagiotaki, & Pawson, 2009). It may be the case that young children are able to take intent into account when their attention is oriented towards this feature of an event, as in the studies mentioned above (e.g. "What did X want to do?" or ""Did [the character] want [the relevant outcome to occur]?''), but they do not independently focus on intent until later ages, or at least do not articulate intent when explaining their reasoning. Moral reasoning is often measured as an indicator of an individual's highest capacity for reasoning across different questions or moral dilemmas and research has found that these abilities develop with age (Chiasson, Vera-Estay, Lalonde, Dooley, & Beauchamp, 2017b; Colby, Kohlberg, Gibbs, Lieberman, Fischer, & Saltzstein, 1983; Gibbs et al., 1992; Humphries, Parker, & Jagers, 2000; Vera-Estay, Seni, Champagne, & Beauchamp, 2016).

1.8.2 The neuroscience of moral decision-making and development.
Social neuroscience studies can reveal which brain regions are more active during moral decision-making, or how damage to certain brain regions affects moral decision-making. Neuroimaging studies using moral decision-making tasks have found that the brain region most commonly activated is the vmPFC (Fumagalli & Priori, 2012). The vmPFC is involved in emotional processing (Etkin, Egner, & Kalisch, 2011) so its recruitment during moral decision-making offers some support for the view that moral decisions are driven by emotions. Neuroimaging studies into moral decision-making typically employ tasks which involve judging the actions of others rather than making your own response decisions about how to act; it remains to be explored whether the vmPFC is involved in all types of moral decision-making.

The large majority of neuroimaging studies of moral decision-making involve adults and there is limited research into how the maturation of relevant brain regions may correlate with mature moral decision-making. Harenski and colleagues (2012) did include 15 adolescents in their functional magnetic resonance imaging (fMRI) sample (aged 13-18 years) alongside an adult sample (aged 19-53 years) and

found a positive correlation between age and hemodynamic activity in the temporoparietal junction (TPJ) when participants rated the severity of moral transgressions. This region is known to contribute to mentalising during moral decision-making in adults, so the authors concluded that adolescents use mentalising less than adults when rating moral transgressions. There were no significant age differences for ratings of transgressions, indicating that adults and adolescents were similarly able to identify violations and rate their severity. It may, therefore, be the case that adolescents use mentalising as much as adults when rating transgressions, but that mentalising in adolescence activates other regions in the network; neuroimaging research of cognition has found that children and adolescents activate networks more extensively, while adults show activation in more specific regions (Scherf, Sweeney, & Luna, 2006; Tamm, Menon, & Reiss, 2002).

A brain injury may directly disrupt moral decision-making if brain regions or networks thought to be required for making moral decisions are damaged. Additionally, a brain injury may indirectly affect moral development if it damages brain areas required for related processes, such as empathy or working memory, or if it impacts or limits interaction with peers and role-taking opportunities, which can in turn impact on the development of perspective taking. There has been some research into moral decision-making following an ABI, though this has mostly focused on the types of moral decisions, (typically moral judgements and evaluations), made in hypothetical scenarios and dilemmas, and has not always been grounded in developmental psychology. In studies using hypothetical scenarios which depict a protagonist either intending to cause harm or not to another (intent) and resulting in either harm or no harm (outcome), it has been found that adult patients with damage to the vmPFC, and patients with frontal lesions, judge attempted harm (intent) as more permissible than healthy comparison groups (Baez et al., 2014; Young, Bechara, Tranel, Damasio, Hauser, & Damasio, 2010). These results suggest that adults with damage to frontal regions of the brain judge intent differently to neurologically healthy (NH) adults when assessing the permissibility of other people's actions. Numerous studies have investigated moral decision-making in individuals with brain damage using Greene and colleagues' dilemmas (2001), or adapted versions. Such studies have found that adults with TBI or damage to the vmPFC show an abnormal utilitarian response pattern for personal dilemmas, judging more as appropriate compared to NH comparison participants (Ciaramelli, Muccioli, Làdavas, & di Pellegrino, 2007; Koenigs et al., 2007; Martins,

Faisca, Esteves, Muresan, & Reis, 2012; Moretto, Làdavas, Mattioli, & di Pellegrino, 2010; Thomas, Croft, & Tranel, 2011). Evidence for increased utilitarian decision-making for personal moral dilemmas in individuals with TBI has been interpreted as TBI resulting in an impairment emotional processing. Martins and colleagues (2012) found that patients with TBI showed impairments in an emotion recognition task compared to comparison participants, but this reduction in emotion recognition performance did note mediate the link between TBI and utilitarian decision-making. It has also been found that only TBI patients displaying apathy symptoms make more utilitarian moral decisions compared to NH participants (Njomboro, Humphreys, & Deb, 2014), suggesting that apathy may mediate the relationship between TBI and utilitarian decision-making.

There is limited developmental research which measures moral reasoning in individuals with ABI, but the available studies have suggested that children and adolescents with TBIs and frontal or temporal lesions are reasoning at a lower level than would be expected of their chronological age. Couper and colleagues (2002) found that children with frontal lobe lesions had lower levels of moral maturity than an age-matched comparison group, as measured by the SRM-SF (Gibbs et al., 1992). Dooley and colleagues (2010) did not find a significant difference between moral reasoning abilities, as measured by the So-Mature section of the So-Moral, for adolescents with TBIs and an age-matched comparison group. In a subsequent study using the same measure, the authors did find a significant difference, with TD participants scoring higher on moral reasoning than adolescents with TBI (Beauchamp, Dooley, & Anderson, 2013). The discrepancy between the results on the So-Moral may be due to the comparison groups used. While both used a sample of 25 adolescents with TBI (mean age 13 years) including a majority of mild TBIs, Dooley et al (2010) used an age-matched TD comparison group of 26 adolescents and Beauchamp et al (2013) compared moral reasoning of the TBI group to 66 TD participants, not age-matched to the TBI group. A recent study by Chiasson, Elkaim, Weil, Crevier, and Beauchamp (2017a) using the So-Mature found that moral reasoning in 15 adolescents (aged 8-12 years) with frontal or temporal lobe lesions was significantly lower than a TD comparison group, matched on age, gender and parental education. Lower moral reasoning has also been found for older adolescents and adults with TBIs; Wigg (2013) found that individuals aged 17-25 years with TBIs had significantly lower SRM-SF scores than a NH comparison group matched on age, gender and SES.

Most moral neuroscience research focuses on patterns of utilitarian decision-making (i.e. approving harmful actions that maximise good consequences) and cannot provide detail about how damage to certain areas of the brain may affect other types of moral decisions, or what brain regions are involved in other types of moral decision. There has been some research using developmental psychology methods for measuring moral maturity in individuals with brain injuries (Beauchamp et al., 2013; Chiasson et al., 2017a; Couper et al., 2002; Dooley et al., 2010). Such research provides promise that developmental psychology and social neuroscience approaches can be brought together to provide a richer picture of typical and atypical moral development.

1.8.3 Relationships between moral reasoning maturity and cognitive and affective processes.

While a strong relationship between moral reasoning and mental capacity, or general intellectual functioning, has long been established (Hoffman, 1977; Stewart & Pascual-Leone, 1992), there has been limited research investigating whether the specific cognitive and affective components proposed to be important for moral development, (e.g. empathy and working memory), correlate with moral reasoning maturity. There is some evidence of a positive relationship between empathy and moral reasoning for TD adolescents, but the research uses different measures of both moral reasoning and empathy. Dooley et al. (2010) found positive correlations between self-report empathy and moral reasoning scores on the So-Mature for 11-19 year olds. Humphries and colleagues (2000) found a positive correlation between the perspective taking and empathic concern scales of the Davis empathy scale (Davis, 1983) and scores on the SRM-SF in TD children and adolescents aged 10-13 years old. In contrast to this, while Littler (2015) found a positive association between working memory and SRM-SF scores in TD adolescents aged 11-14 years old, she found no associations between SRM-SF scores and cognitive flexibility, empathy, or self-reported behaviour. Relationships between empathy and SRM-SF scores have also been found for juvenile delinquents aged 13-21 years, even after controlling for self-serving cognitive distortion and social desirability (Barriga, Sullivan-Cosetti, & Gibbs, 2009). There is limited research which has investigated relationships between moral reasoning and other cognitive and affective processes. A recent study by Vera-Estay and colleagues (2016) found that moral reasoning (as measured by the So-Mature) correlated positively with inhibition, verbal fluency, attentional control, ToM and affect recognition in TD children and adolescents aged

6-12 years old. This study also found that age, verbal fluency and ToM predicted moral maturity (Vera-Estay et al., 2016).

Many of the aforementioned studies indicated that the relationships between moral reasoning and empathy for individuals with TBIs are mixed. Beauchamp, Dooley, and Anderson (2013) found a significant positive correlation between empathy and moral reasoning (as measured by the So-Mature) in a TBI group. Conversely, Wigg (2013) found no significant relationship between empathy and moral reasoning (as measured by the SRM-SF) in a TBI group. This discrepancy may be due to either the different ages of the samples, or the different moral reasoning measures used. Wigg (2013) did find a relationship between SRM-SF scores and empathy for the NH comparison group (aged 17-25 years), with empathy accounting for 12% of variance in moral reasoning scores, and higher empathy associated with more mature moral reasoning. Similarly, Beauchamp et al. (2013) found that general intellectual functioning and empathy explained 11.7% of the variance in moral reasoning maturity, with empathy making a larger contribution, in a sample of TD adolescents and adolescents with TBIs. The relationship between moral reasoning and empathy (both cognitive and affective) remains unclear and there is a lack of research measuring relationships between moral reasoning and other cognitive and affective processes in individuals with ABIs.

1.8.4 Development of cognitive and affective processes. While there is little research which explores relationships between the cognitive and affective processes proposed to be required for moral development, and moral reasoning maturity, there is research into the typical and atypical development of these processes. Findings about how these processes typically develop can allow for hypotheses to be made about their potential interaction, and how they may relate to moral maturity at different ages. There is evidence that individuals with ABIs may show developmental delays or impairments in some of the components of moral development, which can allow for hypotheses to be made about how this in turn may affect moral maturity, decision-making and behaviour. There is also evidence from neuroimaging research of which brain regions are involved in the component processes, and some developmental neuroimaging research, which can provide detail about how recruitment of brain networks for these components may develop and change with age.

1.8.4.1 *Perspective taking.* The component cited by most theories as being crucial for moral development is perspective taking. Perspective taking in this context is considered to be the cognitive component of empathy and refers to the ability to infer another's mental states and attributions; also referred to as mentalisation ability or ToM. Perspective taking is important for moral development as it allows for the thoughts and feelings of others to be taken into account when making moral decisions, as attributions of intent can affect how moral decisions are processed, and whether empathy is triggered. While perspective taking is the component most frequently proposed to be involved in moral development, as discussed, there is little research linking the development of perspective taking to moral decision-making. Research has found that visual perspective taking (taking into account what others can see) develops between 12-14 months (Sodian, Thoermer, & Metz, 2007) and that by four years old children can pass false belief tasks (Wellman, Cross, & Watson, 2001), showing an understanding that a person can have a belief that contradicts reality. There is limited research into the development of perspective taking in adolescence but it has been found that more complex perspective taking, such as the ability to take into account another person's perspective to direct appropriate behaviour, and the ability to understand another's emotional states are still developing into late adolescence (Dumontheil, Apperly, & Blakemore, 2010; Vetter, Altgassen, Phillips, Mahy, & Kliegel, 2013). It has been found that males only show increases in perspective taking from 15 years onwards, suggesting gender differences in developmental trajectories (Van der Graaff, Branje, De Wied, Hawk, Van Lier, & Meeus, 2014).

Perspective taking is hypothesised to develop through social interaction and pretend play (Kohlberg, 1976, 1981; Piaget, 1932; Selman, 1976). The importance of peer interaction for perspective taking development in adolescence has been emphasised over parent interaction (Baird, 2008) and research has found that children's competence in peer interaction is significantly related to ToM understanding (Peterson, Slaughter, Moore, & Wellman, 2016). Children and adolescents with ABIs can experience difficulties in peer relationships (Tonks, Yates, Williams, Frampton, & Slater, 2010; Yeates et al., 2013) and limited social participation (Bedell & Dumas, 2004), which may impact upon role-taking opportunities with peers, and subsequently perspective taking development. Gracey, Watson, McHugh, Swan, Humphrey, and Adlam (2014) found that age at injury was significantly associated with more peer relationship problems in children with ABIs, and this relationship was mediated by metacognitive skills (working

memory, planning/organising and monitoring). As perspective taking develops through an interaction with the social environment, social factors (e.g. SES) can influence its development, which in turn affects moral development. A framework of moral development, therefore, needs to include perspective taking, along with the factors affected by perspective taking (e.g. affective empathy), and factors which influence the development of perspective taking (e.g. peer interaction).

"The brain regions that undergo the most significant development during adolescence overlap with those that have been linked to the ability to take other people's perspectives and infer mental states." (Choudhury, Blakemore, & Charman, 2006, p. 168). A study into the development of the neural network associated with perspective taking found that in adults (aged 25-32 years), activity increased in the left inferior parietal cortex and precuneus when processing third person, compared to first person judgments, and children (aged 8-10 years) additionally showed increased activity in the dorsolateral PFC and the right inferior parietal cortex (Dosch, Loenneker, Bucher, Martin, & Klaver, 2010). There was also a decrease in reaction time differences between third and first person perspective judgements with age, suggesting that adults are more efficient at processing third person perspectives (Dosch et al., 2010). Sebastian and colleagues (2012) found an increased neural response in the vmPFC for adolescents compared to adults during an affective ToM task, but no significant difference during a cognitive ToM task, and an increased amount of errors in the adolescent group for the affective but not the cognitive ToM condition. These findings suggest that the development of affective ToM, understanding the emotional states of others, is more complex and continues beyond that that of cognitive ToM. Bivona and colleagues (2014) found evidence suggesting a causal relationship between low self-awareness and perspective taking difficulties in adults with TBIs, and adults with moderate-severe TBIs have been found to exhibit difficulties inhibiting self-referential thoughts to cater for another's perspective (McDonald, Gowland, Randall, Fisher, Osborne-Crowley, & Honan, 2014). Perspective taking difficulties have also been found for children with TBIs (Dennis et al., 2013).

1.8.4.2 *Attention and working memory.* The cognitive processes of attention and working memory are proposed to be required for moral development (Gibbs, 2013). Development of working memory can refer to both an increase in capacity, i.e. the amount of information that can be temporarily stored while processing information, and to an increased ability to direct attention to relevant information while ignoring irrelevant information (Baddeley & Hitch, 1974; Engle, Tuholski, Laughlin, & Conway, 1999). A linear increase in performance from age 4-15 years has been found for working memory measures associated with the phonological loop (phonological short-term store where rehearsal takes place), the visuospatial sketchpad (stores visual and spatial material) and the central executive (responsible for regulatory functions including attention and problem solving) (Gathercole, Pickering, Ambridge, & Wearing, 2004). de Wilde, Koot, and van Lier (2016) found that lower working memory scores were related to increases in teacher-child conflict one year later, and that teacher-child conflict was negatively associated with the development of working memory, suggesting that working memory can affect social development, and vice-versa. Decision-making is more difficult in situations with high working memory load, i.e. when there is a lot of information from different sources. Increased working memory load can lead to more impulsive decisions (Hinson, Jameson, & Whitney, 2003) and prevent somatic markers from being produced (Hinson, Jameson, & Whitney, 2002), suggesting that adolescents with low working memory capacity are likely to have more difficulty making moral decisions when working memory demands are high.

A longitudinal study into the neural networks of working memory in a sample of 6-25 year olds revealed that working memory capacity correlated with activity in frontal and parietal regions, cortical thickness in the parietal cortex, and white matter structure of fronto-parietal and fronto-striatal tracts, while fractional anisotropy in white matter tracts and caudate activity predicted future working memory capacity (Darki & Klingberg, 2015). It has been found that adults show similar patterns of neural activation as children and adolescents during working memory tasks, but adults have more refined, localised activation of regions (Scherf et al., 2006). A meta-analysis found that children and adolescents with TBIs exhibited deficits in the central executive and phonological loop but not the visuospatial sketchpad (Phillips, Parry, Mandalis, & Lah, 2017). A separate meta-analysis concluded that moderate-severe TBI results in deficits in verbal and visuospatial working memory and verbal short-term memory (Dunning, Westgate, & Adlam, 2016). Additionally, it has been found that TBI significantly reduces levels of activation and connectivity between

areas of the working memory brain network (Manktelow, Menon, Sahakian, & Stamatakis, 2017).

Attention works as a filtering process to determine what information from the environment is selected for subsequent perception (Amso & Scerif, 2015) and development of attentional processes may allow individuals to focus on more details within a situation, or filter out irrelevant information. Three main visuospatial attention functions have been proposed: alerting (a state of arousal elicited by an unexpected external cue), orienting (shifting attention to select information in the environment) and executive attention (resolving conflict between competing inputs) (Fan, McCandliss, Sommer, Raz, & Posner, 2002). It has been found that visual attention develops rapidly during the first 5-10 months (Ross-Sheehy, Schneegans, & Spencer, 2015) and staying alert to cues shows significant developmental improvement after age 7 years in terms of speed of processing (Pozuelos, Paz-Alonso, Castillo, Fuentes, & Rueda, 2014). Executive attention develops strongly between ages 4-6 years (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005) showing further improvements in late childhood (Pozuelos et al., 2014). A study of 400 3-12 year olds found a staging in the development of attention and executive functions from age 6 years, starting with the maturing of inhibitory functions, followed by maturation of auditory and visual attention at age 10 years and the development of fluency in adolescence (Klenberg, Korkman, & Lahti-Nuuttila, 2001).

A magnetic resonance imaging (MRI) study of children (aged 7-12 years) and adults (aged 18-31 years) found that children showed greater functional connectivity of regions in the dorsal attention network compared to adults, whereas adults showed greater functional connectivity between regions within the ventral attention network than children (Farrant & Uddin, 2015). This pattern of development of attention networks may be a neural signature of the developmental shift from bottom-up attention mechanisms to top-down attentional capacities (Farrant & Uddin, 2015). Research has found that orienting and executive attention are significantly affected after a mild TBI, but alerting is not, with deficits in executive attention taking longer to recover than orienting processes (Halterman et al., 2006). A meta-analysis of the effects of childhood TBI on attention concluded that divided and sustained attention are the most vulnerable to TBI, and deficits often persist into adulthood (Ginstfeldt & Emanuelson, 2010). In addition, deficits for both cognitive

and behavioural aspects of attention have been found in children with severe TBIs compared to children with OIs (Yeates et al., 2005).

1.8.4.3 *Abstract reasoning.* Abstract reasoning has also been proposed to be important for moral development (Baird, 2008; Piaget, 1932) and refers to the ability to base reasoning on relationships between representations rather than just simple features of a stimulus (Dumontheil, 2014). Abstract reasoning may be important for moral development if it enables moral concepts to be understood and applied across different settings, even those not previously experienced. The Wisconsin Card Sorting Task is used as a measure of abstract reasoning, attention regulation and working memory in research studies, and performance on the task has been found to increase with age (Bujoreanu & Willis, 2008; Somsen, 2007). A shift from using concrete to abstract strategies to solve algebra problems has been found by age 15-16 years (Susac, Bubic, Vrbanc, & Planinic, 2014) and abstract reasoning has been found to be impaired in children and adolescents with autism spectrum disorders (Solomon, Buaminger, & Rogers, 2011).

A neurodevelopmental study of relational reasoning (abstract reasoning) found that similar to adults, children recruited the rostrolateral PFC when processing relations but failed to use this region when integrating across two relations (Crone, Wendelken, Van Leijenhorst, Honomichl, Christoff, & Bunge, 2009). Despite the proposal of the importance of abstract reasoning to moral reasoning development, there is a lack of research linking these components.

1.8.4.4 *Affective empathy, emotion regulation and emotion recognition.* Perspective taking, the ability to know and understand the mental states of other people, is the cognitive component of empathy, while affective empathy allows individuals to experience the feelings of others. Affective empathy (hereafter referred to as empathy) is the main affective process proposed to be important for moral development. It is proposed that empathy can act as a motivator for moral behaviour and also a powerful retrieval cue (Hoffman, 2000). Similarly to moral terms, there are issues with how empathy is defined in the literature (Decety & Cowell, 2014) and it is often unclear what aspect of empathy is being measured in studies.

Concern for others has been measured in infants aged 8-16 months, based on their responses to a caregiver and a peer in distress, finding that levels of affective and cognitive empathy were evident before 12 months and increased

gradually to 16 months (Roth-Hanania, Davidov, & Zahn-Waxler, 2011). It was also found that empathy at 10 months predicted prosocial behaviour assessed 2-4 months later (Roth-Hanania et al., 2011). Children as young as 18 months old have been found to help adults in instrumental, empathic and altruistic contexts, although empathic helping required greater communication input from the adults (Svetlova, Nichols, & Brownell, 2010).

A critical review of affective empathy did not find a consistent relationship between empathy and aggression in children but did find evidence of a negative relationship between empathy and aggression in adolescence (Lovett & Sheffield, 2007). Research has found that self-reported empathy develops during adolescence (Carlo, Mestre, Samper, Tur, & Armenta, 2011) but there is some evidence that empathic concern does not develop between ages 10-14 years (Garaigordobil, 2009), 13-18 years (Van der Graaff et al., 2014) or during adulthood (Grühn, Rebucal, Diehl, Lumley, & Labouvie-Vief, 2008). Neuroimaging research has found evidence of separate neural systems for cognitive and affective empathy, with the affective network consisting of the inferior frontal gyrus, the inferior parietal lobe, the anterior cingulate and the anterior insula (See Shamay-Tsoory, 2011 for a review). Patients with TBI and lesions in the PFC have been found to have impaired cognitive and affective empathy (de Sousa, McDonald, Rushby, Li, Dimoska, & James, 2010, 2011; Shamay-Tsoory, Tomer, Goldsher, Berger, & Aharon-Peretz, 2004).

The role of empathy in moral development may be linked to other processes; for empathy to motivate moral behaviour, individuals must to be able to correctly recognise the emotions of other people, regulate their own emotions, and retrieve relevant empathy-cognition bonds from memory. Emotion regulation is the control of emotional experience and expression (Campos, Campos, & Barrett, 1989) and consists of extrinsic and intrinsic processes responsible for monitoring, evaluating and modifying emotional reactions (Thompson, 1994). It has been suggested that there are multiple dimensions of emotion regulation, including difficulties controlling impulses and engaging in goal-directed behaviours when experiencing negative emotions and difficulties (Gratz & Roemer, 2004). Eisenberg and colleagues (2000) found that emotion regulation predicted externalising behaviour for children prone to negative emotionality and Lockwood, Seara-Cardoso and Viding (2014) found that emotion regulation moderated the relationship between empathy and self-reported prosocial behaviour in TD adults. A review of emotion regulation concluded that it

develops through observational learning and modelling, and its development can be affected by parenting style and the family environment (Morris, Silk, Steinberg, Myers, & Robinson, 2007). The brain regions involved in emotion regulation, including the limbic region and PFC, undergo structural and functional development during adolescence (See Ahmed, Bittencourt-Hewitt, & Sebastian, 2015 for a review) and damage to the PFC has been found to be related to deficits in emotion regulation (Anderson, Barrash, Bechara, & Tranel, 2006; Salas, Castro, Yuen, Radovic, d'Avossa, & Turnbull, 2016).

The ability to correctly identify emotions has been proposed to be indirectly involved in moral development; emotion recognition facilitates social interactions which lead to increases in perspective taking abilities (Anderson & Beauchamp, 2012; Taber-Thomas & Tranel, 2012). Children as young as 4-6 months old are able to distinguish between different emotions, and recognise emotions from faces (Serrano, Iglesias, & Loeches, 1992), but these abilities continue developing into adulthood (Thomas, De Bellis, Graham, & LaBar, 2007). Various brain regions have been found to be involved in emotion recognition from facial expressions and from speech, including the amygdala, orbitofrontal cortex and the fusiform gyrus (See Adolphs, 2002 for a review), while different emotions appear to activate different brain regions, suggesting separate neural systems for different emotions (Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). The ability to correctly recognise emotions from faces has been found to be compromised following brain injuries. Reviews have concluded that affect recognition difficulties are a frequent and significant problem related to adult TBI (Babbage, Yim, Zupan, Neumann, Tomita, & Willer, 2011; Radice-Neumann, Zupan, Babbage, & Willer, 2007) and deficits in emotion recognition and processing have been found in children and adults with a brain injury (Croker & McDonald, 2005; Ryan et al., 2014; Tonks, Williams, Frampton, Yates, & Slater, 2007).

1.8.5 Moral decision-making and behaviour. Moral psychology research tends to focus on reasoning or judgements rather than on behaviour as the end point. It has been found that moral reasoning does not always correlate with behaviour (Blasi, 1983) but there is some research showing relationships between moral decision-making and behaviour. A recent meta-analysis found a significant association between moral decisions or reasoning (measured using various instruments) and behaviour, associated with a medium effect size. $d=.20$ (Villegas de Posada & Vargas-Trujillo, 2015). Dooley and colleagues (2010) found a strong

negative correlation between moral reasoning scores on the So-Mature and aggressive behaviours and oppositional defiant symptoms in TD adolescents while positive relationships have been found for prosocial moral reasoning and prosocial behaviour in TD children and adolescents (Carlo et al., 2011; Miller, Eisenberg, Fabes, & Shell, 1996). The mixed evidence of a link between moral decision-making and behaviour may be partly due to differences in the measures of moral decision-making (e.g. productive vs. recognition instruments of moral reasoning) and behaviour measures (e.g. self vs. other reported behaviour) used across different studies.

There is some research comparing moral decision-making for groups whose behaviour is known to differ, such as offenders vs. non-offenders, and patients diagnosed with psychopathy vs. healthy controls. Using hypothetical moral dilemmas, Blair (1995) found that patients diagnosed with psychopathy were unable to distinguish between moral and conventional transgressions while Koenigs, Kruepke, Zeier, and Newman (2012) found that low-anxious psychopaths exhibited abnormally utilitarian personal moral judgements. Baez, Herrera, García, Manes, Young, and Ibáñez (2017) found that terrorists judged accidental harm as less permissible and attempted harm as more permissible n non-criminals, and these differences were not affected by executive skills. Political violence has also been found to impact on the development of moral reasoning; Ferguson and Cairns (1996) found that children and adolescents living in areas of high political violence in Northern Ireland scored lower on the SRM-SF than those in areas of low political violence. Meta-analyses have revealed a strong relationship between immature moral reasoning and adolescent offending (Nelson, Smith, & Dodd, 1990; Stams, Brugman, Deković, van Rosmalen, van der Laan, & Gibbs, 2006). A study of male sex offenders with a mean age of 45 years found that, on average, they were reasoning at the transitional Stage 2(3) on the SRM-SF showing developmental delay (Amador, 2016). However, there are some conflicting results, as Tarry and Emler (2007) did not find relationship between moral reasoning (as measured by the SRM-SF) and delinquency, with or without controlling for effects of age, general intellectual functioning and social background in a sample of males aged 12-15 years old. It may be that persistent developmental delay into adulthood becomes a risk factor for engaging in offending behaviour.

There is evidence of a link between brain injuries and offending, with high rates of TBI among offender populations (Farrer & Hedges, 2011; Hughes, Williams,

Chitsabesan, Walesby, Mounce, & Clasby, 2015; Shiroma, Ferguson, & Pickelsimer, 2010; Williams, Cordan, Mewse, Tonks, & Burgess, 2010), and childhood TBI has been found as a risk factor for engaging in offending behaviour later in life (McKinlay, Grace, McLellan, Roger, Clarbour, & MacFarlane, 2014). There is evidence that prisoners with a self-reported TBI show greater impairments on neuropsychological measures, have committed significantly more offences, and are more likely to have committed a violent offence compared to prisoners without TBIs (Pitman, Haddlesey, Ramos, Oddy, & Fortescue, 2015). Luiselli, Arons, Marchese, Potoczny-Gray and Rossi (2000) reported that almost one third of a community sample of children and adolescents with an ABI had engaged in criminal acts, and the majority of those who had committed offences had multiple violations. Their sample included TBI and also nTBIs such as brain abscess, stroke and tumour, and found no significant differences in the types of brain injury sustained by the participants, which suggests that all types of ABI may be a risk factor for engaging in criminal behaviour. As moral reasoning has been found to be delayed for offenders and individuals with brain injuries, moral reasoning may be a mediator in the relationship between brain injury and offending behaviour, but further research in this area is needed.

1.8.6 The importance of adolescence for moral development.

Adolescence is the period of growth and development that occurs between childhood and adulthood, between the ages of 10-19 years and is characterised by many physical, neurodevelopmental and social changes (World Health Organisation, 2017). It is a sensitive period for brain development, moral development, decision-making and moral behaviour. The brain continues developing into the mid-20s (Blakemore, 2008; Giedd, 2004). Brain development is a non-linear process and adolescence is second only to infancy in terms of the rate of developmental change in the brain, with a dramatic development of structure and function taking place during adolescence (Andersen, 2003; Arain et al., 2013). Cortical grey matter development follows the functional maturation sequence. Brain regions associated with basic functions such as motor and sensory brain areas mature first, with the PFC, involved in executive functions, being the last to mature (Gogtay et al., 2004). There are sex differences in the development of the adolescent brain, with females reaching peak values of brain volumes earlier than males (Giedd et al., 2006; Giedd et al., 1996; Lenroot & Giedd, 2010). Relevant brain regions, such as those in the social brain network, develop during adolescence (Mills, Lalonde, Clasen, Giedd, & Blakemore, 2014), which can aid the

maturation of cognitive and affective processes involved in moral development (e.g. working memory and empathy). Damage to the brain which occurs before these processes have matured may affect their developmental trajectory, in turn leading to moral developmental delay. Adolescence is a risk period for sustaining a TBI (Yates et al., 2006), and high rates of nTBIs have been found for 15-19 year olds (Chan, Pole, Keightley, Mann, & Colantonio, 2016).

Moral developmental delay has been associated with offending behaviour (Nelson, Smith, & Dodd, 1990; Stams, Brugman, Deković, van Rosmalen, van der Laan, & Gibbs, 2006) and adolescence is a risk period for engaging in offending behaviours (Farrington, 1986; Moffitt, 1993). Adolescent decision-making has been studied in relation to risk-taking behaviours; increased risk-taking during this period may be due to competing reward and control systems in the adolescent brain (Steinberg, 2007). Adolescent decision-making is particularly susceptible to peer influence (Gardner & Steinberg, 2005). Although peer influence may increase risky decision-making during adolescence, increased interaction with peers may facilitate moral development through increasing in role-taking opportunities, which allows for the development of perspective taking abilities, and a move away from egocentrism. Relationships between brain development, decision-making, moral development, and moral behaviour are likely to be complex during adolescence which is characterised as a period of great change.

1.9 Summary

The main moral theories from developmental psychology and social neuroscience were reviewed in this introductory chapter, and SIP theory was introduced as an approach which may be able to bring together components from various disciplines. An integrative framework using a SIP approach has the potential to provide a fuller picture of moral decision-making, moral development and moral behaviour. Research discussed in this chapter highlighted that there is a lack of research measuring relationships between moral reasoning and the cognitive and affective processes proposed to be involved in moral development. In addition, while there is some evidence of a relationship between moral reasoning and behaviour, these two do not always correlate.

Many components are proposed as required for moral development, and as a consequence, the maturation of many brain regions, and connections between regions, may underpin moral development. Furthermore, there is no strong

evidence for a uniquely 'moral brain', as regions involved in moral decision-making are also involved in other processes. Due to the importance of brain development, a brain injury that occurs while the brain is still maturing may affect the developmental trajectory of moral decision-making maturity. Research suggests that children and adolescents with ABIs show developmental delays or deficits in some of the proposed components of moral development, such as emotion recognition (Tonks et al., 2007) and working memory (Phillips et al., 2017), as well as delayed moral reasoning (Beauchamp et al., 2013; Chiasson et al., 2017a; Couper et al., 2002; Dooley et al., 2010). Research into moral decision-making and development in adolescents with ABIs is sparse and not always grounded firmly in developmental psychology. The following chapter will outline how this thesis will attempt to address some of the theoretical and research issues raised in this chapter.

Chapter 2: Aims

2.1 Chapter overview

The overall aim of this thesis is to attempt to link both developmental psychology and social neuroscience approaches to moral decision-making and development. It is hoped that this will prove fruitful for further theory development and research in this area. This thesis will be split into three parts, with Part One addressing theoretical issues and Parts Two and Three presenting original research into moral decision-making and development. In Part One, comprising Chapter 3, theoretical issues will attempt to be addressed by the presentation a new theoretical framework which draws together aspects from social neuroscience and developmental psychology. In Part Two, comprising Chapter 4, a systematic review and meta-analysis of neuroimaging research into moral decision-making will be presented, to investigate which brain regions show increased activation when making different types of moral decisions. In Part Three, comprising Chapters 5, 6, and 7, two empirical studies will be presented which investigated moral development in TD adolescents, and adolescents with ABIs. Specific objectives and research questions for each chapter will now be discussed in turn.

2.2 Objectives and research questions

2.2.1 Part One. Following the review of the main theories related to moral decision-making and its development in Chapter 1, a new, integrative framework will be proposed in Chapter 3. This new framework, the Social Information Processing-Moral Decision-Making (SIP-MDM) framework is based on a SIP approach and incorporates concepts from traditional moral theories and more recent findings from social neuroscience, placing brain development at the centre. The framework attempts to explain both how real-time decisions are made, and how they mature over time, expanding the definition of moral development to incorporate the maturation of moral decisions, reasoning and related component skills and processes such as empathy and SIP skills. The SIP-MDM framework is also an attempt to reconcile the debate concerning whether moral decisions are driven by reasoning or intuitions, by suggesting how both can be incorporated into an explanation of moral decision-making. The specific objectives of Chapter 3 were to:

- Highlight the theoretical components of moral development proposed by various theories.

- Incorporate the main components of moral developmental theory into a new framework based on a SIP approach.
- Explain how this new framework can be used both as an explanation of real-time moral decision-making, and of moral development.
- Outline some of the hypotheses generated by the framework and how they can be investigated.

2.2.2 Part Two. In Chapter 4, the 'brain development' component of the SIP-MDM framework proposed in Chapter 3 will attempt to be expanded on by systematically reviewing the neuroimaging evidence pertaining to moral decision-making. A meta-analysis that aimed to assess which brain regions are consistently activated when making one's own moral response decisions and when making moral evaluations will be presented in Chapter 4. The specific objectives of Chapter 4 were to:

- Systematically review the neuroimaging literature on moral decision-making.
- Differentiate between studies which measure brain activation while making one's own moral response choices and those which involve evaluating or judging the moral permissibility of others' actions or identifying moral issues.
- Employ the co-ordinate based meta-analysis technique of activation likelihood estimate analysis (ALE) to investigate which brain areas are consistently activated for: (a) moral response decisions, (b) moral evaluations, and (c) to assess convergent and divergent activation for both types of decision.
- Compare the findings to results of related meta-analyses.

2.2.3 Part Three. In Part Three of the thesis, developmental psychology and social neuroscience approaches will be integrated by investigating hypotheses generated by the integrative SIP-MDM framework. Some hypotheses of this framework will be explored in TD adolescents, and moral maturity will be explored in adolescents with ABIs. Chapter 5 presents Study 1 which was an exploration of some of the hypotheses of the SIP-MDM framework in TD adolescents. Whether the cognitive and affective processes proposed by various theories to be important for moral development relate to moral maturity, and whether moral maturity correlates with behaviour in TD adolescents was explored in Study 1. The specific research questions addressed were:

- Do moral reasoning, and the cognitive and affective processes hypothesised to be required for moral development (empathy, perspective taking, emotion recognition and working memory) develop with age in TD adolescents?
- Do these cognitive and affective processes relate to moral reasoning maturity in TD adolescents?
- Does moral reasoning maturity relate to behavioural difficulties in TD adolescents?

Whether components of the SIP-MDM framework relate to information processing at different steps of the framework, (e.g. does emotion recognition relate to encoding of information?) were also explored in Study 1. The specific research questions addressed were:

- Do components of the SIP-MDM framework mature with age amongst TD adolescents?
- Do components in the centre of the framework (e.g. SES and working memory) relate to processing at each step of the SIP-MDM framework?
- Do components listed under the steps of the SIP-MDM framework (e.g. emotion recognition at Step 1) relate to processing at that step?

Before hypotheses related to the SIP-MDM framework can be fully explored in an ABI sample, suitable measures need to be identified. In Chapter 6, Study 2 will be presented which: (a) explored the psychometric properties of two measures of moral reasoning when used with adolescents with ABIs, (b) compared developmental levels of moral reasoning for an ABI group compared to a NH comparison group, matched on age and gender, and (c) investigated behavioural differences between the groups, and whether moral reasoning is related to behaviour. This study was a first step towards exploring relationships of the SIP-MDM framework in populations with a brain injury. The specific research questions addressed in Study 2 were:

- What are the psychometric properties, specifically internal consistency, convergent validity and test-retest reliability of the SRM-SF and the So-Mature measures of moral reasoning in a sample of adolescents with ABI, and a NH comparison group?
- Is the ABI group reasoning at a lower level than the NH group on these two measures of moral reasoning?
- Do the ABI group show more behavioural difficulties than the NH Group?

- Does moral reasoning score relate to behaviour in the ABI and NH group?

In Chapter 7 the main findings from the systematic review and empirical studies will be summarised, and strengths and limitations of these studies will be discussed. Clinical and theoretical implications will be outlined, as well as areas for future research.

Part One: Integrating developmental psychology and social neuroscience theory

Chapter 3: A Social information processing-moral decision-making framework

"Judgments and decisions of any sort-including those that involve matters of morality-are not a matter of magic but result from processing of information."

(Fiedler & Glöckner, 2015, p. 139)

3.1 Chapter overview

For a full picture of moral decision-making, moral development and moral behaviour it is necessary to understand: (a) how real-time moral decisions are made (including relevant social and contextual factors), (b) what processes are required to develop to enable mature moral decisions, and how these develop over time, and (c) how moral decisions relate to behaviour. In a first step towards this full picture, an integrative framework will be introduced in this chapter, which can be used to guide further research and theory development in this area. Proposed components of moral development will firstly be introduced before they are integrated into a new framework based on a SIP approach. The framework will incorporate situational factors, show how both affective and cognitive processes can guide moral decisions, and will integrate aspects from developmental psychology and social neuroscience. How this framework goes beyond previous SIP models will then be outlined, followed by a discussion of how it can explain both real-time moral decisions and moral development. This chapter will conclude with how the SIP-MDM framework could be used to guide future research and theory development in this area.

3.2 The components of moral decision-making and development

"Central to any discussion of developmental issues is the consideration of 'what develops'" (Crick & Dodge, 1994, p. 80). Table 3.1 displays the main components of moral development suggested by the various theories and perspectives reviewed in Chapter 1, grouped into broad categories of cognitive, affective, social and other. Some of the affective components listed could be viewed as either cognitive or affective (e.g. emotion regulation) but within this thesis they have been considered as by and large affective. Selected research into how the

main components typically develop, and are affected following a brain injury was discussed in Chapter 1. This research outlined that there are various components relevant and related to moral development, and these develop and mature with age, with some abilities or processes being evident in early infancy and developing partly due to increased socialisation and brain maturation. Taken together, neuroscience research into development of the components suggests that various brain regions and networks are involved in moral development, and that the structure and functional connectivity of these networks change over time. Some components such as perspective taking and empathy are proximal factors of moral development, while other components are more distal factors. For example, social skills, while distal factors, still affect the development of components such as moral schemas and perspective taking by facilitating opportunities for social perspective taking, which in turn facilitates moral development.

There are many bi-directional relationships between components; for example, peer interaction influences the development of perspective taking abilities, which in turn can affect peer interactions. Some research has found developmental and predictive relationships between components, (e.g. Vera-Estay et al., 2016), suggesting that the various components could be integrated into one framework of moral development. Neuroscience research has highlighted that moral decision-making is a dynamic process emerging from the integration and coordination of widely distributed brain regions (Van Bavel et al., 2015) and so neuroscience has much to offer the field of moral psychology, moving it towards a more dynamic explanation. An integrative framework could include both affective and cognitive processes, show how both intuitions and reasoning can guide moral decisions and bring together aspects from developmental psychology and social neuroscience. The components of moral development will now be integrated into a SIP framework, which expands on previous SIP models, in an attempt to explain moral decision-making, moral development, and moral behaviour.

Table 3.1 The components of moral development.

Component type	Component	Main theories to have proposed this component is involved in moral decision-making or development
Cognitive	Working memory	Gibbs (2013)
	Perspective taking	Baird (2008); Piaget (1932); Gibbs (2013); Kohlberg (1976; 1984a, b); Rest (1984; 1999)
	Attention	Gibbs (2013); Crick and Dodge (1994)
	Abstract thought/reasoning	Baird (2008); Piaget (1932)
	Logical reasoning	Piaget (1932); Kohlberg (1984a, b)
	Schemas/ scripts	Gibbs (2013); Hoffman (2000); Rest et al. (1999); Crick and Dodge (1994); Arsenio and Lemerise (2004); Lemerise and Arsenio (2000)
	Attributions	Hoffman (2000); Gibbs (2013); Crick and Dodge (1994); Arsenio and Lemerise (2004); Lemerise and Arsenio (2000)
	Self-control	Rest (1984; 1999)
Affective	Affective empathy	Hoffman (2000); Kohlberg (1984a, b); Gibbs (2013)
	Emotion regulation	Lemerise and Arsenio (2000)
	Emotion recognition	Anderson and Beauchamp (2012); Taber-Thomas and Tranel (2012)
	Somatic markers	Baird (2008); Taber-Thomas and Tranel (2012)
	Intuition	Haidt (2001)
Social	Social functioning/ competence/ skills	Anderson and Beauchamp (2012); Gibbs (2013); Yeates et al (2012)
	Peer interaction/ socialisation	Piaget (1932); Gibbs (2013); Hoffman (2000); Haidt (2001); Turiel (1983); Smetana (2006); Yeates et al (2012); Lemerise and Arsenio (2000)
	Socio-economic status	Anderson and Beauchamp (2012); Yeates et al (2012)
	Culture	Haidt (2001); Anderson and Beauchamp (2012)
	Parenting/family function	Piaget (1932); Hoffman (2000) Palmer (2003); Anderson and Beauchamp (2012); Yeates et al (2012)
Other	Brain development and integrity	Baird (2008); Kagan (2008); Taber-Thomas and Tranel (2012); Anderson and Beauchamp (2012); Yeates et al (2012)
	Temperament/ personality	Haidt (2001); Kagan (2008); Lemerise and Arsenio (2000)
	Social information processing	Arsenio and Lemerise (2004); Palmer (2000)

3.3 Moral decision-making and development: Toward an integrative framework

Moral decision-making differs from other types of decision-making because the situation has moral rules or principles attached, which may invoke moral reasoning and the activation of morally relevant schemas from memory. Moral decision-making also shares similarities with other types of decision-making as it involves the processing of information and making judgements, evaluations, and response decisions, which may lead to behavioural action. Like other types of decision-making, moral decision-making is subject to influences such as situational factors, personality factors and biases. SIP theory can provide a useful framework for explaining how decisions are made, and can be adapted to include the components of moral development. Moral principles are necessary but not sufficient for moral behaviour, (Kohlberg, 1984a); other components and factors which affect decision-making and behaviour enactment need to be considered. The original SIP model was proposed as an explanation of aggressive behaviour in children (Crick & Dodge, 1994) and it has been found that aggressive children display atypical SIP skills, and SIP problems are predictive of aggressive behaviour (Dodge et al., 2002; Lansford et al., 2006; Oostermeijer et al., 2016; Ziv & Sorongon, 2011). Such research suggests that the SIP model provides a sound basis for explaining behaviour, which has not been the focus of previous moral theories. What is known about the development of moral maturity and related components, therefore, needs to be linked with what is known about decision-making, to gain a better understanding of how moral decisions are made, how they mature over time, and in turn, have a better understanding of moral behaviour.

Although many social, biological and psychological factors are involved in the development of behaviour, the actual behavioural act is preceded by a decision-making process, whether cognitive, affective or both, which serves as the proximal control mechanism (Burks, Laird, Dodge, Pettit, & Bates, 1999). Moral response decisions can be conceptualised as the response decision step in a SIP framework, as the proximal decision before a behavioural response, although a behavioural response may only follow if it is perceived that one is necessary, and the intended behaviour is able to be carried out. Emotional processes, such as empathic arousal were incorporated into the SIP model by Lemerise and Arsenio (2000), suggesting that a SIP approach can be used to bridge the cognition vs. affect division within moral psychology.

3.4 The SIP-MDM framework

Within this section, a conceptual, illustrative framework of moral decision-making and development is introduced, showing how the components of moral development suggested by various theories can be integrated into one dynamic explanation of how moral decisions are made and mature over time. This has been termed the Social Information Processing–Moral Decision-Making (SIP-MDM) framework. The format owes much to the original (Crick & Dodge, 1994) and more recent models (Arsenio & Lemerise, 2004; Lemerise & Arsenio, 2000) but components have been added to each step and the centre of the model has been reconceptualised, incorporating ideas from developmental psychology and social neuroscience.
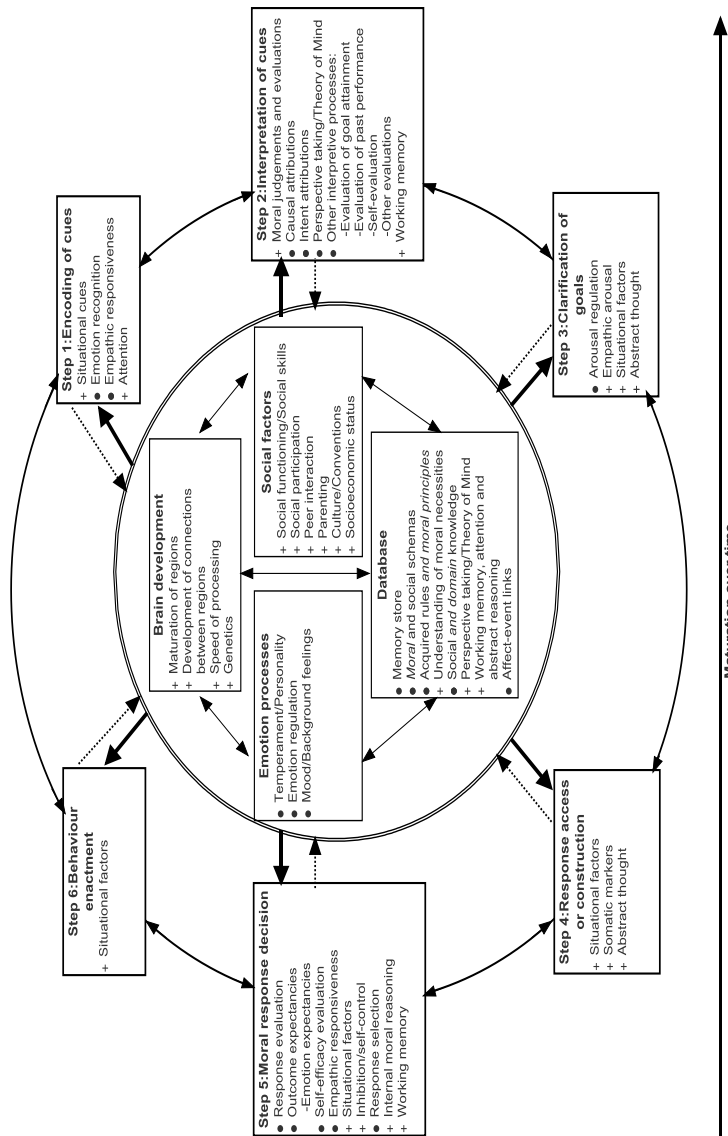
Figure 3.1. The Social Information Processing-Moral Decision-Making Framework (SIP-MDM).

3.4.1 How this framework differs from previous SIP models. Arsenio and Lemerise (2004) incorporated some aspects of moral theory by integrating SIP with domain theory, but the SIP-MDM framework takes integration further by adding components from other moral theories and attempting to add a developmental aspect. Components marked with a '+' bullet point have been added to previous models. Italics have been used to show where a component is not completely new but has been amended slightly, e.g. '*moral*' added to social schemas. Relevant components have been added at each step, the centre has been reformulated and Step 5 has been conceptualised as *moral* response decision. A horizontal arrow has been added to represent maturation over time and each component is hypothesised to develop over time, increasing the capacity for more mature moral decisions.

Conceptualising Step 5 as moral response decision allows for the framework to explain response decisions made within a moral dilemma, i.e. a situation within the moral domain where a response decision is required. The SIP-MDM framework could also be used to explain decision-making in other domains, but if a situation is in the moral domain, and recognised by the individual as having moral rules or principles attached, then components relevant to moral decision-making, such as moral reasoning, will be activated. The 6 steps of the SIP-MDM framework specifically indicate the processing that is occurring when making a decision about how to behave in a moral dilemma. Although the steps of the framework are not strictly sequential, a moral response decision is the proximal step made before behaviour enactment. Moral decisions which are not response decisions, such as judging or evaluating the actions of others have been added at Step 2. Such moral judgements and evaluations made when interpreting a situation can influence whether a situation itself is viewed as moral or not and can have an effect on subsequent processing, including the response decision that is chosen at Step 5.

Reformulation of the centre of the SIP-MDM framework expands the database component of previous models by adding aspects relevant to moral decision-making and development such as moral schemas and perspective taking. The database can be viewed as a 'store' of resources that can be drawn upon when processing information. Social factors and brain development have also been added to the centre alongside the database (Crick & Dodge, 1994) and emotion processes (Lemerise & Arsenio, 2000). Social factors can influence the development of other components. For example, peer interaction can influence the development of perspective taking through role-taking with peers (Gibbs, 2013; Piaget, 1932), and

the relationships between parenting practice and behaviour may be mediated by SIP (Palmer, 2000). Brain development can influence moral decision-making directly, as brain regions relevant to real-time decision-making mature, and also indirectly, via its influence on the development of component processes such as working memory and empathy. Connections between regions can also lead to increases in processing efficiency. Decreases in reaction times for adults compared to adolescents when making moral decisions indicates that adults become more efficient at processing such information (Dosch et al., 2010).

Adding these components to the centre of the framework shows how they can be used in making real-time decisions, but also that their development over time can lead to more efficient processing and mature moral decision-making. All the relationships in this framework are multi-directional: the components in the centre of the framework can influence each step of information processing, and engaging in processing can influence the development of components within the centre of the (e.g. moral schemas), in turn influencing future moral decision-making. The thick arrows from the centre to each step indicate the components in the centre influencing real-time decisions, and the dashed arrows indicate information processing influencing development of components in the centre. The arrows are separate as this relationship is not entirely cyclical; although engaging in SIP can influence development of factors in the centre, development occurs over time and so cannot be used in the same situation.

This SIP-MDM framework suggests how moral decisions can be driven by both automatic processes and by reasoning. Somatic markers have been added (Step 4), as a component which can affect decision-making, narrowing down possible responses in a situation. It has been found that typical immoral events require shorter judgement decision times than atypical events (Fransson & Ask, 2010), suggesting that more common moral decisions may require less reasoning. Moral reasoning has been added at Step 5, as a component involved in making a moral response decision. Moral reasoning is just one of the processes which guides moral decisions, although it draws upon and is dependent upon other components such as emotion expectancies, attention, encoding, working memory, and perspective taking. Even though initial decisions may be driven by some somatic markers or automatic activation of a moral schema at Step 4, reasoning is required to confirm, reject or reformulate this into a moral decision (Kahneman, 2011). Moral

reasoning in a given situation depends on the processing at other steps of the framework, and to what extent the situation activates moral schemas.

Cognitive and affective components suggested by various moral theories have been added at relevant SIP steps. Crick and Dodge (1994) hypothesised that SIP abilities develop with age partly due to developmental shifts in attentional ability, and Gibbs (2013) proposed that attention is important for moral development, but it has not been explicitly included in previous SIP models. Here, attention has been added to Step 1. It is proposed that at Step 1, where cues are encoded, attentional abilities (e.g. shifting attention and executive attention) and attentional bias will influence what information is encoded, which then impacts upon what information is available for subsequent processing. Attention has also been added to the database as a process that can develop over time and lead to increased efficiency of SIP and the capacity for more mature moral-decisions. Working memory has been added to Steps 2 and 5, and to the database of the SIP-MDM framework. It is hypothesised that increases in working memory capacity, and the ability to direct attention to relevant information while ignoring irrelevant information will aid the interpretation of cues and the moral decision-making step. Inhibition/self-control has been added at Step 5, as a process that can guide response decisions (Rest, 1984; Rest et al., 1999), as certain possible responses may need to be inhibited.

Perspective taking/ToM has been added at Step 2 and the database. Making appropriate attributions at Step 2 relies on the ability to accurately infer the beliefs and intentions of other people, and as perspective taking develops over time, it can influence all SIP steps by making processing less egocentric. Emotional processes were added to the SIP model by Lemerise and Arsenio (2000) but the SIP-MDM framework also includes empathic arousal at Step 3 and it is proposed that individuals with greater empathic arousal will select more prosocial goals. Abstract thought/ reasoning has been added at Steps 3 and 4 and to the database. At Step 3, abstract thought will allow individuals to think of a goal not previously experienced, and at Step 4 it will allow for responses not previously enacted to be constructed. Development of abstract reasoning skills can impact on other steps of processing through its effect on moral development; it allows for moral concepts to be understood and applied across different settings, including those not previously encountered. 'Situational factors' have been added at Steps 1,3,4,5 and 6. Level of moral reasoning varies according to context or situation (Krebs, Vermeulen, Carpendale, & Denton, 2014), and can be influenced by factors such as alcohol

intake (Denton & Krebs, 1990). Situational factors may be of most importance at Step 6 following the moral response decision at Step 5 and may account for differences between moral decisions and moral behaviour. While the SIP-MDM framework acknowledges that situational factors need to be taken into account when explaining moral decision-making and behaviour, further research is needed into the relevant situational factors.

3.4.2 Moral decision-making in the SIP-MDM framework. Although the six steps are not necessarily how processing occurs in every situation, the order of the six steps will now be used to illustrate how a moral response decision may be made in an everyday moral dilemma (a situation with moral rules or principles attached where a response decision is required), using the example of deciding whether to cheat during a game of Monopoly with friends (an example scenario used in the So-Moral, Dooley et al., 2010). How an individual may decide to cheat in this situation, based on the suggested framework will be discussed, but how an alternative behavioural action (not cheating) may occur will also be outlined.

At Step 1 the individual will encode the cues such as looking at how much money each player has, encoding the other players' emotions, including their own emotions, and encoding situational cues such as the opportunity to cheat (e.g. other players are distracted or have left the room). Encoding these cues will require attention abilities and emotion recognition, and which cues are encoded will affect subsequent processing. Encoded cues are then interpreted at Step 2; this is an important step and is where a situation is recognised as having moral rules attached or not, through moral judgements and evaluations. For cheating at the game to occur, an individual may either not recognise that this situation has moral rules attached, e.g. they may think that because it is a game with friends, "moral rules" governing cheating may not apply, or they do recognise the moral rules attached, but still decide to cheat for various reasons, e.g. they are losing and want to win, which is an attribution and evaluative process. In interpreting cues, the individual may engage in perspective taking; thinking how their friends might feel if they cheated, or thinking how they would feel if their friends cheated, which could influence the goals they set in the situation. In interpreting cues, the individual may also engage in various evaluations such as evaluating theirs and their friends' past performances of playing Monopoly, which will require working memory in order to keep various sources of information in mind.

At Step 3, goals for the situation are set, and these can be influenced by whether or not empathic arousal occurs, and also influenced by situational factors (e.g. does the opportunity to cheat still exist). This step is where an individual decides what they want from the situation, such as to cheat at the game by possibly gaining more money to play with, and increasing their chances of winning. Possible responses are accessed or constructed at Step 4. In this example, an individual may think of various ways in which they can cheat, such as taking some extra money from the bank or hiding some of the other players' money. Responses thought about at this step can be influenced by somatic markers and situational factors, and may require abstract thought. A Step 5, the moral response decision is made, i.e. to cheat and how to cheat, or to not cheat and continue to play by the rules. Deliberation occurs at this step, which may include engaging in moral reasoning and evaluating the expected outcome. A self-efficacy evaluation may also occur at this step, where the individual evaluates their ability to carry out their intended behavioural action, e.g. evaluating if they would be able to take extra money without being caught by the other players. Deliberation at this step could lead to a change in the selected goal, or a change to the chosen response option. The response decided upon at Step 5, to cheat or not to cheat at the game, will be enacted at Step 6 unless situational factors change (e.g. the opportunity to cheat no longer exists, or increases), or the individual over estimated their ability to carry out their chosen course of action. As stated, the steps do not necessarily occur in this order, and processing can be rapid.

In terms of choosing a moral or prosocial course of action, in the Monopoly example, an individual may not cheat either because they do not consider cheating as a possible action, or they may consider it but decide against it for various reasons. If an opportunity to cheat was either not encoded (not noticed), or was not interpreted as such, then there is no moral dilemma and no response decision to be made. An individual may recognise the opportunity to cheat but not consider it a possible action, which may be due to knowledge of moral rules related to the specific situation (knowledge that cheating is bad), or due to a deeper understanding and moral necessities (an appreciation of fairness). As individuals develop moral maturity, more decisions will be made based on a deeper understanding of moral necessities, rather than on situation specific moral rules. At each step, certain components can influence an individual's decision-making, leading them to decide not to cheat. For example, engaging in perspective taking at

Step 2 may lead an individual to decide that the other players would be distressed and less likely to trust them if they cheated, or thinking about the ways to cheat at this step might trigger a somatic marker, or affective empathy, which feels unpleasant and rules out cheating as a viable option. As previously stated, the 6 steps are not sequential and can impact on each other, for example, which cues are encoded Step 1 can be affected by existing goals or motivation, which can bias encoding of cues through selective attention.

3.4.3 Moral development within the SIP-MDM framework. In terms of the *development* of moral decision-making in such a framework, the development of each of the components of the framework leads to an increased efficiency of decision-making. For example, increases in the ability to recognise emotions (Step 1) will enable such cues to be encoded and used in processing a situation, and increases in working memory, including attentional control (Step 2) will allow for more relevant features of a situation to be taken into account when making a decision. However, to fully achieve the capacity for mature moral decision-making, the components in the database also need to develop. One important difference to this framework compared to previous SIP models is the extension of the database to add components thought to be crucial for moral development, such as perspective taking, an understanding of moral necessities, working memory, attention and abstract reasoning. Moral development is not just achieved through an increase in moral knowledge, but also involves the development of perspective taking and an appreciation of moral necessities for "growth beyond the superficial" (Gibbs, 2013). This framework is dynamic and is in line with the argument made by Rest and colleagues (1999) that development is gradual rather than one step at a time. The horizontal arrow at the bottom of the framework is to illustrate that the whole process develops over time, but this developmental aspect could be greatly expanded upon by research into developmental relationships between components.

Based on this framework, to be able to make a mature moral decision to a moral dilemma, an individual needs to have both a developed database and sufficiently developed component skills and processes to be able to process information in a situation. In addition to this, situational factors will affect whether a mature moral decision is actually made, and what behavioural response is enacted. More mature moral decisions may result in prosocial behaviour but other factors also influence behaviour, and such factors and their effects (e.g. peer influence) can change over time. Behaviour enactment, at Step 6 of this framework is a result of

processing that occurs in a situation, the integrity of the component skills and processes at each step and in the centre of the framework, and also situational factors.

3.4.4 Using the SIP-MDM to guide research. The framework presented here attempts to consider how moral decision-making may occur and how development of the components can increase the capacity for mature moral decision-making. Research is needed to either confirm or reject the predictions of this framework, for example, does developmental progression in emotion recognition abilities affect what is encoded in a moral dilemma, and does this in turn have any effect on moral decision-making and behaviour? The suggested framework can be used to generate hypotheses about moral decision-making and moral development, to guide research and theory development. Testing some of these hypotheses in TD samples can provide information about the typical developmental relationships between components. Testing hypotheses of the SIP-MDM framework in atypically developing samples can provide information about how difficulties in certain components can impact the moral decision-making process and moral development.

Further research into which brain areas are recruited when making different types of moral decisions is needed in order to expand on the brain development component of the SIP-MDM framework. Developmental neuroimaging studies could provide insight into how the brain networks for moral decisions change with age. Evidence from neuroscience suggests that the vmPFC is the brain region most commonly recruited for moral decision-making, but neuroscience studies tend to use utilitarian hypothetical dilemmas involving life or death choices (Greene et al., 2001), which do not to reflect the everyday moral decision-making of most people. Furthermore, the vmPFC has been found to be recruited during other types of decision-making, such as decisions relating to food choice (Hare, Malmaud, & Rangel, 2011), so it is not a uniquely moral brain region. Many components, such as empathy, perspective taking and working memory are proposed to be important for moral decision-making maturity, so a wide range of brain regions and networks may underpin moral decision-making and development.

Conceptualising moral response decisions within a SIP framework allows for such decisions to be measured with a SIP instrument, using vignettes which depict violations of moral rules or principles. Measuring moral decisions this way could

allow for an investigation of how more real-life moral response decisions are made, based on a response constructed by the individual rather than forced-choices in hypothetical dilemmas. For example, the social information processing test (van Nieuwenhuijzen et al., 2011) includes a vignette of a boy in a wheelchair being bullied, which relates to the moral principles of justice and harm, and decisions about this dilemma are more 'real-life' than choosing to kill one person or to kill five people (Greene et al, 2001). Future studies could use a SIP measure alongside measures of moral reasoning and other component processes, to provide a better understanding of relationships between the components of moral development

Measuring some of the components of this framework in individuals (e.g. their moral reasoning level and SIP skills) may allow for a prediction of how they are likely to act in moral situations, but without further exploration of all relevant situational factors, behavioural prediction would not be possible. Further research into the situational factors that may affect moral decision-making will help to better predict moral behaviour. Situational factors have been incorporated into some steps of the SIP-MDM framework but this is an area that needs further research and clarification in order to improve the predictive power of such a framework in different situations. Research from criminological literature can add to our knowledge of relevant contextual and situational factors for offending behaviour, and how these interact with other factors. For example, adolescents are more likely to offend when unsupervised with peers (Wikström, Ceccato, Hardie, & Treiber, 2010). Developmental studies may also be useful here, as situational factors that affect moral decision-making may change over time. For example, peer influences are particularly important during adolescence; the presence of peers can affect adolescents' decision-making (Gardner & Steinberg, 2005).

3.5 Summary

Moral development is a complex process involving many factors. The SIP-MDM framework expands the definition of moral development to incorporate the maturation of the component skills or processes, as well as the maturation of moral decision-making, including moral reasoning. Development of component skills and processes, including the database, can lead to an increase in the capacity for making more mature moral decisions, but whether a mature moral response decision is made, and results in a moral behaviour, depends on situational factors and the processing that occurs in that situation. While there is promise of what a

fully integrative working model of moral decision-making and development could offer, developing such a model that predicts moral decision-making, moral development and moral behaviour is an ambitious task. In incorporating all of the components thought to be involved in moral development, there is a risk of creating a theory of everything, which is too broad and non-specific, or overly complicated. There are also challenges in reconciling differing theories and philosophical viewpoints, and also incorporating social neuroscience research which has largely developed separately from developmental psychology research. While recognising these limitations, the SIP-MDM framework is the first attempt to incorporate all of the suggested relevant components into one descriptive framework of moral decision-making and behaviour. Such a framework can explain how moral decisions are made, and can help in describing the components that need to develop in order for mature moral decisions to be able to occur. Further research in this area can provide either support for this framework, or arguments for reformulation. For a fully working model which explains both moral decision-making and behaviour alongside moral development, specific situational factors need to be further explored and developmental processes, including brain development, expanded upon.

Part Two: Social neuroscience research into moral decision-making

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Chapter 4: The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decisions

4.1 Chapter overview

The SIP-MDM framework introduced in Chapter 3 brings together perspectives from developmental psychology and social neuroscience. Brain development is included in the centre of the SIP-MDM framework, as a component central to moral decision-making and development. This could be expanded on by further exploration of which brain regions are recruited during moral decision-making. In this chapter, a systematic review will be presented that was carried out to investigate which brain regions consistently show increased activation during different types of moral decision-making. Firstly, different types of tasks used in moral decision-making neuroscience studies will be outlined, followed by a discussion of previous work in this area, and whether there is evidence for a moral brain network. The aims and method will be presented, including an explanation of activation likelihood estimate (ALE) analysis, which is used to perform the meta-analysis of this systematic review. Results will be discussed in relation to previous meta-analyses and the quality of included studies.

4.2 Background

4.2.1 Moral tasks. Over the past decade, fMRI has increasingly been used to measure the neural correlates of moral decision-making, adding to our understanding of the cognitive and affective processes involved. Nevertheless, there are issues with a lack of consistency amongst studies (Christensen & Gomila, 2012); a variety of different tasks have been used, and there are no agreed definitions, meaning that moral terms such as judgement, reasoning, sensitivity and moral cognition are all used differently across experiments. The moral tasks used in fMRI experiments which involve an active decision (as opposed to passive judgements) can be grouped into two categories based on the questions posed following the stimuli. Moral response decision (MRD) tasks ask individuals to make a response decision about what they would do in a hypothetical moral dilemma and moral evaluation (ME) tasks ask an individual to judge the appropriateness or moral permissibility of another's actions, or asks them to identify or judge a moral issue or violation.

MRDs require an individual to think about what they would do in a moral dilemma, whereas MEs require judging the moral permissibility or appropriateness of the actions of others in a moral dilemma. Discrepancy has been found for answers to MRD ("Would you do X?") and ME questions ("Is it wrong to do X?") in moral dilemmas (Tassy, Oullier, Mancini, & Wicker, 2013); "it seems that deciding *what to do* is not processed in the same way as deciding whether an action is *right or wrong*, and that in moral dilemmas it is the first that matters"(Christensen, Flexas, Calabrese, Gut, & Gomila, 2014, p. 607). A systematic review of moral decision-making which compares brain activation patterns for MEs and MRDs can help to address whether these different questions are indeed processed in different ways in the brain. It was hypothesised that making one's own decisions about what to do in a moral dilemma and judging the moral actions of others will show increased activation of different brain areas compared to non-moral decisions, with MRDs showing greater activation in self-referential regions and MEs showing greater activation in ToM regions.

A few recent meta-analyses have gone some way to differentiating between task types and compared brain activation for different types of moral decision-making task, but do not make the same distinction as the current review proposes, of MRDs and MEs. For instance, Boccia et al. (2016) compared brain activation for first and third person perspective moral tasks. Some of the first person perspective tasks presented the moral task in the first person but asked a moral evaluation question ('is it appropriate to do X?') rather than specifically asking 'would you do X?' or 'what would you do?', therefore still measuring evaluations of others rather than what someone would do themselves in a moral dilemma. Bryant, Wang, Deardeuff, Zoccoli, and Nam (2016) contrasted right/wrong judgements with moral dilemma decisions. Within their decision-making domain they did not differentiate between studies which asked respondents to make their own decisions about what to do, and those which asked if it is acceptable for others to do certain moral actions. Han (2016) looked at moral sensibility and moral judgements but within the moral judgement domain did not differentiate between making one's own moral response choices and other moral decisions. Task-type needs to be taken into account when conducting a systematic review and meta-analysis of moral decision-making. Whether or not moral decisions relating to the one's own decisions involve different processes and activate different brain areas relative to moral decisions about others has not yet been considered in previous systematic reviews.

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4.2.2 The moral brain. There appears to be no evidence for a uniquely "moral brain" (Young & Dungan, 2012), as brain areas that show increased activation during moral tasks are also involved in other functions. The brain region which appears to be of particular importance for morality, based on neuroimaging and lesion studies, is the vmPFC (Blair, Marsh, Finger, Blair, & Luo, 2006; Fumagalli & Priori, 2012; Marazziti, Baroni, Landi, Ceresoli, & Dell'Osso, 2013; Raine & Yang, 2006). The vmPFC is thought to be involved in emotion regulation, and activation during moral decision-making tasks is seen as evidence of the involvement of emotion processes in making moral decisions (Greene et al., 2001). Reviews of moral neuroimaging evidence have also suggested that ToM is a key cognitive input to moral decisions because ToM brain regions show increased activation when making moral judgements (Blair et al., 2006; Young & Dungan, 2012). However, this conclusion may have been overstated, because most neuroimaging experiments utilise ME tasks, where participants are asked to evaluate the actions of *others.* So while ToM is likely to be involved in judging the moral permissibility or appropriateness of others' actions, it remains to be seen whether ToM brain regions are as active when making one's own moral response decisions.

Two recent meta-analyses of brain activation in moral decision-making studies are Bzdok et al. (2012) and Sevinc and Spreng (2014). Bzdok et al (2012) performed an ALE analysis of morality, empathy and ToM and found overlap in activation for ToM and morality. Experiments were only included in the 'moral cognition' domain, which they defined as a "reflection of the social appropriateness of people's actions" (p. 789) if the task required participants to make judgements of other people's actions. It is, therefore, not surprising that there was overlap with ToM brain activation, as ME tasks require thinking in the third person to evaluate the actions of others, which may include inferring the intentions of others in order to judge the permissibility of their actions. It remains to be investigated whether such an overlap with ToM regions would occur for MRD tasks. Sevinc and Spreng's (2014) systematic review of brain processes underlying moral cognition found increased activation in the default mode network, a network which is typically most active during a resting state but does show increased activation for some tasks (Greicius, Krasnow, Reiss, & Menon, 2003). They compared brain activity for active vs. passive judgements and found that active judgements showed more activity in the TPJ, angular gyrus, and temporal pole compared to passive viewing. However,

within the active domain, they did not distinguish between MRDs and MEs, so it still remains to be investigated whether brain activity differs between these two types of moral decisions.

4.3 Aims

The aims of the current systematic review and meta-analysis were twofold: (a) to investigate which brain areas are consistently show increased activation when making (i) MRDs, or (ii) making MEs compared to non-moral or neutral decisions or evaluations; and (b) to compare brain activation patterns for these two types of moral decisions, to determine shared or significant differences in brain activation. A quality assessment of the included experiments was also undertaken, something which is often omitted from ALE reviews.

All neuroimaging experiments of any type of moral decision-making were systematically searched and retrieved. Eligible experiments were categorised as either response decisions, or evaluations. ALE analysis was used to assess brain areas significantly more activated for both types of moral decisions, while conjunction and contrast analyses were performed to determine areas of significant difference. This allowed for the potential discrepancy in brain activation between task-type to be considered.

4.4 Method

4.4.1 Search strategy. A systematic search was conducted to identify all neuroimaging experiments of moral decision-making. Three databases, PubMed, PsycInfo and Web of Science were searched up to March 2015 using the terms "Moral" AND "Neuroimag* OR neural OR fMRI OR functional magnetic resonance OR PET OR positron emission tomography OR MEG OR magnetoencephalography OR brain". Where the database allowed, results were limited to humans, English language and full text articles (excluding letters, editorials etc.). This search returned 3563 results (2521 after duplicates removed) which were exported to EndNote X7. A title screen was performed to remove those obviously irrelevant, followed by an abstract screen (see Figure 4.1 for PRISMA flowchart). One hundred and twenty-one references remained for full text screening, which was performed based on the eligibility criteria (Table 4.1). Reference lists of related systematic reviews (Bzdok et al., 2012; Sevinc & Spreng, 2014) were also screened for additional references. The initial search, title and abstract screen was carried out by

the researcher. Full text screening was carried out by the researcher and their primary supervisor independently and decisions were compared. Where there was a disagreement, these were discussed with reference to the inclusion criteria and a joint decision was reached.
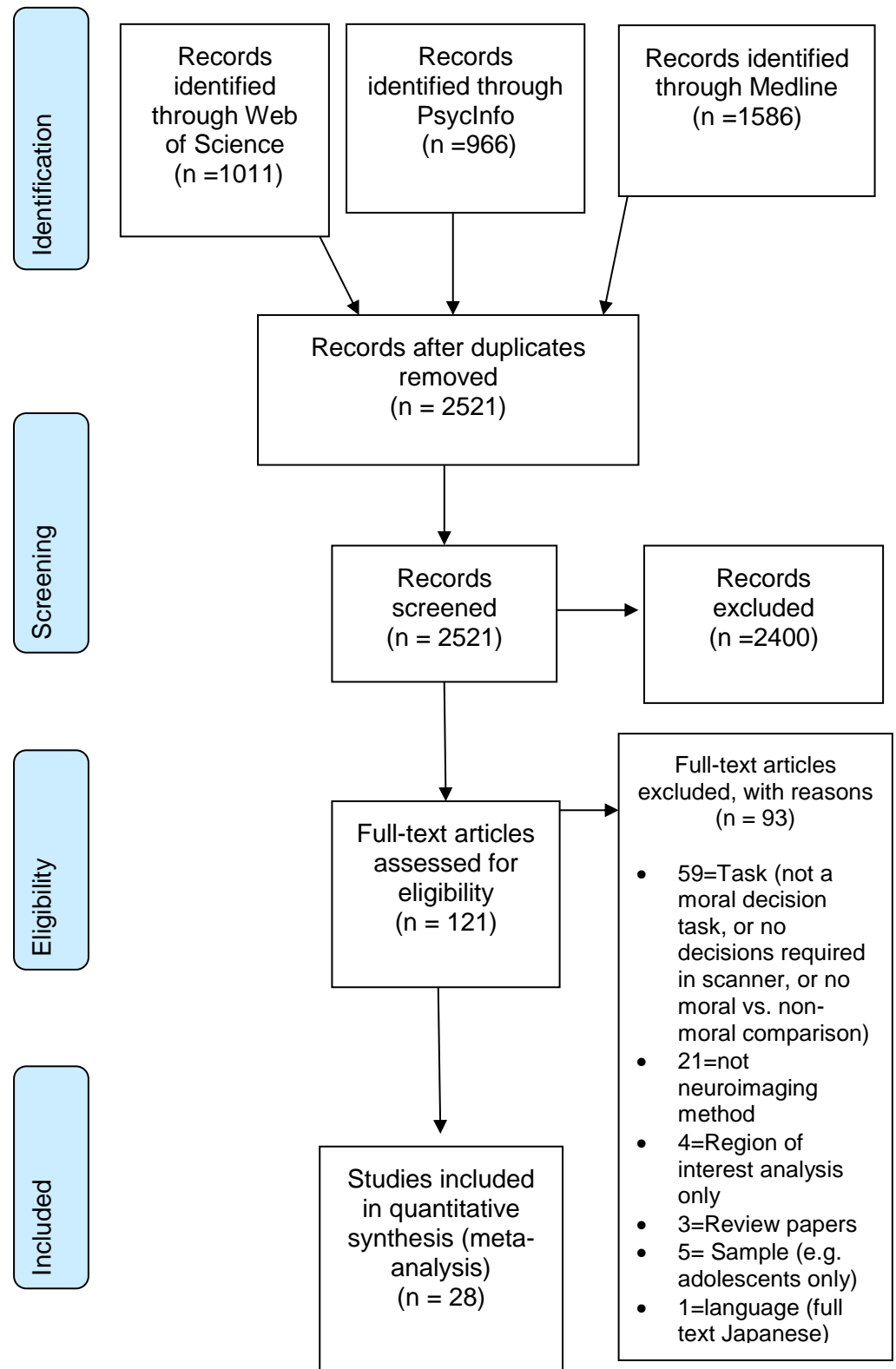
Figure 4.1 PRISMA flowchart (From Moher, Liberaiti, Tetzlaff & Altman, 2009)

Table 4.1 Eligibility criteria for experiments

Inclusion criteria	Exclusion criteria
Moral decision-making task with active decision required (response decision or evaluation)	Not moral task, or passive moral task (e.g. just viewing moral stimuli with no decision required)
Neuroimaging method	No neuroimaging method used
Talairach or MNI coordinates reported for whole brain analysis	No coordinates reported, or region of interest analysis only
Moral task activation compared to non-moral or neutral task activation	No control task, or no moral vs. non-moral/neutral comparison coordinates reported
Typical/healthy adult subjects. (If experiment also includes non-typical participants, data for comparison group must be reported separately)	Subjects with developmental or neurological disorder, psychopathy, drug dependency or children/adolescents (can include if comparison group/adult data reported separately)
English language paper	Not English language

Data extraction was performed for the included experiments. Details of task type and description were extracted, along with relevant foci co-ordinates for the ALE analysis. Experiments were either categorised as MRDs or MEs based on task design. Coordinates of moral vs. non-moral/neutral conditions were extracted into an Excel file and any coordinates reported in Montreal Neurological Institute (MNI) space were converted to Talairach using the icbm2tal transformation in GingerALE 2.3.6 (Laird et al., 2010; Lancaster et al., 2007). Where an experiment did fit the inclusions criteria but did not report coordinates of moral vs. non-moral/neutral conditions, the main author was contacted via email to request these data. If there was no response after three weeks, the experiment was excluded due to lack of appropriate data to extract for ALE analysis. Where an experiment included a sample of non-typically developing adults, it was only included if coordinates for the comparison group were presented separately, and only these data were extracted for analysis. For some experiments, there was more than one moral condition (e.g., moral personal and moral impersonal) and these were collapsed together to make moral vs. non-moral for extraction purposes. Where there was more than one comparison condition to a moral condition, data were extracted for moral vs. the most neutral condition (i.e., if there was a non-moral and a neutral condition, the

moral vs. neutral comparison was extracted). Different experiments had different thresholds for significant clusters, but for each experiment, coordinates were extracted for moral vs. non-moral or neutral if they met the whole brain threshold set by the authors. In some papers, authors reported coordinates under the threshold because they related to an a priori hypothesis or region of interest; these coordinates were not extracted for the meta-analysis.

A quality assessment tool was developed by the researcher and their primary supervisor, based on guidelines for reporting an fMRI study (Poldrack, Fletcher, Henson, Worsley, Brett, & Nichols, 2008), using a binary scale: 1= evidence reported, 0= no evidence reported/unclear/not explicit (see Appendix A). Experiments scoring 0-10 were classed as low quality, 11-20 classed as medium quality and 21-30 classed as high quality. The researcher performed quality assessment for all included experiments and the primary supervisor performed quality assessment on 20% of included experiments independently.

4.5 Analysis

ALE analysis is a commonly used method for coordinate based meta-analysis. This method assesses the patterns of activation foci reported in different experiments, to establish where in the brain convergence is higher than would be expected if foci were normally distributed throughout the brain (Eickhoff, Bzdok, Laird, Kurth, & Fox, 2012; Eickhoff, Laird, Grefkes, Wang, Zilles, & Fox, 2009; Turkeltaub, Eickhoff, Laird, Fox, Wiener, & Fox, 2012), taking sample sizes of experiments into account. ALE analysis was performed using GingerALE 2.3.6 on the x, y, z coordinates of moral vs. non-moral or neutral conditions. Firstly, ALE analysis was performed for all ME experiments and then for all MRD experiments. A conjunction analysis was then performed to find shared brain activation for ME and MRD decisions. Contrast analyses were performed to assess differences in brain activation (MRD-ME and ME-MRD).

Conjunction analysis comparing the results of the present ALE to results from recent ALE systematic reviews was not possible without knowledge of exactly which foci had been extracted for each included experiment of previous reviews, and was also not practical due to differences in inclusion and exclusion criteria. The results of the present ALE were instead compared visually with results from two recent reviews (Bzdok et al., 2012; Sevinc & Spreng, 2014) where appropriate, and

outlined in the discussion. Results from these previous reviews were reported in MNI coordinates, so for an easier comparison with the results of the current review, their reported coordinates were transformed to Talairach coordinates using the using the icbm2tal transformation in GingerALE 2.3.6 (Laird et al., 2010; Lancaster et al., 2007) and then areas were labelled using Talairach client (Lancaster et al., 1997; Lancaster et al., 2000).

4.6 Results

4.6.1 Significant clusters of activation. After full text screening, 28 separate experiments were eligible for inclusion, with a total of 271 foci from 642 participants. All experiments used fMRI, 10 used a MRD task and 18 used a ME task. Table 3.1 displays the main characteristics of the included experiments.

ALE analysis was performed for all ME experiments and all MRD experiments, *cluster-level* = .05, 1000 *permutations*, *p* = .001. Conjunction and contrast analyses were then performed, *p* = .01, 1000 *permutations*, *minimum cluster* = 200mm³, to assess shared and divergent brain activation between the two task types. Table 4.3 shows the results of the ALE analysis, and Figure 4.2 shows the largest significant clusters of brain activation found for each ALE analysis. All coordinates are reported in Talairach space.

Four significant clusters of activation were found across the ME experiments (18 experiments, 174 foci, 383 participants): the left medial frontal gyrus (MFG), the left and right superior temporal gyrus (STG) and the left cingulate gyrus (CG). Four significant clusters were found across the MRD experiments (10 experiments, 97 foci, 259 participants): the left and right middle temporal gyrus (MTG), left precuneus and the right MFG. Conjunction analysis revealed three clusters of shared activation for both moral task types: the left MTG, left CG and left MFG. A contrast analysis of MEs-MRDs did not find any significant clusters. However, a contrast analysis of MRDs-MEs found three significant clusters: the right MTG, right precuneus, and left MTG.

Table 4.2. Characteristics of included experiments

Reference	Subjects	Conditions	No. foci	Moral stimuli	Moral task instructions/response format
Moral response decisions					
Borg et al. (2006)	24	Moral vs. non-moral	7	Written moral scenarios	Yes/No button press to "Is it wrong to do it ?" and "Would you do it?" after each scenario
Chiong et al. (2013)	16	Moral personal vs. non-moral	3	Modified Greene (2001) dilemmas presented as written text and also audible narration	Yes/No button press to "Would you do X in order to X?" after each dilemma
FeldmanHall et al (2014)	38	Moral (difficult and easy) vs. non-moral (difficult and easy)	10	Written moral scenarios	Yes/No button press to "Do you do (proposed response)?" after each scenario
Han et al (2014)	16	Moral (personal and impersonal) vs. neutral	28	Modified Greene et al (2001) dilemmas, moral-personal and moral-impersonal, presented as text	Yes/no button press to "Is it appropriate for you to do (proposed solution)?"
Harrison et al (2012)	73	Moral vs. nondilemma	11	Vignettes of modified Greene et al (2001) dilemmas. Participants familiarised with vignettes within 1 week of scanning session using illustrations and examiner-read descriptions. Voice-prompts in scanner.	Yes/no finger raise to "Would you do X?" after each dilemma
Pujol et al (2012)	22	Moral vs. nondilemma	14	As Harrison et al 2012	As Harrison et al 2012

Table 4.2 Continued. Characteristics of included experiments

Schneider et al (2012)	28	Moral vs. baseline	4	Written moral dilemmas. Social-ethical dilemmas and individual gain vs. collective losses	Agree or disagree with proposed solution using button press after each dilemma
Sommer et al (2010)	12	Moral vs. neutral	6	Written stories describing moral conflict	"What should I do?" Choose between two response alternatives after each dilemma with a button press
Sommer et al (2014)	16	Moral vs. social	6	As Sommer et al 2010	As Sommer et al 2010
Verdejo-Garcia et al (2014)	14	Moral vs. nondilemma	8	As Harrison et al 2012	As Harrison et al 2012

Moral evaluations

Avram et al (2013)	16	Moral vs. esthetic	8	Written moral statements	Decide whether each moral statement could be considered 'right' by pressing button
Avram et al (2014)	16	Moral (1st and 3rd person) vs. non-moral	10	Written moral statements	Rate each statement as 'right' or 'wrong' using button press
Bahnemann et al (2010)	25	Moral vs. physical	10	Animated stimuli of two people in a social interaction. Protagonist's behaviour was either in accordance with or in violation of a social norm	Yes/no button press to "Is the protagonist violating a norm?" after each moral dilemma
De Achával et al (2013)	13	Moral vs. non-moral	6	Modified version of Moral Dilemmas Test (Greene et al, 2001) presented as text	Yes/ no button press to "Would you consider it appropriate to….?" after each dilemma

Table 4.2 Continued. Characteristics of included experiments

Harada et al (2009)	18	Moral vs. gender judgement	9	Written stories of protagonist performing good or bad deed	Yes/no button press to "Is the protagonist's behaviour morally bad?"
Harenski et al (2008)	28	Moral vs. non-moral	15	Moral pictures from IAPS and media, depicting unpleasant social scenes indicating a moral violation	Determine if the picture represented a moral violation and rate the severity of the violation on scale of 1-5 using button press to stop rating bar
Harenski et al (2012)	36	Moral vs. neutral	7	Moral pictures from IAPS and media, depicting unpleasant social scenes indicating a moral violation	Rate moral violation severity of picture on scale of 1-5 using button press to stop rating bar
Harenski et al (2014)	46	Moral vs. neutral	23	Moral pictures from IAPS and media, depicting unpleasant social scenes indicating a moral violation	Rate severity of moral transgression in pictures from 1-5 using button press to stop rating bar
Heekeren et al (2003)	8	Moral vs. semantic	9	Written sentences (German)	Judge whether actions described in sentences were "appropriate" or "inappropriate" with button press
Heekeren et al (2005)	12	Moral vs. semantic	8	Written sentences (German)containing bodily harm or not	Judge if actions described in moral sentences were "appropriate" or "inappropriate" with button press
Moll et al (2001)	10	Moral vs. factual	10	Moral sentences presented aurally	Think about each statement and judge whether they are 'right' or 'wrong'. No overt judgement in scanner
Moll et al (2002)	7	Moral vs. non-moral neutral	2	Written moral statements	Covertly judge each sentence as 'right' or 'wrong'. No overt judgement in scanner
Parkinson et al (2011)	30	Moral (harmful, dishonest and disgust) vs. neutral	30	Written moral scenarios	Decide if main character's actions were 'wrong' or 'not wrong' with button press

Table 4.2 Continued. Characteristics of included experiments

Prehn et al (2008)	23	Socio-normative vs. grammatical	6	Written sentences	Decide if action described was a social norm violation or not with yes/no button press
Reniers et al (2012)	24	Moral vs. non-moral	6	Written scenarios of moral decision-making	Yes/no to "Is it ok for X to do this?" using button press
Robertson et al (2007)	16	Moral (care/justice) vs. neutral nonmoral	5	Written business case scenario describing workday of a fictional marketing research analyst	Press button when identify an important point or issue
Schleim et al (2011)	40	Moral vs. personal	6	Written stories adapted from moral issues in media	Had to judge if behaviour in stories was right from a moral point of view. Decide between 'yes, rightly' and 'no, not rightly' using button press
Takahashi et al (2008)	15	Moral (beauty and depravity) vs. neutral	4	Written sentences (Japanese)	Read sentences silently and rate according to how moral/immoral or praiseworthy/blameworthy the events were (no overt judgement in scanner)

Note. Number of subjects is the number included in the analysis that was extracted for this review (e.g., number of subjects in control group sample) not necessarily the total number of subjects in the experiment. The coordinates for the control group in Harenski et al. (2014) were sent by main author after an email request.

Table 4.3. Significant clusters of activation for moral evaluations, moral response decisions, and conjunction and convergence analysis.

	#	Volume (mm^3)	X	y	z	Cerebrum	Label	Brodmann area
Moral evaluations	1	3296	-6	44	20	Left	MFG	9
	2	2176	-44	-56	18	Left	STG	39
	3	2024	-2	-56	26	Left	CG	31
	4	744	50	6	-20	Right	STG	38
Moral response decisions	1	1968	-44	-64	20	Left	MTG	39
	2	1928	-2	-60	30	Left	Precuneus	7
	3	1512	2	44	36	Right	MFG	6
	4	1248	44	-60	24	Right	MTG	39
Conjunction of moral evaluations and moral response decisions	1	712	-44	-60	18	Left	MTG	19
	2	680	-2	-56	28	Left	CG	31
	3	312	-6	44	40	Left	MFG	8
Moral response decisions-moral evaluations	1	896	42.9	-56.9	23.4	Right	MTG	39
	2	328	2	-61	31	Right	Precuneus	7
	3	280	-39	-64.5	16.5	Left	MTG	39

Note. X, y, z coordinates are reported in Talairach space and refer to the maximum value of each cluster. Moral evaluation and moral response decision ALE analyses performed using cluster-level=.05, 1000 permutations, p=.001. Conjunction and contrast analysis performed using p=.01, 1000 permutations, minimum volume=200mm³. Labels and Brodmann areas generated by GingerALE 2.3.6. MFG=medial frontal gyrus, STG=superior temporal gyrus, CG=Cingulate gyrus, MTG=middle temporal gyrus.
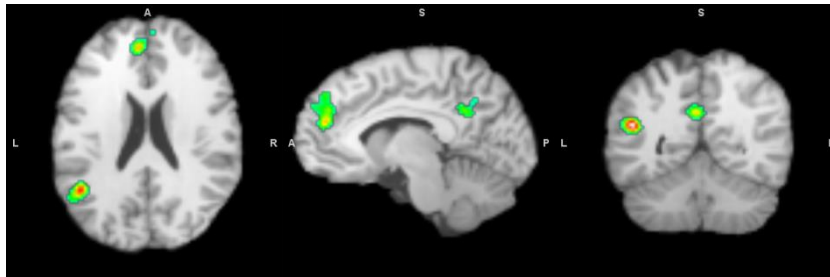
Moral evaluation clusters
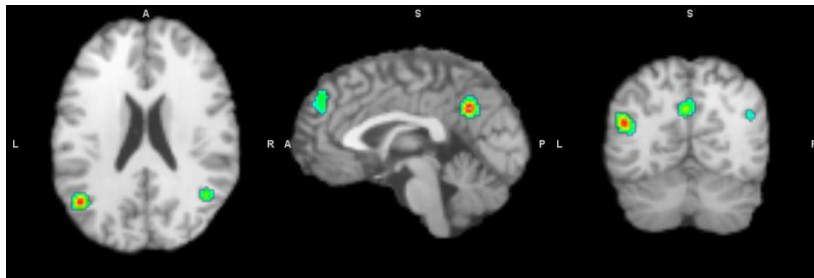
Moral response decision clusters
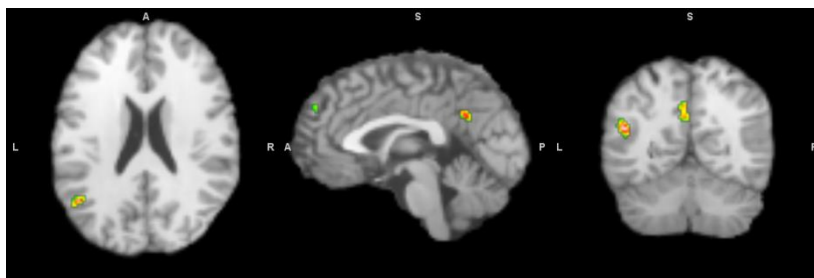
Conjunction analysis: Shared activation for moral evaluation and moral response decisions

Contrast analysis: Moral response decisions-moral evaluations

Figure 4.2 Brain activation maps showing significant clusters of activation

*Note.*Images created in GingerALE 2.3.6, overlaid onto Colin 2x2x2 template in Mango (Lancaster & Martinez, Copyright 2006-2015).Brain images are axial, sagittal and coronal view of main clusters of activation for each ALE analysis. Image labels: L=left, R=right, P=posterior, A=anterior, S=superior.

It was hypothesised that MRDs would show increased activation in self-referential brain areas. This was supported, as relative to MEs, MRDs showed increased activation in the precuneus which is a brain region more highly developed in humans than other animals and involved in higher order cognitive processes including self-processing and consciousness (Cavanna & Trimble, 2006) and egocentric spatial processing (Freton, Lemogne, Bergouignan, Delaveau, Lehéricy, & Fossati, 2014). It was also hypothesised that the ME tasks would be associated with increased activation of more ToM related areas than MRD tasks, as they involve thinking about the mental states of other people in order to judge moral behaviour. This hypothesis was not supported, as the contrast analysis for MEs-MRDs did not reveal any significant clusters. The right temporoparietal junction (rTPJ) has been suggested as an area important for ToM (Saxe & Powell, 2006). The rTPJ is a vaguely defined area but is also referred to as Brodmann area (BA) 39 (Bzdok et al., 2013). Contrary to the hypothesis, the ALE analysis revealed that the rTPJ (BA 39, MTG) showed significantly increased activation across the MRD tasks (cluster 4) but not across the ME tasks. The surprising finding of significant activation of this area for MRDs but not MEs suggests that ToM processes are even more involved when making one's own moral decisions than when making evaluations of others. One explanation may be that when thinking about what to do in a moral dilemma, individuals think about the consequences of their possible actions for others, e.g. "would my actions upset/harm someone?"

4.6.2 Comparison with previous meta-analyses. The findings from the present meta-analysis were compared to those of two recent systematic reviews of moral decision-making, Bzdok et al. (2012) and Sevinc and Spreng (2014). As previously stated, the criteria for Bzdok et al.'s (2012) moral cognition domain was that participants were required to make appropriateness judgements, which is what the current review termed moral evaluations. The ALE analysis results for MEs in the current review were compared to Bzdok et al.'s (2012) results for the moral cognition domain. The ME results are somewhat comparable to Bzdok et al.'s (2012); both revealed a significant cluster in the right STG (BA 38, labelled by Bzdok et al. as the right temporal pole). However, their results showed significant clusters of activation in both the left and right MFG, whereas the current analysis only revealed a significant cluster in the left MFG, BA 9. In line with Bzdok et al.'s (2012) analysis, the current review found a cluster of activation in the left STG (labelled by Bzdok et al. as left TPJ). This cluster was BA 39 in the current analysis and BA 22 in Bzdok et al (2012), although these are adjacent areas. As previously

stated, Bzdok et al. (2012) found a cluster of activation in the rTPJ (BA 39), which the current review did not find. Another discrepancy between the ME activation clusters found here, and Bzdok et al.'s (2012) for moral cognition are that they found a cluster of activation in the left amygdala, which the current review did not find. Also, Bzdok et al. (2012) reported activation in the precuneus, which was not found to be a cluster of significant activation for the ME experiments in the current analysis, although results did reveal activation in the adjacent cingulate gyrus. Differences between the current review and Bzdok et al.'s (2012) may be partly due to discrepancies between Talairach labels and the SPM anatomy toolbox, and also due to the differences of tasks for the included experiments; Bzdok et al. (2012) included only experiments where participants were required to make appropriateness judgements on the actions of one individual towards others while the current review included any ME judgement, including tasks where participants had to judge moral sentences. The ALE analysis results for MRDs are not comparable with Bzdok et al.'s (2012) moral cognition results, supporting the finding that judging the appropriateness of others actions increases activation of different brain regions compared to when making one's own moral response decisions.

Sevinc and Spreng's (2014) systematic review compared brain activation for active and passive moral tasks. As the current review only included tasks that required an active decision, findings for MRDs and MEs were compared to Sevinc and Spreng's (2014) findings for active tasks. ALE results for MEs are fairly comparable to Sevinc and Spreng's (2014) ALE results for active tasks, with both finding clusters of activation in the left MFG (BA 9, labelled by Sevinc & Spreng as medial PFC and anterior superior frontal sulcus), right STG (BA 38, labelled by Sevinc & Spreng as MTG) and the left cingulate gyrus (BA 31, labelled by Sevinc & Spreng as posterior cingulate cortex). Comparing results for MRDs to Sevinc and Spreng's (2014) active results, there is no direct overlap but there are some similarities. Sevinc and Spreng (2014) found a cluster of activation in the left MTG, BA 22, whereas the ALE analysis for MRDs in the current review revealed a cluster in the left MTG BA 39, adjacent to BA 22. Again, differences may be due to discrepancies between Talairach and MNI labelling and also differences between tasks of the included experiments. For Sevinc and Spreng's (2014) active domain, four of the included experiments were also included in the MRD domain, but the current review included an additional six MRD experiments, and the majority of the active experiments in Sevinc and Spreng (2014) were MEs.

4.6.3 Quality assessment. Quality assessment indicated that 20 experiments were high quality, eight were medium quality and none were low quality (see Appendix B). The medium quality experiments did not report as much information as the high quality experiments. Analyses included all experiments regardless of quality, but issues regarding the quality of included experiments are outlined in the discussion and should be taken into consideration when interpreting the results. Agreement between the researcher and their primary supervisor for quality assessment was $k=1$ ($p=.14$), ICC$=.88$ ($p=.005$). As far as the researcher is aware, this review is the first ALE meta-analysis to report on the quality of included experiments. In the absence of a pre-existing standardised quality assessment tool for an ALE systematic review, the quality assessment tool was adapted from guidelines for reporting fMRI studies (Poldrack et al., 2008). Future reviews could use this checklist, or similar quality assessment tools, and should exclude low quality experiments from ALE analysis. While the majority of included experiments in this systematic review were found to be of high quality, based on the adapted checklist, there were issues with some of the tasks used.

4.7 Summary

This systematic review and meta-analysis builds on previous reviews in the field by differentiating between MRD's and ME's, to assess similarities and differences in patterns of brain activation between these two types of moral decisions. The ALE analyses found three significant clusters of shared brain activation for both task types: the left MTG, CG and MFG. Contrast analysis revealed that MRDs additionally activated the right MTG, right precuneus and left MTG. These findings show that making one's own moral decisions about what to do in a moral dilemma is associated with increased activation of additional brain areas, suggesting that different processes are involved.

The brain region which has been most commonly implicated in moral decision-making, based on neuroimaging and lesion studies is the vmPFC. This region is not precisely defined in the literature but usually refers to any brain areas in the ventromedial frontal lobe, and BA's 10, 11, 24, 25 and 32 (Nieuwenhuis & Takashima, 2011). The current meta-analysis only found one significant cluster of activation in this region for MEs, (MFG, BA 9) adjacent to the regions commonly referred to as the vmPFC, and found no significant clusters of activation of the vmPFC for MRDs. The lack of a significant cluster of activation in the vmPFC for MRDs highlights that most previous conclusions about brain activation for moral

decision-making have been made based on ME tasks; further research on the involvement of this region for MRDs is needed, as the current review only identified 10 relevant MRD experiments. Further neuroimaging studies employing MRD tasks of real life scenarios are needed before strong conclusions can be made about which brain areas are involved when making one's own, every day MRDs. Developmental neuroimaging studies can help to understand how different brain regions and networks may be activated at different ages when making moral decisions, which could also help to expand on the 'brain development' component of the SIP-MDM framework. In addition to further social neuroscience research, developmental psychology research could explore whether reasoning maturity in relation to different moral values, such as life and justice, correlates with reasoning maturity about response decisions made in hypothetical moral dilemmas, i.e. do people apply their understanding and appreciation of moral values to their own decision-making?

Part Three: Moral development in typically developing adolescents and adolescents with acquired brain injuries

Chapter 5: Study 1: Investigating hypotheses of the SIP-MDM framework in typically developing adolescents

5.1 Rationale

Within this thesis, it is proposed that moral decision-making is a complex process, involving many different component skills and processes that develop with age. The current study aimed to measure multiple components of the SIP-MDM framework in TD adolescents (age 11-18 years) to explore how these components develop with age and investigate relationships between components in order to test some of the hypotheses generated by the SIP-MDM framework. Findings from the current study may either provide some initial support for the framework, or evidence that the framework may need to be reformulated.

Although theory and research has suggested various skills and processes are required for moral development, studies do not tend to measure these possible determinants of moral development simultaneously. For example, while perspective taking is the component process most frequently theorised to be involved in moral development, there is not a wealth of research exploring the developmental relationships between perspective taking and moral decision-making. Study 1 firstly aimed to address this by measuring moral reasoning alongside cognitive and affective processes such as working memory and perspective taking, in order to explore relationships between development of these processes and moral reasoning maturity. In terms of links between moral reasoning and behaviour, while there is evidence of delayed moral reasoning in offender populations (Nelson et al., 1990; Stams et al., 2006) there is limited evidence of a link between moral reasoning level and behaviour in TD populations. Based on the SIP-MDM framework, a relationship between moral reasoning and behaviour would be expected, although mature moral reasoning does not necessarily lead to prosocial behaviour. Another aim of Study 1 was to explore whether moral reasoning maturity was related to self and parent reported behaviour in a sample of TD adolescents.

The SIP-MDM framework outlined in Chapter 3 proposed six steps that occur when making a moral decision. At each step, certain component skills and process are suggested to be involved, for example, emotion recognition is proposed to be important for Step 1, encoding. Some cognitive and affective processes have previously been measured alongside SIP skills, concluding that emotion recognition and interpretation are particularly important for predicting SIP skills (van

Nieuwenhuijzen & Vriens, 2012). However, these relationships have so far only been tested in children with intellectual disabilities and remain to be explored for TD adolescents. SIP theory has previously been integrated with moral theory (Arsenio & Lemerise, 2004) and SIP skills have been hypothesised to be related to moral development (Palmer, 2000) but there is a lack of research investigating the relationship between SIP skills and moral reasoning maturity.

A further aim of Study 1 was to explore relationships between the components and steps of the framework, to explore whether the components proposed to be involved at each step relate to proficiency at that SIP step. For example, do higher empathy scores relate to more prosocial goals being selected at Step 3? Additionally, the SIP-MDM framework proposed that components in the centre can affect all steps of SIP, so relationships between components in the centre and SIP skills were also explored. The SIP-MDM framework proposed that all components develop with age, facilitating more efficient processing and increasing the capacity for more mature moral decision-making. For example, increases in attention and working memory can aid encoding and interpretation, and development of perspective taking abilities can allow for the feelings of other people to be taken into account, and may therefore result in more prosocial goals being selected. The current study therefore also aimed to measure whether SIP skills mature with age in a sample of TD adolescents.

5.2 Hypotheses

5.2.1 Moral reasoning, cognitive and affective processes and behaviour. It was hypothesised that:

1. Moral reasoning, empathy, perspective taking, working memory and emotion recognition will all correlate positively with age.
2. There will be significant positive relationships between moral reasoning and: empathy, perspective taking, working memory and emotion recognition.
3. The cognitive and affective processes of empathy, perspective taking, working memory and emotion recognition will predict moral reasoning level.
4. Moral reasoning will show a significant negative relationship with self and parent-reported behavioural difficulties.

5.2.2 Steps of the SIP-MDM framework. It was hypothesised that:

5. SIP steps will correlate positively with age. Older participants will score more highly on SIP encoding and interpretation variables, and will select more prosocial goals, generate more prosocial response options and make more prosocial decisions.

Components in the centre of the SIP-MDM framework are hypothesised to influence processing that occurs at each step of the framework. The components in the centre of the framework which were measured for this study were perspective taking, working memory, moral reasoning (as a measure of moral schemas, rules and principles), current mood (positive and negative affect), and SES. It was hypothesised that:

6. There will be significant relationships between all SIP steps and perspective taking, working memory, moral reasoning, current mood and SES.

In addition to the relationships between SIP steps and components in the centre of the SIP-MDM framework, it was hypothesised that there would be significant relationships between SIP steps and components listed under each step. It was hypothesised that:

7. There will be significant relationships between emotion recognition and encoding (Step 1).
8. There will be a significant relationship between empathy and goal generation, with a positive relationship between empathy and prosocial goal generation, and a negative relationship between empathy and antisocial goal generation (Step 3).
9. There will be a significant relationship between empathy and response decisions, with a positive relationship between empathy and prosocial response decision, and a negative relationship between empathy and antisocial response decision (Step 5).
10. SIP steps will be predicted by relevant variables at each step, including variables in the centre of the SIP-MDM framework.

In addition to these hypotheses, exploratory analyses will also be conducted to explore the effect of gender on key variables and on relationships between variables, as gender differences have been found for the development of cognitive skills (Van der Graaff et al., 2014) and there are sex differences in brain development (Giedd et al., 2006; Giedd et al., 1996; Lenroot & Giedd, 2010). If

appropriate, age will be broken down into age groups in order to explore whether the younger adolescents significantly differ from older adolescents on key variables.

5.3 Methods

5.3.1 Participants. Eighty TD participants, aged 11-18 years old (M age=14.05, SD=2.25, 31 Male, 49 Female) were recruited from schools and colleges in Norwich and Devon, and through advertisements at the University of East Anglia. Eligibility criteria are presented in Table 5.1.

Table 5.1 Eligibility criteria for sample

Inclusion criteria	Exclusion criteria
Age 11-18	Outside of age range
Typically developing	Diagnosis of developmental disability or brain injury
Capacity to provide consent/assent	Lack of capacity to consent/assent
English speaking	Non-English speaking

The required sample size was calculated using GPower3 (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007), with 1-$β$=.80 and $α$=.05. Calculations were hypothesis driven, with estimations based on previous research and theoretical assumptions. The largest sample size from these calculations was 72, which was rounded to 80.

5.3.2 Recruitment. Participants were recruited from schools and colleges in Norwich (Open Academy, n=36) and Devon (Coombeshead Academy, n=26 and Exmouth Community College, n=6), and through advertisements at the University of East Anglia (n=12). All participants were entered into a prize draw, with 20 prizes of £20 vouchers. Winners were selected using a random number generator at the end of the study. Winners of the prize draw were given a choice of either a £20 Amazon, Tesco's or iTunes voucher.

For school recruitment, the researcher summarised the study at a school assembly and students who were interested took letters home to their parents. The parent letters invited their child to take part in the study and included relevant information sheets. If parents or caregivers wanted their child to take part in the study they could return a signed consent form to the child's school. Those with parental consent were then seen for the study sessions during the school day. Sixth

form students were invited to take part at an assembly, with interested students emailing the researcher, or providing the researcher with their school email address. Participant information sheets for over 16 year olds were provided for sixth form students. The study was also advertised at the University of East Anglia, through staff bulletins, and the researcher presenting details of the study at a summer school, where interested students could take letters home to their parents.

      5.3.3 Design and procedure. This study made use of a cross-sectional design using a convenience sample. All participants completed a test battery containing all of the measures. The test battery was completed in a one-to-one session with the researcher, either at the participant's school, their home or at the University of East Anglia. The testing sessions took about 1.5 hours to complete, though this was two hours for some younger participants. Where necessary, or appropriate, the testing session was split into two sessions, with the second half usually completed the following day.

      An undergraduate psychology intern from the University of Exeter assisted with some of the testing sessions in Devon, to increase the number of participants that could be seen for the study during a school day. The intern was recruited by the researcher's secondary supervisor and was trained on the protocol by the researcher. The intern administered part of the test battery (digit span, emotion recognition task, participant booklet, animated triangles task). Some participants (n=9) were also part of another study (see Chapter 6); where there was an overlap of measures, participants only completed these once and the same score was used for both studies (for the SRM-SF, the score from Time 1 of the linked study was used for the current study). The SRM-SF responses were scored by the researcher after completing self-training using the manual (Gibbs et al., 1992) and 20% of the SRM-SFs (n=16) were also scored by the researcher's primary supervisor for inter-rater reliability. Results indicated excellent agreement between raters with respect to total score (ICC =.95).

5.4 Ethical considerations.

      This study received a favourable ethical opinion from the University of East Anglia ethics committee (see Appendix C). Consent was sought from the Head teacher of the schools and colleges involved. Consent was obtained for all participants and they were made aware that they could withdraw from the study at any time. All participants provided informed consent to take part in this study, while

parental consent was additionally sought for those under the age of 16 years. The participant information sheets and consent forms for those under age 16 used simpler language. All testing sessions were on a one-to-one basis with the researcher who was able to look out for signs of fatigue and offer breaks where necessary. No questions asked in this study were expected to cause distress but a disclosure sentence was added to the information sheets and consent forms, making participants aware that if they disclosed any information suggesting they were at risk of harm, the researcher may have to pass this information onto relevant people. The PANAS presented in the participant booklet for the current study asked participants to rate how much they were currently feeling different emotions, including 'distressed' 'upset' and 'afraid'. The researcher checked completed PANAS scales during the testing session, to see whether a participant had ticked that they were feeling these emotions 'quite a bit', or 'extremely', to be dealt with on a case-by-case basis with advice from the researcher's supervisors. All participants were debriefed after the study and provided with the researcher's contact details.

5.5 Measures

     5.5.1 Moral reasoning. Moral reasoning was assessed using the SRM-SF (Gibbs et al., 1992). The SRM-SF is a widely used moral reasoning instrument in developmental psychology and has been shown to have excellent levels of test-retest reliability (.88) and internal consistency (.92) (Gibbs et al., 1992). The SRM-SF (Gibbs et al, 1992) measures reasoning in the sociomoral constructs of contract, truth, affiliation, life, property, law and legal justice. The SRM-SF consists of eleven short-answer items that address sociomoral values such as keeping a promise and saving a life, e.g. "Think about a time when you've made a promise to a friend of yours. How important is it for people to keep promises, if they can, to friends?" Participants choose between very important, important or not important and are then asked "why is it very important/important/not important?" Participants gave their answers orally and these were audio-recorded by the researcher. Responses to the "why" questions were scored using a reference manual which assesses the developmental level of reasoning (Gibbs et al, 1992). Scoring the SRM-SFs requires around 30 hours of self-training and completion of practice questions (Gibbs et al, 1992). At least seven of the eleven questions must have scorable answers in order for the SRM-SF to be reliably scored. Each answer is given a value between 1 and 4 (or U for unscorable) using the reference manual; all scorable answers are then

summed, and a mean calculated. The mean score is multiplied by 100 to give a score out of 100-400, related to a global moral stage (see Table 5.2).

Table 5.2. SMR-SF scores in relation to global moral stage

SRM-SF score	Global stage	Global stage description
The immature level		
100-125	Stage 1	Unilateral and physicalistic: Justifications based on unilateral authority, especially physical power, and absolute rules
126-149	Transition 1(2)	
150-174	Transition 2 (1)	
175-225	Stage 2	Exchanging and instrumental: Justifications based on pragmatic deals or exchanges
226-249	Transition 2 (3)	
250-274	Transition 3 (2)	
The mature level		
275-325	Stage 3	Mutual and prosocial: Justifications based on prosocial understanding of caring and conduct, including empathic role-taking, and appeals to mutual sentiments in relationships.
326-349	Transition 3 (4)	
350-374	Transition 4 (3)	
375-400	Stage 4	Systemic and standard: Justifications based on societal requirements and responsibilities, and basic rights or values.

Note. From Gibbs et al (1992).

5.5.2 Empathy. The Index of Empathy for Children and Adolescents (IECA; Bryant, 1992) was used as a self-report measure of empathy. This questionnaire was developed to assess affective empathy in children aged 6 years and over. For 12/13 year olds the measure has good internal consistency (.79) and test-retest reliability (.83) (Bryant, 1992). The IECA has 22 items requiring a 'Yes' or 'No' response, such as "I get upset when I see a girl being hurt" and takes around 5

minutes to complete. The IECA was administered as part of a pen and paper participant booklet.

5.5.3 Perspective taking. Perspective taking was measured using the animated triangles task (Abell, Happe, & Frith, 2000) in which participants are shown animations of two moving triangles on a computer screen. For the current study, the triangles task was presented on a Toshiba laptop. Some of the animations are random and others involve actions such as the triangles chasing each other or dancing together. Participants are asked to verbalise what they think is happening in the animations and their answers are scored according to a manual. Participants' answers were audio-recorded to allow for scoring. Answers were scored for appropriateness and intentionality, with these scores added together to give a total score. This measure took about 15 minutes to complete.

5.5.4 Working memory. Working memory capacity was assessed using the digit span (forwards and backwards) subtest of the Wechsler Intelligence Scale for Children IV (WISC-IV) (Wechsler, 2003) or the Wechsler Adult Intelligence Scale IV (WAIS-IV) (Wechsler, 2008), depending on the participant's age. This measure took 5-10 minutes to administer.

5.5.5 Emotion recognition. Emotion recognition was measured using a version of the Cambridge Cognition Emotion Recognition Task (ERT; Cambridge Cognition, 2014), which takes 10 minutes to administer. This task was presented using a Toshiba laptop. Computer morphed images derived from facial features of real individuals are displayed on a computer screen one at a time for 200ms. Participants are then asked to identify which emotion the face was displaying, as quickly and as accurately as possible, by clicking one emotion from a choice of six possible emotions (fearful, angry, happy, sad, disgusted and surprised). There are a total of 90 faces presented, with 15 of each emotion. Scores were calculated for accurate responses to each of the six emotions, and a total accuracy score out of 90, which was used for the current study.

5.5.6 Behaviour. Behavioural difficulties were measured using the strengths and difficulties questionnaire (SDQ; Goodman, 1997; Goodman, Meltzer, & Bailey, 1998). The SDQ is a 25-item questionnaire comprised of five sub scales (emotional symptoms, conduct problems, hyperactivity/inattentions, peer relationship problems and prosocial behaviour). The subscales (excluding prosocial behaviour) are then added together to generate a total difficulties score. The SDQ is a widely used

measure and has been found to have good psychometric properties even though it is very brief (Goodman & Scott, 1999). A review found that the psychometric properties are strong and that it measures both problem behaviours and competencies at an early age use (Stone, Otten, Engels, Vermulst, & Janssens, 2010). The self-report, parent-report and teacher-report versions were administered in the current study, with the self-report SDQ administered as part of the participant booklet. For all participants, their parent of caregiver was invited to fill in a parent SDQ and return it to the researcher. For participants recruited from schools and colleges, their form teacher was also invited to fill in a teacher SDQ.

5.5.7 Social information processing skills. Social information processing skills were measured using cartoons and picture vignettes taken from the Social information processing test (SIPT; van Nieuwenhuijzen, 2009, 2011, 2012) which is based on the SIP model (Crick and Dodge, 1994; Lemerise and Arsenio, 2004). This instrument presents vignettes as three comic strips and four situation drawings, followed by an interview which asks questions to measure certain SIP skills. Each of the situations depicts a form of social disadvantage (e.g. a boy in a wheelchair being bullied). The SIPT was administered in a one-to-one interview between the researcher and participant and took about 20 minutes to complete. Participants gave their answers orally and these were audio recorded to be scored according to the SIPT manual.

Step 1, encoding, was measured by asking participants what was happening in the situation (comic or drawing), and coding their answers as either emotional cues (e.g. "he looks sad") verbal cues (e.g. "he is saying…"), non-verbal cues (e.g. "he's looking at her") or interpretation cues (cues relevant to the situation but not actually seen). Scores were generated based on how many times each type of cue was mentioned for the three comics and four situations (total of 7), and a total cues encoded variable was generated by summing these (total of 28). These Step 1 outcome variables were a measure of which cues from the situation a participant had encoded. Irrelevant cues mentioned by participants were coded but not scored. Participants were then asked if the action in the comic or situation happened accidently or on purpose. The situation cards presented ambiguous situations, so responses to this question for the situations measured hostile intent attribution, proposed to be a component of Step 2, interpretation of cues.

Step 2 was measured by asking participants "How can you tell this?" after they had attributed the intent in the comic or situation. Responses to this question

were scored similarly to Step 1, coding answers as either emotional, verbal, non-verbal or interpretation. Scores were generated based on how many of each type of cue was mentioned for the three comics and four situations (total of 7), and a total intent cues variable was generated by summing these (total of 28). These Step 2 outcome variables were a measure of which cues participants took into account while interpreting intent.

For the four situation cards, participants were asked what they would do in the situation, followed by a question asking "Why would you do what you said in the previous question?" as a measure of goal clarification (Step 3). Answers to this question were coded as either internal assertive (e.g. "so I'm not mad at her"), internal vengeful (e.g. "because they deserve it"), internal avoidance (e.g. "I'd be scared"), external social positive (e.g. "so they like me"), external social negative (e.g. "so they know I'm strong), external practical (e.g. "otherwise I'd have to wait") and other (e.g. "just because"). The internal assertive and external social positive goals were then summed to create a prosocial goals variable, and the internal vengeful and external social negative goals were summed to create an antisocial goals variable.

Step 4, response access or construction, was measured by asking participants "What would you do in this situation" for the four situation cards, and after the initial response, asking "What else could you do?" to encourage participants to think of other possible response options. Response options were coded as either assertive/prosocial (e.g. "talk to him about it"), aggressive/antisocial (e.g. "fight him, get angry"), submissive/passive (e.g. "do nothing and let the situation continue"), selected controlled emotion (e.g. "go and do something else") or ask authority for help (e.g. "ask my mum for help"). For the first response given, assertive/prosocial responses were summed across the four situations to create a prosocial first response variable and aggressive/antisocial first responses were summed to create an antisocial first response variable. Subsequent prosocial and antisocial responses were summed to create prosocial and antisocial response variables. Step 5, response decision, was measured by asking participants to choose a response from one of three response options for each of the four situations. Possible response options were assertive, aggressive, or submissive. The assertive response decisions were summed to create a prosocial decisions variable and the aggressive response decisions were summed to create an antisocial decisions variable.

5.5.8 General intellectual functioning. General intellectual functioning was measured to be included within analysis as a potential covariate. General intellectual functioning was measured using a two-subtest version of the Wechsler Abbreviated Scale of Intelligence - Second Edition (WASI–II; Wechsler, 2011), designed for use with ages 6-90 years. The two subtests are vocabulary and matrix reasoning. The WASI-II was the most appropriate measure for the current study as it provides an estimate of general intellectual functioning but takes just 15 minutes to administer, compared to the 90 minutes for the WISC-IV or WAIS-IV, which would add too much burden to an already long test battery. The WASI-II has good reliability and validity (Wechsler, 2011).

5.5.9 Mood. Current mood is a component in the centre of the SIP-MDM framework, hypothesised to have an effect on all steps of processing. Current mood was measured using the PANAS (Watson et al, 1988) which has good psychometric properties when used with children and adolescents (Huebner and Dew, 1995; Melvin and Molly, 2000) and is a brief measure that was included in the participant booklet. In this instrument participants are asked to rate, on a scale, how much they currently feel various feelings and emotions such as excited or nervous. This measure was presented before the SIP test, during the same testing session, due to the hypothesis that current mood can affect SIP.

5.5.10 Socio-economic status. SES was measured to be included within analysis as a potential covariate. SES measures which ask adolescents about parental education and occupation have typically shown poor completion rates (Currie, Elton, Todd, & Platt, 1997; Wardle, Robb, & Johnson, 2002) while studies which have asked adolescents about material indicators of SES have found good completion rates (Currie et al., 1997; Wardle et al., 2002). The Family Affluence Scale II (FAS-II Currie et al., 1997; Currie et al., 2004) was used as a measure of SES status. This measure consists of four questions which ask adolescents how many cars their family own, whether they have their own bedroom, how many family holidays they have taken in the last 12 months, and how many computers are owned by their family. The FAS-II was administered as part of the participant booklet.

5.5.11 Social desirability. The social desirability bias is the tendency for respondents to answer in a manner that will be favourable to others, and was measured as covariate in the current study. The Marlowe-Crowne scale (Crowne & Marlowe, 1960) is a frequently used measure of social desirability and was updated

by Stöber (2001), as the original reflected social standards of the 1950s. Stöber's Social Desirability Scale (SDS- 17) has shown a Cronbach's alpha of 0.72 and a test-retest correlation of 0.82, and a correlation of 0.74 with the Marlowe-Crowne scale (Stöber, 2001). The SDS-17 was originally developed to be used for people aged 18 and over but Johnson and Krettanauer (2011) administered the SDS-17 to 205 adolescents ranging in age from 11.33-19.08 years and found that the internal consistency was not lower for younger participants compared with the older adolescents. For the proposed study, the SDS-17 was used as a measure of social desirability. Some of the items were amended to match the age of the sample, resulting in 15 items, such as "I am always polite and considerate of others" and "I always eat a healthy diet". The SDS-17 was administered as part of the participant booklet.

5.5.12 Demographic information. In addition to the measures mentioned above, data were also collected on age and gender of the participants using a demographic questionnaire, which was part of the participant booklet.

5.6 Data analysis

All data were entered into IBM SPSS Statistics Version 22. Data were checked for normality in three ways: 1) visual inspection of histograms and P-P plots, 2), converting skewness and kurtosis scores to z-scores, 3) running the Kolmogrov-Smirnov test. Most of the variables showed a significant departure from normality, apart from positive affect scale, general intellectual functioning, emotion recognition score and moral reasoning score. Due to departures from normality for the remaining variables, bootstrapping using 5000 samples was performed for all subsequent analyses, with 95% bias corrected and accelerated confidence intervals calculated and reported in [ ].

Pearson's correlations (two-tailed) with bootstrapping (5000 samples) with 95% bias corrected and accelerated confidence intervals were performed to explore relationships between variables. Correlations with confidence intervals crossing 0 were interpreted as being non-significant. Age, general intellectual functioning, SES and social desirability were explored as potential covariates for moral reasoning. Only the cognitive and affective variables which were significantly related to moral reasoning were used as predictor variables within the regression analysis and only variables which significantly correlated with SIP outcome variables were entered into the regression analyses.. For hierarchical multiple regressions, the enter

method was used, with covariates entered into the first block, and predictor variables entered into the second block. Independence of errors and multicollinearity were examined for the multiple regressions and assumptions were not violated.

5.7 Results

5.7.1 Descriptive statistics. The descriptive statistics for the sample are displayed in Table 5.3. All 80 participants completed all measures.

Table 5.3 Descriptive statistics of sample

	M (SD)
Age (years)	14.05 (2.25)
Gender	31 Male, 49 Female
WASI-II	101.52 (11.42)
FAS-II	6.11 (1.71)
SDS-17	9.89 (3.00)
SRM-SF	277.46 (31.42)
IECA	16.75 (2.67)
Animated triangles task	23.41 (4.70)
Digit span	16.80 (3.51)
ERT	54.49 (8.16)
Self-report total difficulties SDQ	12.19 (5.14)
Parent-report total difficulties SDQ	9.37 (6.23)
Positive affect scale	26.67 (7.34)
Negative affect scale	13.86 (4.34)
SIPT Emotion cues encoded	1.03 (1.20)
SIPT Verbal cues encoded	.36 (.53)
SIPT Non-verbal cues encoded	6.34 (.76)
SIPT Interpretation cues encoded	3.88 (1.46)
SIPT Total cues encoded	11.60 (2.28)
SIPT Emotion intent cues	2.51 (1.37)
SIPT Verbal intent cues	.21 (.44)
SIPT Non-verbal intent cues	2.64 (1.55)
SIPT Interpretation intent cues	4.07 (1.21)
SIPT Total intent cues	9.44 (1.85)
SIPT Prosocial goals	.95 (.88)
SIPT Antisocial goals	.35 (.70)
SIPT Prosocial first response	1.18 (.81)
SIPT Antisocial first response	.23 (.50)
SIPT Total prosocial responses	3.19 (1.22)
SIPT Total antisocial responses	4.15 (1.61)
SIPT Prosocial decisions	3.14 (.82)
SIPT Antisocial decisions	.04 (.19)

Note. Means (*M*) and standard deviations (*SD*).

5.7.2 Relationships between moral reasoning, cognitive and affective processes and age.
Age was significantly related to moral reasoning, (r= .51, p <.000, [.34, .65]) and working memory (r=.33, p=.003, [.14, .50]. These relationships were positive, indicating that older participants scored higher on these measures, and as predicted, these constructs would mature with development. There were no significant relationships between empathy (r=.09, p=.425, [-.14, .28]), perspective taking (r=.02, p=.880, [-.18, .22]) or emotion recognition (r=.17, p=.142, [-.07, .40]) and age. Hypothesis 1, that moral reasoning and the cognitive and affective processes would correlate positively with age was only partly supported.

5.7.3 Relationships between moral reasoning and cognitive and affective processes.
There was a significant positive relationship between moral reasoning and working memory (r=.29, p=.010, [.06, .48]). There were no significant relationships between moral reasoning and empathy (r=.11, p=.341, [-.09, .28]), perspective taking (r=.02, p=.853, [-.22, .26]) or emotion recognition (r=.17, p=0.136, [-.07, .38]). Hypothesis 2, that there will be significant positive relationships between moral reasoning and the cognitive and affective processes was only party supported, as only a significant relationship was found for moral reasoning and working memory. The predictive relationship of working memory for moral reasoning level was explored for Hypothesis 3.

In exploring potential covariates for the regression analysis, moral reasoning was significantly related to general intellectual functioning (r=.43, p<.000, [.21, .61]). There were no significant relationships between moral reasoning and SES (r=-.01, p=.912, [-.21, .18]) or social desirability (r= -.23, p=.044, [-.43, .00]). Due to the significant relationships between age and general intellectual functioning with moral reasoning, these were entered as covariates in the regression analysis for moral reasoning. A regression analysis was firstly run without controlling for covariates and found that working memory significantly predicted moral reasoning (p=.010), explaining 8% of the variance in moral reasoning. After controlling for age and general intellectual functioning, working memory did not significantly predict moral reasoning, while 45% of the variance in moral reasoning was explained .Results of the regression analyses are found in Table 5.4. Hypothesis 3, that the cognitive and affective processes would predict moral reasoning level was not supported.

Table 5.4 Results of moral reasoning regression analysis.

Block	Predictors	B [95% BCa CIs]	SE	β	R²	Adjusted R²	R² Change
1	Constant	**234.61 [199.03]***	17.68	-	.08	.07	**.08**
	Working memory	**2.56 [.31, 4.35]**	.99	.29			
1	Constant	53.29 [-8.10, 115.30]	32.00	-	.45	.44	**.45***
	Age	**7.22 [4.97, 9.43]***	1.13	.52			
	General intellectual functioning	**1.21 [.681, 1.738]***	.27	.44			
2	Constant	53.212 [-8.12, 115.45]	32.13	-	.45	.43	.00
	Age	**7.19 [4.69, 9.74]***	1.28	.52			
	General intellectual functioning	**1.21 [0.64, 1.74]***	.28	.44			
	Working memory	.06 [-1.65, 1.82]	.88	.01			

Note * Significant at .05, **Significant at .01, ***Significant at .001. Confidence intervals (CIs) and standard errors (SE) based on 5000 bias corrected (BCa) bootstrap samples.

5.7.4 Relationships between moral reasoning and behaviour. All participants (*n*=80) completed a self-report SDQ, 62 participants had a completed parent-report SDQ and 23 had a completed teacher-report SDQ. For this analysis, only self and parent-report SDQs were used as measures of behaviour due to the low number of teacher-report SDQs. There was a significant relationship between self and parent report SDQs (*r*=.45, *p*=.00, [.23, .62]). There was no significant relationship between moral reasoning and self-report behaviour (*r*=.10, *p*= .451 [-.20, .37]) or between moral reasoning and parent-report behaviour (*r*= -.22, *p*=.086, [-.47, .05]), so Hypothesis 4 was not supported.

5.7.5 Relationships between SIP skills and age. Age was significantly related to number of interpretation cues encoded (r=.24, p=.029 [.04, .43]), total number of cues encoded (r=.26, p=.018 [.07, .45]), emotion intent cues (r=.33, p=.003 [.13, .51]) and total intent cues (r=.36, p=.001 [.18, .53]). These relationships were positive, indicating that older participants scored higher on these measures. Age was also significantly related to the number prosocial first responses (r= -.32, p=.004, [-.51, -.10]) and prosocial decisions (r= -.45, p <.000, [-.60, -.26]). These relationships were negative, indicating that older participants generated fewer prosocial responses as their first response, and selected fewer prosocial decisions. Hypothesis 5, that SIP steps will correlate positively with age was only supported for some Step 1 variables, namely number of interpretation cues and total number of cues encoded and some Step 2 variables, namely emotion intent and total intent cues.

5.7.6 Relationships between components in the centre of the SIP-MDM framework and SIP steps. Table 5.5 displays the correlations between SIP outcome variables and perspective taking, working memory, moral reasoning, SES and current mood (positive and negative affect). Hypothesis 6, that there would be significant relationships between SIP steps and perspective taking, working memory, moral reasoning, SES and current mood was only partially supported. Working memory significantly correlated with total number of cues encoded, and number of emotion intent and total intent cues. Moral reasoning significantly correlated with number of emotion cues, non-verbal cues, interpretation cues and total cues encoded. Moral reasoning also significantly correlated with number of emotion intent, interpretation intent and total intent cues. There were no significant relationships between perspective taking, SES, positive or negative affect and any of the SIP variables.

Table 5.5. Correlations between components in the centre of the SIP-MDM framework and SIP steps.

Step of SIP-MDM framework	SIP outcome variable	Perspective taking	Working memory	Moral reasoning	SES	Positive affect	Negative affect
1	Emotion cues	-.10 [-.30, .13]	.24 [-.02, .46]	**.32 [.12, .51]****	.05 [-.19, .30]	-.20 [-.38, -.00]	.02 [-.23, .26]
	Verbal cues	-.02 [-.24, .20]	-.14 [-.36, .10]	-.18 [-.39, .05]	-.21 [-.42, .01]	.06 [-0.18, 0.32]	-.04 [-.23, .18]
	Non-verbal cues	-.03 [-.25, .17]	.18 [-.05, .37]	**.24 [.01, .47]***	.13 [-.12, .35]	.06 [-.18, .29]	.23 [-.48, .03]
	Interpretation cues	.02 [-.19, .23]	.15 [-.10, .37]	**.34 [.11, .55]****	-.06 [-.26, .16]	.13 [-.09, .33]	.09 [-.13, .27]
	Total cues encoded	-.05 [-.27, .18]	**.25 [.02, .46]***	**.43 [.24, .58]****	-.01 [-.23, .20]	.01 [-.17, .21]	-.02 [-.23, .17]
2	Emotion intent	005 [-.18, .28]	**.29 [.03, .51]****	**.33 [.13, .51]****	.05 [-.16, .25]	.03 [-.17, .25]	-.08 [-.27, .09]
	Verbal intent	.08 [-.11, .28]	-.01 [-.18, .16]	.01 [-.18. .18]	.02 [-.21, .26]	.08 [-.17, .31]	-.06 [-.22, .12]
	Non-verbal intent	.11 [-.12, .31]	-.02 [-.2, .23]	-.06 [-.29, .18]	-.10 [-.27, .07]	-.10 [-.31, .14]	.13 [-.08, .32]

	Interpretation intent	-.14 [-.38, .10]	.10 [-.12, .30]	**.25 [.03, .45]***	-.16 [-.35, .04]	.07 [-.16, .27]	-.07 [-.30, .20]
	Total intent cues	.05 [-.19, .26]	**.26 [.05, 0.47]***	**.36 [.18, .52]****	-.15 [-.38, .09]	.01 [-.20, .22]	-.01 [-.19, .16]
	Hostile intent attribution	.07 [-.14, .27]	-.16 [-.38, .06]	.01 [-.21, .21]	-.06 [-.24, .13]	.01 [-.22, .25]	.05 [-.15, .22]
3	Prosocial goals	-.12 [-.32, .09]	.24 [-.00, .46]	.13 [-.06, .31]	-.15 [-.35, .09]	-.05 [-.27, .16]	.03 [-.15, .21]
	Antisocial goals	.03 [-.19, .29]	-.14 [-.39, .07]	-.04 [-.22, .11]	-.04 [-.21, .14]	-.17 [-.34, .03]	-.05 [-.20, .14]
4	Prosocial first response	.11 [-.12, .34]	.04 [-.20, .27]	-.01 [-.22, .20]	.05 [-.18, .29]	.13 [-.06, .30]	.06 [-.19, .27]
	Antisocial first response	.02 [-.21, .23]	-.08 [-.31, .19]	-.14 [-.32, .04]	-.03 [-.21, .14]	-.13 [-.31, .05]	.03 [-.14, .21]
	Number of prosocial responses generated	.08 [-.16, .30]	.06 [-.15, .26]	.06 [-.16, .27]	-.06 [-.30, .21]	.00 [-.19, .19]	.12 [-.07, .30]
	Number of antisocial responses generated	.06 [-.17, .28]	.04 [-.20, .28]	.14 [-.05, .32]	.11 [-.07, .28]	-.04 [-.23, .16]	-.11 [-.35, .11]
5	Prosocial decisions	.05 [-.16, .26]	-.14 [.36, .08]	-.21 [-.42, .00]	.02 [-.20, .23]	.14 [-.08, .33]	-.05 [-.25, .16]
	Antisocial decisions	.03 [-.19, .26]	-.16 [-.36, .05]	.00 [-.08, .09]	-.05 [-.16, .02]	-.05 [-.27, .13]	-.07 [-.17, .02]

Note. * Significant at .05, **Significant at .01, ***Significant at .001. [ ]= 95% BCa CIs.

5.7.7 SIP Step 1 and emotion recognition Table 5.6 displays correlations between emotion recognition and SIP encoding variables (Step 1). There were no significant relationships between emotion recognition and any of the encoding variables, so Hypothesis 7 was not supported.

Table 5.6. Correlations between emotion recognition, empathy, and Steps 1, 3 and 5 of the SIP-MDM framework.

Step of SIP-MDM framework	SIP outcome variable	Emotion recognition	Empathy
1	Emotion cues	.08 [-.17, .31]	.07 [-.13, .27]
	Verbal cues	.06 [-.14, .26]	.00 [-.20, .18]
	Non-verbal cues	.12 [-.11, .34]	-.05 [-.30, .11]
	Interpretation cues	-.11 [-.30, .09]	-.10 [-0.31, 0.12]
	Total cues encoded	.03 [-.20, .27]	-.04 [-.27, .19]
3	Prosocial goals	-	-.01 [-.20, .17]
	Antisocial goals	-	-.10 [-.34, .12]
5	Prosocial decisions	-	-.11 [-.29, .09]
	Antisocial decisions	-	-.18 [-.50, .14]

5.7.8 SIP Step 3 and empathy. Table 5.6 shows correlations between empathy and Step 3 variables. There were no significant relationships between empathy and prosocial goals or antisocial goals so Hypothesis 8 was not supported.

5.7.9 SIP Step 5 and empathy. Correlations between empathy and Step 5 variables are displayed in Table 5.6. There were no significant relationships between empathy and prosocial decisions or antisocial decisions so Hypothesis 9 was not supported.

5.7.10 Predictive relationships of the SIP-MDM. Where significant relationships were found between SIP outcome variables and other variables, regression analyses were performed. Regression analyses were performed for Steps 1 and 2 of the SIP-MDM framework. Pearson's correlations were firstly performed to assess whether general intellectual functioning and social desirability should be entered as covariates for these regressions, with results shown in Table 5.7. Relationships with age were explored for Hypothesis 5 and relationships with SES were explored for Hypothesis 6. No variables correlated with SES but age was entered as a covariate for interpretation and total cues (Step 1) and emotion intent and total intent cues (Step 2). General intellectual functioning was entered as a covariate for non-verbal cues and social desirability was entered as a covariate for total cues encoded, emotion intent and total intent cues. Covariates were entered into the first block of the regression analyses, using the enter method, with predictor variables entered in the following block.

Table 5.7. Correlations for covariates of SIP outcome variables

Step of SIP-MDM framework	SIP outcome variable	General intellectual functioning	Social desirability
Step 1 Encoding	Emotion cues	.17 [-.03, .37]	-.19 [-.37, -.01]
	Non-verbal cues	**25** **[.02, .45]*.**	-.14 [-.33, .06]
	Interpretation cues	.10 [-.16, .35]	-.13 [-.31, .06]
	Total cues encoded	.23 [-.02, .47]	**-.23** **[-.40, -.06]***
Step 2 Interpretation	Emotion intent	.13 [-.08, .31]	**-.26** **[-.45, -.06]***
	Interpretation intent	.10 [-.13, .32]	-.10 [-.33, .15]
	Total intent cues	.01 [-.23, .21]	**-.27** **[-.46, -.07]****

Note. * Significant at .05, **Significant at .01, ***Significant at .001

Table 5.8 displays the results for the regression analyses performed for Steps 1 and 2. Moral reasoning and working memory were the only variables found to correlate with SIP steps so were entered as predictor variables in regression

analyses. Analysis was firstly performed without controlling for covariates, followed by an analysis controlling for covariates where relevant.

For Step 1, moral reasoning significantly predicted number of emotion cues but did not significantly predict number of non-verbal cues encoded. Moral reasoning significantly predicted 12% of the variance in number of interpretation cues encoded before controlling for age. After controlling for age, moral reasoning still significantly contributed to the model accounting for 12% variance. Moral reasoning significantly predicted the number of total cues encoded before controlling for age and social desirability, and remained a significant contributor to the model after these were controlled for, accounting for 21% of variance. Working memory did not predict number of total cues encoded, suggesting that the number of cues that can be encoded in a situation does not rely on working memory capacity. For Step 2, moral reasoning significantly predicted emotion intent cues before controlling for age and social desirability but did not remain a significant predictor after analysis controlled for age and social desirability. Working memory did not predict emotion intent. For interpretation intent cues, moral reasoning predicted 6% of variance. Moral reasoning significantly predicted total intent cues before controlling for age and social desirability but did not remain significant after analysis controlled for age and social desirability. Working memory did not predict total intent cues. Hypothesis 10, that SIP steps will be predicted by relevant variables at each step, including variables in the centre of the SIP-MDM framework was only partially supported. Moral reasoning significantly predicted number of emotion cues and total cues encoded at Step 1. At Step 2, moral reasoning significantly predicted interpretation intent cues. Moral reasoning also significantly predicted emotion intent and total intent cues at Step 2 but not after controlling for age and social desirability.

Table 5.8. Regression analyses for Steps 1 and 2 of the SIP-MDM framework.

Step of SIP-MDM framework	Dependent variable	Block	Predictors	B [95% BCa CIs]	SE B	β	R²	Adjusted R²	R² Change
1	Emotion cues	1	Constant	**-2.41 [-4.42, -.30]****	1.02	-	.11	.09	**.11****
			Moral reasoning	**.01 [.01, .02]***	.00	.32			
	Non-verbal cues	1	Constant	4.70 [2.84, 6.30]	.89	-	.06	.05	**.06***
			Moral reasoning	.01 [.00, .01]	.00	.24			
		1	Constant	**4.67 [3.15, 6.21]*****	.80	-	.06	.05	**.06***
			General intellectual functioning	**.02 [.00, .03]***	.01	.25			
		2	Constant	**4.0 [1.88, 5.92]****	1.06	-	0.084	.06	.02
			General intellectual functioning	.01 [-.00, .03]	.01	.17			
			Moral reasoning	.00 [-.00, .01]	.00	.17			
	Interpretation cues	1	Constant	-.51 [-3.08, 2.22]	1.39	-	.12	.10	**.12****
			Moral reasoning	**.02 [.01, .03]****	.01	.34			
		1	Constant	1.64 [-.34, 3.55]	.97	-	.06	.05	**.06***
			Age	**.16 [.03, .29]***	.07	.24			
		2	Constant	-.76 [-3.28, 1.96]	1.37	-	.12	.10	**.06***
			Age	.06 [-.10, .23]	.09	.10			
			Moral reasoning	**.01 [.00, .026]***	.01	.29			
	Total cues encoded	1	Constant	2.29 [-1.55, 5.77]	1.84	-	.20	.18	**.20*****
			Working memory	.09 [-.07, .22]	.01	.39			
			Moral reasoning	**.03 [.01, .05]*****					
		1	Constant	9.78 [6.34, 13.38]	1.81	-	.10	.07	**.10***
			Age	.22 [.017, .42]	.10	.22			
			Social desirability	-.13 [-.26, -.00]	.07	-.17			
		2	Constant	3.78 [-1.30, 8.20]	2.49	-	.21	.17	**.12***
			Age	.01 [-.21, .24]	.11	.01			

Step	Outcome	Model	Variable	B [95% CI]	SE	β	R²	Adj. R²	sig.
			Social desirability	-.09 [-.23, .06]	.07	-.12			
			Working memory	.08 [-.09, .21]	.08	.36			
			Moral reasoning	**.26 [.01, .05]****	.01	.12			
2	Emotion intent cues	1	Constant	-2.12 [-5.10, .59]	1.14	-	.15	.13	**.15****
			Working memory	.08 [-.02, .18]	.05	.21			
			Moral reasoning	**.01 [.00, .02]***					
		1	Constant	1.01 [-1.32, 3.61]	1.21	-	.14	.12	**.14***
			Age	**.17 [.04, .30]***	.07	.28			
			Social desirability	-.09 [-.19, .00]	.05	-.19			
		2	Constant	-1.24 [-4.77, 2.23]	1.7		.19	.15	.05
			Age	-09 [-.03, .21]	.08	.15			
			Social desirability	-.07 [-.17, .021]	.05	-.15			
			Working memory	.06 [-.04, .16]	.05	.16			
			Moral reasoning	.01 [-.00, .02]	.01	.18			
	Interpretation intent cues	1	Constant	1.42 [-1.05, 3.68]	1.28	-	.06	.05	**.06***
			Moral reasoning	**.01 [.00, .020]***	.01	.25			
	Total intent cues	1	Constant	2.80 [-.63, 5.90]	1.7	-	.16	.14	**.16*****
			Working memory	.09 [-.03, .20]	.00	.17			
			Moral reasoning	**.02 [.01, .03]****	.01	.31			
		1	Constant	**7.00 [4.21, 9.74]*****	1.322	-	.17	.14	**.17****
			Age	**.26 [.11, .40]****	0.077	.31			
			Social desirability	-.12 [-.24, .01]	0.060	-.19			
		2	Constant	**4.00 [.37, 7.15]***	1.779	-	.21	.17	.04
			Age	.15 [-.05, .35]	0.101	.18			
			Social desirability	-.10 [-.22, .03]	0.061	-.16			
			Working memory	.10 [-.06, .17]	0.055	.11			
			Moral reasoning	.01 [-.00, .03]	0.007	.20			

Table 6.6 Continued. Regression analysis for Steps 1 and 1 of the SIP-MDM framework.

Note. * Significant at .05, **Significant at .01, ***Significant at .001. Confidence intervals (CIs) and standard errors (SE) based on 5000 bias corrected (BCa) bootstrap samples. [ ] = 95% BCa CIs.

5.7.11 Exploratory analyses. Exploratory analyses were conducted to assess the effect of gender on key variables and on relationships between variables. Independent *t*-tests revealed that there were no significant differences between males (*n*=31) and females (*n*=49) on moral reasoning, cognitive and affective processes, self and parent-reported behaviour or SIP variables. Exploring whether gender had an effect on relationships between key variables, correlations revealed that there was a significant relationship between age and moral reasoning for both males (*r*=.44, *p*=.014, [.12, .67]) and females (*r*=.53, *p*=<.000, [.30, .71]). There was a significant relationship between age and working memory for females (*r*=.40, *p*=.005, [.18, .58]) but not males (*r*=.27, *p*=.146, [-.08, .56]). For females there was also a significant relationship between age and emotion recognition (*r*=.41, *p*=.004, [.14, .63]) but this relationship was not significant for males (*r*=-.27, *p*=.137, [-.56, .08]). There were no significant relationships between age and empathy or perspective taking for either males or females. In terms of the relationships between moral reasoning and cognitive and affective processes, working memory was significantly related to moral reasoning for females (*r*=.33, *p*=.041, [.03, .60]) but not for males (*r*= -.20, *p*= .366, [-.56, .21]). There were no significant relationships between moral reasoning and empathy, perspective taking or emotion recognition for males or females.

The age range of the sample was 11-18 years but the mean of 14.05 (2.25) years suggests that the sample were more slightly in the younger range. In order to explore whether younger and older adolescents showed significant differences on key variables, the sample was split into two age groups of 11-14 year olds and 15-18 year olds. Independent *t*-tests revealed that there were significant differences between age groups for moral reasoning (*t (60) = -4.28, p <.000*, [-45.07, -19.66]). The mean moral reasoning score for the 11-14 year olds was 265.48 (29.56) and 293.68 (26.48) for the 15-18 year olds. There were also significant differences between the age groups for working memory (*t* (60) = -2.86, *p*= .006, [-4.18, -.82]). The mean working memory score for 11-14 year olds was 15.91 (3.31) and 18 (3.47) for the 15-18 year olds. There were no significant differences between the age groups for emotion recognition, empathy, perspective taking and self or parent-reported behaviour.

5.8 Summary

Partial support was found for Hypothesis 1, as moral reasoning and working memory were found to correlate positively with age. This was supported by

exploratory analysis which found that the 15-18 year olds had significantly higher moral reasoning and working memory scores than the 11-14 year olds. There were no significant correlations between age and empathy, perspective taking, and emotion recognition. This suggests that these processes may not show measurable improvements between the ages of 11-18 years, as assessed by the measures used in this study, which may partly be due to issues with the measures chosen. The lack of correlation between age and perspective taking and emotion recognition is in contrast to research which has found that both continue to develop in adolescence (Dumontheil et al., 2010; Thomas et al., 2007; Van der Graaff et al., 2014), although exploratory analysis revealed that there was a significant correlation between age and emotion recognition for females. The evidence for the development of affective empathy during adolescence has been less convincing. While the lack of correlation between age and empathy does not support the proposal within the SIP-MDM framework, it is consistent with previous research which has not found development of affective empathy during adolescence (Garaigordobil, 2009; Van der Graaff et al., 2014).

Hypotheses 2 and 3 proposed that the cognitive and affective processes would significantly relate to and predict moral reasoning. Working memory was found to correlate positively with moral reasoning, but after controlling for age and general intellectual functioning, working memory did not significantly predict moral reasoning. There were no significant relationships between moral reasoning and the other cognitive and affective variables (perspective taking, emotion recognition and empathy). The cognitive and affective processes measured in this study are proposed to be important for moral development, and are components of the SIP-MDM framework, but the findings of this study suggest that they do not relate to moral maturity levels, as measured by the SRM-SF in TD adolescents. The lack of correlation between moral reasoning and perspective taking is particularly surprising as perspective taking is the component most frequently cited as being important for moral development.

No support was found for Hypothesis 4 as there was no relationship between moral reasoning and either self-report or parent reported behavioural difficulties. Previous research has found relationships between low moral reasoning on the SRM-SF and offending behaviour, and between scores on the So-Mature and aggressive behaviour amongst TD adolescents. However, findings from the current study suggest that moral reasoning as measured by the SRM-SF does not

relate to self-report or parent reported behavioural difficulties in TD adolescents. Based on the SIP-MDM framework it is proposed that moral reasoning can affect all steps of processing and influence moral decision-making, but other factors, such as situational factors are also relevant to moral behaviour. Individuals displaying aggressive or offending behaviour have been found to show biases, such as hostile intent attribution (Dodge et al., 2002; Schönenberg & Jusyte, 2014). Such biases can influence SIP across different situations, and may result in the relationship between moral reasoning and behaviour being consistent, i.e. hostile intent attributions are made in most situations and result in biased processing and a higher likelihood of aggressive or antisocial behaviour. For TD adolescents who do not display such biases which affect SIP in all situations, the role that moral reasoning plays in moral decisions and behaviour may vary depending on situational and contextual factors, making the relationship between moral reasoning and behaviour less consistent.

Partial support was found for Hypothesis 5, as age positively correlated with number of interpretation cues encoded, total number of cues encoded, number of emotion intent cues and total number of intent cues. This suggests that older adolescents encode more interpretation cues (cues relevant to the situation but not actually seen) and more total cues when assessing what is happening in a situation. It also suggests that older adolescents use more emotion cues and total cues when assessing intent. While it was hypothesised that older participants would generate more prosocial responses and make more prosocial decisions, the opposite was found, with results indicating that older participants generated fewer prosocial first responses and selected fewer prosocial decisions. Increases in prosocial responses and decisions were expected based on the SIP-MDM, due to moral development being related to less egocentric processing, and an increased ability to take the perspectives of others into account. Additionally, previous research has found that endorsing aggressive responses decreases with age in children (Feldman & Dodge, 1987). The current study found that moral reasoning correlated positively with age for this sample of adolescents and the sample were reasoning on average at Stage 3. However, no significant correlation between moral reasoning and response generation or response decision was found, suggesting that mature levels of moral reasoning did not translate to more prosocial decision-making. It may be that younger participants in this sample who were reasoning at the immature stages, generated more prosocial responses and made more prosocial decisions based on

rules or appeals to authority, which represents curvilinear moral development (Bear & Rys, 1994; Langdon, Clare, & Murphy, 2011).

Hypothesis 6 proposed that there would be significant relationships between components in the centre of the SIP-MDM framework and SIP outcome variables. There was partial support for this hypothesis, with some significant correlations between components in the centre of the SIP-MDM framework and variables at Step 1 and 2. Working memory correlated with total number of cues encoded, emotion intent and total intent cues. These results suggest that higher working memory abilities are associated with encoding more cues in a situation, and using more emotion and total cues in assessing intent. Moral reasoning correlated with number of emotion cues, non-verbal cues, interpretation cues and total cues encoded. Moral reasoning also correlated with emotion intent, interpretation intent and total intent cues. This suggests that moral reasoning maturity is associated with encoding more emotion, non-verbal, interpretation and total cues in a situation, and using more emotion, interpretation and total cues to assess intent. There were no significant relationships between perspective taking, SES, positive or negative affect and any of the SIP steps.

No support was found for Hypothesis 7, as emotion recognition was not significantly correlated with any of the encoding variables. This suggests that increases in emotion recognition abilities did not relate to more cues being encoded in a situation. This finding is in contrast to van Nieuwenhuijzen and Vriens (2012) who found that emotion recognition significantly predicted number of emotion and interpretation cues encoded for children and adolescents with intellectual disabilities. The lack of correlation for emotion recognition and Step 1 found for the current study may have been due to the situations on the SIPT involving drawings rather than photographs or videos of situations which would provide more detail from facial expressions. The study by van Nieuwenhuijzen and Vriens (2012) used video vignettes in addition to the drawings and cartoons. It was hypothesised that empathy would significantly correlate with goal generation (Hypothesis 8) and response decisions (Hypothesis 9) but no significant correlations were found. This suggests that increase in empathy did not correlate with more prosocial goals being generated or more prosocial responses being made. Again, it may be the case that this was affected by the situations being presented as drawings, which may have limited the extent to which empathy was activated when thinking about goals and making response decisions.

Hypothesis 10, that SIP steps will be predicted by relevant variables at each step, including variables in the centre of the SIP-MDM framework was partially supported. Only moral reasoning and working memory were found to correlate with some of the SIP variables, and only for Steps 1 and 2. Moral reasoning significantly predicted the number of emotion cues encoded. After controlling for age, moral reasoning also predicted the number of interpretation cues and total cues encoded. Moral reasoning predicted interpretation intent cues but did not predict emotion intent or total intent cues after controlling for age and social desirability. Working memory was not found to significantly predict any of the variables at Steps 1 and 2.

Moral reasoning is a component in the centre or the SIP-MDM framework proposed to affect all steps of processing, but these results suggest that moral reasoning only predicted some encoding and interpretation variables at Steps 1 and 2. Working memory is also a component in the centre of the SIP-MDM framework but additionally added at Steps 1 and 5, as it is proposed to be particularly important at those steps. The findings of the current study suggested that increases in working memory abilities are related to but do not predict the amount of information encoded at Step 1, and are not related to decision making at Step 5. While increases in working memory abilities can facilitate moral decision-making by allowing more features of a situation to be encoded and then kept in mind while making decisions, it does not necessarily follow that this will always lead to more prosocial decisions and moral behaviour. It is not just the amount of information encoded and used for processing that is important, it also depends on the content of this information; if encoding and processing is biased towards negative information, this will increase the likelihood of antisocial responses being made. Additionally, factors such as current mood and situational factors can affect other steps of processing which then determine how the encoded information is processed and decisions that are made.

Chapter 6: Study 2: Moral reasoning and behaviour in adolescents with acquired brain injuries.

6.1 Rationale

In Study 1 hypotheses generated by the SIP-MDM framework were investigated in a sample of TD adolescents. Children and adolescents with ABIs have been found to have difficulties or developmental delays in some of the components of the SIP-MDM, such as moral reasoning (Beauchamp et al., 2013), perspective taking (Dennis et al., 2013) and peer relationships (Tonks et al., 2010; Yeates et al., 2013). Based on the SIP-MDM framework, it is proposed that adolescents with ABIs may show atypical moral decision-making and delayed moral development due to either damage to the brain networks involved in real-time moral decision-making, or due to the negative impact upon maturation of component processes of the SIP-MDM framework. Additionally, damage to the brain can either impact upon the development of component processes directly, if brain networks related to these components are compromised, or indirectly if social participation and interaction with peers is limited following a brain injury, which in turn can impact upon the development of perspective taking. Testing hypotheses related to the SIP-MDM in adolescents with ABIs can add to our knowledge about the relationships between components, and how difficulties in certain components may impact upon the moral decision-making process and moral development.

Before hypotheses generated by the SIP-MDM framework can be explored in adolescents with ABIs, firstly, appropriate measures to use with this population need to be validated. The study presented in this chapter focused on exploring the psychometric properties of two measures of moral reasoning when used with adolescents with ABIs, as a first step. The SRM-SF (Gibbs et al., 1992) and So-Mature (Dooley et al., 2010), both production measures of moral reasoning have been used to measure moral reasoning in adolescents and young adults with ABIs, and several studies reported ABI participants to be reasoning at a significantly lower level than NH comparison groups. For example, Wigg (2013) found that adults (aged 17-25 years) with TBI were reasoning at transition Stage 3 (2) on the SRM-SF while the comparison group were reasoning at Stage 3. Beauchamp and colleagues (2013) found that adolescents (mean age 13.34 years) with mild TBIs were reasoning at the same stage as the TD comparison group (Stage 3) on the So-Mature, though scored significantly lower, while those with moderate-severe TBIs

were reasoning at Stage 2. Chiasson and colleagues (2017a) found that children and adolescents (aged 8-16 years) were reasoning at Stage 2 on the So-Mature while the TD comparison group were reasoning at Stage 3.

The main aim of this study was to investigate the psychometric properties, specifically internal consistency, convergent validity and test-retest reliability of the SRM-SF and So-Mature in adolescents with and without an ABI. The SRM-SF and the So-Mature are both production measures of moral reasoning, based on similar theories, but the convergent validity has not yet been explored, either in TD or ABI populations. The scoring manual of the So-Mature is based on Kohlberg's theory (Kohlberg, 1984b) and the scoring manual of the SRM-SF is based on Gibbs' theory (Gibbs, 2013; Gibbs et al., 1992), which updated Kohlberg's theory, so it could be expected that these measures will show convergent validity. However, the measures use different methods to elicit justifications to be scored developmentally. The SRM-SF scores justifications elicited in response to questions about moral values (e.g. How important is it for people to keep promises to friends?) while the So-Mature scores justifications following response decisions made by participants in hypothetical dilemmas (e.g. choosing 'yes'; or 'no' to cheating at a game of Monopoly with friends). Investigating the convergent validity of the SRM-SF and So-Mature can help to explore whether adolescents' reasoning about moral values correlates with their reasoning about response decisions they have made in moral dilemmas.

The SRM-SF is a widely used moral reasoning instrument in developmental psychology and has been shown to have excellent levels of test-retest reliability ($r = 0.88$) and internal consistency ($k = 0.92$) when used with TD populations (Gibbs et al., 1992). The psychometric properties of the SRM-SF have not yet been looked at when used with ABI populations; Couper and colleagues (2002) did not report inter-rater reliability, which is a requisite of the SRM-SF, to ensure reliable scoring, and they, similarly to Wigg (2013), did not report the test-retest reliability or internal consistency. The So-Moral/So-Mature was developed specifically to be used for young people with brain injuries, with the authors claiming that the lack of appropriate measures significantly limits our understanding of moral reasoning impairments associated with TBI (Dooley et al., 2010). While the So-Mature has been used with both brain injury and TD samples, the internal consistency and test-retest reliability have not yet been reported.

A second aim of the current study was to use the SRM-SF and So-Mature to compare levels of moral reasoning across both adolescents with ABIs and a NH comparison group. So far, research into moral reasoning in adolescents with ABIs has only focused on frontal or temporal lesions (Chiasson et al., 2017a; Couper et al., 2002), and TBIs (Beauchamp et al., 2013; Dooley et al., 2010; Wigg, 2013), which typically causes damage to frontal and/or temporal lobes (Bigler, 2007). This may be due to the vmPFC being implicated in moral decision-making (Blair et al., 2006; Fumagalli & Priori, 2012; Marazziti et al., 2013; Raine & Yang, 2006). However, the meta-analysis presented in Chapter 4 revealed that there is not a uniquely moral brain network, and non-temporal and non-frontal regions, namely the precuneus and the left cingulate gyrus, are recruited during moral decision-making. Furthermore, the SIP-MDM framework proposed that many varied component processes are involved in moral-decision making and development, so damage to any area of the brain may have an impact upon real-time moral decision-making and moral maturity. The study presented here therefore includes both TBIs and nTBIs among the ABI sample.

A final aim of this study was to explore the relationship between moral reasoning, (as measured by the SRM-SF and So-Mature), and behavioural difficulties (both parent and self-report SDQ), and to compare behaviour of the ABI group to the NH group. Scores on the So-Mature have been found to negatively correlate with aggressive behaviours and oppositional defiant symptoms in TD adolescents (Dooley et al., 2010) and a strong relationships has been found between low moral reasoning and adolescent offending (Nelson et al., 1990; Stams et al., 2006). Based on the SIP-MDM framework, relationships between moral reasoning and behaviour would be expected. Study 1, presented in Chapter 5, found no significant relationships between moral reasoning and self or parent-reported behavioural difficulties for TD adolescents but these relationships remain to be explored in adolescents with ABIs.

It has been found that social behaviour is impaired after a TBI (Milders, Ietswaart, Crawford, & Currie, 2008) and aggression is a relatively common, long-term problem following a TBI (Baguley, Cooper, & Felmingham, 2006). Behavioural problems have also been reported for children with brain tumours, a type of nTBI (Upton & Eiser, 2006; Wilne, Ferris, Nathwani, & Kennedy, 2006). It would be expected that adolescents with all types of ABIs will show more behavioural difficulties than their NH peers. Additionally, there is evidence of a relationship

between brain injuries and offending and low moral reasoning and offending, suggesting that moral reasoning could be both a mediator and a moderator within the relationship between brain injury and offending behaviour. The current study aimed to undertake an exploratory analysis of offending behaviour and moral reasoning in adolescents with ABIs as a first step towards investigating the relationships between brain injuries, moral reasoning and offending behaviour.

6.2 Hypotheses

Considering the psychometric properties of the moral reasoning measures, it was hypothesised that:

1. The Sociomoral Reasoning Measure Short Form (SRM-SF) will show excellent internal consistency (0.80 or above) and excellent test-retest reliability (0.80 or above) The internal consistency and test-retest reliability of the So-Mature have not been reported so no hypotheses will be made regarding the psychometric properties of this measure.
2. The SRM-SF and the So-Mature will correlate highly with each other (0.70 or above).

In terms of moral reasoning ability, it was hypothesised that:

3. There will be a significant difference in moral reasoning scores between the ABI and NH group on the SRM-SF and So-Mature, with the ABI group reasoning one stage lower than the NH group.

So far, moral reasoning has not been explored for adolescents with nTBIs. This study included participants with nTBIs in the ABI sample and exploratory analyses will be performed to compare moral reasoning for the TBI and nTBI subgroups, and explore whether moral reasoning levels relate to injury severity, age at injury and time since injury. This analysis will be exploratory rather than hypothesis driven due to the small sample size.

In terms of behaviour, it was hypothesised that:

4. The ABI group will display more behavioural difficulties than the NH group, as measured by the self and parent-report behavioural questionnaires.
5. For the ABI and NH group, there will be a significant negative relationship between moral reasoning scores on the SRM-SF and behavioural

difficulties, as measured by the self and parent-report behavioural questionnaires.

6. For the ABI and NH group, there will be a significant negative relationship between moral reasoning scores on the So-Mature and behavioural difficulties, as measured by the self and parent-report behavioural questionnaires.

Exploratory analysis will be carried out to explore the relationship between moral reasoning and offending behaviour for the ABI and NH group.

6.3 Methods

6.3.1 Participants. Twenty participants with ABIs (M age=15.48, SD=2.91) were recruited from NHS services in Norwich, Cambridge and Sheffield, and also through people signing up via the University of Exeter 'Get Involved' webpage. A NH group of 20 participants (M age=15.33, SD=3.09) were recruited through a school and sixth form in Norwich, and also through media advertisements at the University of East Anglia. The NH group were matched to the ABI group on gender, and matched on age as closely as possible. A parent or caregiver of each participant was also invited to take part by completing a parent booklet. Table 6.1 and Table 6.2 present the eligibility criteria for the ABI and NH participants respectively.

Table 6.1. Eligibility criteria for the ABI participants

Inclusion criteria	Exclusion criteria
6 months post injury/diagnosis	Diagnosis of any developmental disorder prior to the ABI
Any type of ABI	Lack of physical, cognitive or communication ability to engage in the assessments
Age 11-21 years at time of testing	Lack of capacity to consent/assent
English speaking	

Table 6.2. Eligibility criteria for the NH participants

Inclusion criteria	Exclusion criteria
Age 11-21 at time of testing	Diagnosis of any developmental disorder
English speaking	History of any type of brain injury
	Lack of capacity to consent
	Lack of physical, cognitive or communication ability to engage in the assessments

Type of ABI was categorised as either TBI or nTBI based on the brain injury information provided by parents in the parent booklet and relevant medical notes. Eleven out of the 20 ABI participants had a TBI, and 9 had a nTBI. Table 6.3 shows the causes of TBIs and nTBIs in the sample. Injury severity data was unreported for six ABI participants. Based on the available GCS scores, of the 20 ABI participants, 11 had a mild injury (GCS 13-15), one had a moderate brain injury (GCS 9-12), two had a severe brain injury (GCS 8 or less) and six had no severity information (1=TBI, 5=nTBI). Table 6.4 shows the age at injury and time since injury for the ABI group as a whole, and for the TBI and nTBI subgroups.

Table 6.3. Causes of traumatic and non-traumatic injuries in the ABI group.

	Cause of injury	Frequency
Traumatic brain injuries	Traffic accident (passenger)	1
	Traffic accident (pedestrian)	3
	Traffic accident (cyclist)	1
	Fall	3
	Sports injury	3
	Total	11
Non-traumatic brain injuries	Brain tumour	1
	Encephalitis	2
	Brain haemorrhage	2
	Chari 1 malformation	1
	Brain surgery complications	1
	Frontal lobe abscess	1
	Infection	1
	Total	9

Table 6.4. Age at injury and time since injury for the ABI group, TBI and nTBI subgroups

	ABI group (*n*=20)	TBI subgroup (*n*=11)	nTBI subgroup (*n*=9)
Age at injury (years)	11.39 (4.38)	11.42 (3.75)	11.34 (5.29)
Time since injury (years)	4.05 (3.15)	3.52 (2.23)	4.70 (4.07)

Means and standard deviations ().

The required sample size for .08 power, and 0.5 probability was calculated using GPower3 (Faul et al., 2009; Faul et al., 2007). Calculations were based on findings from previous similar studies. The largest sample size estimate was 40 participants, so a total of 40 participants were recruited: 20 in the ABI group and 20 in the NH group.

6.3.2 Recruitment. The ABI group was recruited first, with the NH group being recruited afterwards so that they could be matched on gender and age as closely as possible to the ABI group. The ABI group were recruited via three routes: (1) NHS services in Norwich (Colman Centre for Specialist Rehabilitation, *n*=2), Cambridgeshire (Cambridge Centre for Paediatric Neuropsychological Rehabilitation, *n*=2) and Sheffield (Ryegate Children's Centre, in conjunction with co-ordinators from The Children's Trust, *n*=10), (2) through people signing up to the University of Exeter's Get Involved webpage (*n*=4) and (3) through social media adverts posted by the Encephalitis Society (*n*=2).

At the NHS services, clinicians were asked to distribute information about the study to potential participants, or their parents if the child was under 16. Parents or individuals who were interested in taking part could contact the researcher or return the consent to contact form. For the Exeter Get Involved webpage and the Encephalitis Society webpage, the full information sheets were available to view online and anyone interested in taking part could fill out their contact details or contact the researcher. The researcher then contacted those who were interested in taking part (contact was made with the parent or guardian for those under 16 years) to explain the study to them, check their (or their child's) eligibility to take part, and send the relevant information sheets. If individuals wanted to take part after reading the full information sheet, the researcher arranged a convenient date, time and location for both study sessions to take place. Where the study sessions took place at a participant's home, lone worker procedures were followed.

NH participants were recruited via a school and sixth form in Norwich (Open Academy, n=13), as well as through media advertisements (talk at the University of East Anglia's (UEA) summer school, posters and staff bulletin) at the UEA (n=7). Some participants were taking part in another related study (see Chapters 5 and 6) and were invited to also take part in the current study if they matched the age and gender of an ABI participant (n=9). For school recruitment, the researcher summarised the study at a school assembly and students who were interested took letters home to their parents. The parent letters invited their child to take part in the study and included relevant information sheets. If parents or caregivers wanted their child to take part in the study they could return a signed consent form to the child's school. Those with parental consent were then seen for the study sessions during the school day. Sixth form students were invited to take part during an assembly, with interested students emailing the researcher, or providing the researcher with their school email address.

6.3.3 Design and procedure. Two groups of participants (an ABI Group and a matched NH Group) were recruited and completed all the measures at an initial timepoint (unless they had already completed a measure of general intellectual functioning through the NHS in the past year, or as part of study 1). All participants completed the measures during a one-to-one session with the researcher, either at the participant's home (n=22), Open Academy school (n=13) or the University of East Anglia (n=5). For some participants recruited via schools, the first timepoint needed to be split over two sessions due to the time constraints of conducting the study during the school day, but where this was the case, the two moral reasoning measures were conducted during the same session.

Following a two-week interval, participants completed the two moral reasoning measures again, to allow for an investigation of test-retest reliability. Two weeks were chosen as the appropriate time interval, to allow enough time to pass so participants did not remember exactly what they had answered and further development was unlikely to have occurred. "There is no hard and fast rule for assessing the appropriateness of this lag, but the optimal time lag appears to be in the range of 1 to 4 weeks" Thornberry and Krohn (2000, p. 47).

The measure of general intellectual functioning either the WISC-IV, WAIS-IV or the WASI-II was administered first, as this requires the most cognitive effort, and the other measures were presented in a randomised order. For the SRM-SF and So-Mature, participants gave their responses to the justification questions orally,

which were audio recorded by the researcher; verbatim answers were then later transcribed for scoring purposes. The remaining measures were presented in a paper booklet: the FAS-II, SDS-17 and the SDQ, along with demographic questions and questions about police contact. At the end of the second timepoint session, participants were debriefed and paid five pounds as a thank you for taking part.

The participants' parent or caregiver was also asked to complete the parent version of the SDQ. The parent SDQ was included in a short parent booklet which also asked questions about any contact their child may have had with the police. For the parents of the participants with ABI, the booklet also included questions on the participant's age at injury (in order to determine time since injury), the cause and severity of the ABI, including Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) and Post Traumatic Amnesia scores. Consent was sought to access the NHS trust and GP records of the ABI Group, in order to obtain details about their ABI, such as age at injury and severity and type of ABI.

Verbatim responses for the So-Mature were anonymised and sent to researchers in Canada to be scored according to the coding manual (Beauchamp & Dooley, 2012). These researchers were blinded as to whether the participants were from the ABI or NH group, and to whether the responses were for timepoint one or two. The inter-rater reliability of the So-Mature was examined for the current study, with a second rating scoring 20% (n=16). Results indicated excellent agreement between raters with respect to total score (r=.94). The SRM-SF responses were scored by the researcher after completing self-training using the manual (Gibbs et al., 1992). The SRM-SFs were scored by question rather than by participant so the researchers were blind to group allocation, and whether the response was from time one or two. Twenty percent of the SRM-SFs (n=16) were also scored by the primary supervisor, for inter-rater reliability. Results indicated excellent agreement between raters with respect to total score (r=.97).

6.4 Ethical considerations

The study received a favourable opinion from Essex National Health Service Research Ethics Committee (See Appendix C). Consent was obtained for all participants and they were made aware that they could withdraw from the study at any time. All participants provided informed consent or assent to take part in this study, while parental consent was additionally sought for those under the age of 16 years. The participant information sheets for those under age 16 years used simpler

language. All parents were also provided with participant information sheets detailing their own participation in the study and if they consented to take part they were provided with a parent consent form and the parent booklet. Some questions asked as part of the study could potentially have caused distress, particularly questions asking about police contact. This risk was minimised by making it clear to participants that all information they provided was confidential and that their data would be anonymised. All testing sessions were on a one-to-one basis with the researcher who was able to look out for signs of distress or fatigue and offer breaks where necessary. All participants were debriefed after the study and provided with the researcher's contact details.

6.5 Measures

6.5.1 Moral reasoning. The SRM-SF (Gibbs et al, 1992) measures reasoning in the sociomoral constructs measured of contract, truth, affiliation, life, property, law and legal justice. The SRM-SF consists of eleven short-answer items that address sociomoral values such as keeping a promise and saving a life, e.g. "Think about a time when you've made a promise to a friend of yours. How important is it for people to keep promises to friends?" Participants choose between very important, important or not important and are then asked "why is it very important/important/not important?". Participants gave their answers orally and these were audio-recorded by the researcher to allow for scoring according to the SRM-SF manual. Participants' explanations of their answers were scored developmentally according to a reference manual and a score ranging from 100-400 was computed, relating to global moral stage (see Table 5.2). The SRM-SF has been found to be valid when used with people with intellectual disabilities (Langdon, Murphy, Clare, & Palmer, 2010). The SRM-SF has previously been used in two studies with brain injury samples (Couper et al, 2000; Wigg, 2013), which found that the brain injury groups had significantly lower levels of moral reasoning than the NH groups, but these studies did not report the psychometric properties of the SRM-SF.

The So-Mature (Dooley et al., 2010) is a sociomoral reasoning evaluation instrument based on the moral stages proposed by Kohlberg (1983, 1984) and is part of a set of measures, alongside the So-Moral and So-Emotional. The instrument is a computer based task presenting 19 gender-specific everyday socio-moral dilemmas, such as whether to cheat at a game of Monopoly while your friends are not looking, or whether to sneak into the cinema if you don't have enough money for a ticket. Each dilemma is presented on a laptop as three photographs,

followed by presentation of the two possible responses. Participants are instructed to imagine that they are in that situation with their family or friends and following the presentation of each dilemma, to choose between two possible response options, which is the So-Moral section. The So-Moral dichotomous answers are scored and summed, yielding a moral score between 0-19. After choosing what they would do if they were in that situation participants then answer a 'why?' question, explaining why they chose that response, which is the So-Mature part of the instrument. After providing a justification, the participant is then asked to choose which emotion they would feel the most after making this decision, from the ten available emotions (guilt, shame, pride, indifference, anger, happiness, fear, sadness, disgust and regret), referred to as So-Emotional. The So-Moral and So-Emotional sections of the measure were administered as they are part of the So-Mature presentation, but these sections were not used for analysis in the current study. Each So-Mature answer is scored according to a manual, based on a five-stage socio-moral development model which is a simplification of Kohlberg's stages (Beauchamp & Dooley, 2012). So-Mature scores are summed across the 19 dilemmas, yielding a possible maturity score between 0-95, which relate to 5 moral stages (see Table 6.5).

Table 6.5. So-Mature score and corresponding global stage, with interpretation.

So-Mature score	Global socio-moral maturity level	Interpretation
0-19	Stage 1	Does not acknowledge existence of moral dilemmas in certain situations presented. Choices are made based on observation of rules and fear of being punished by authority figures
20-35	Transition from Stage 1-2	Incorporation of reasoning based on interest in obtaining personal benefits. Mutual exchange of favours and pragmatic agreements.
36-51	Transition from Stage 2-3	Incorporation of prosocial reasoning. Prosocial emotions (guilt, pride, honesty)
52-67	Transition from Stage 3-4	Evaluation of situation in light of effects in others. Incorporation of broader morality
68-82	Transition from Stage 4-5	Prosocial attitude and respect for societal standards. Recognition of exceptions to rules to protect fundamental values.
83-95	Stage 5	Analyses situation from various points of view to make fairest decision. Protection of fundamental values and people's rights.

Note. Taken from the Administration and Coding Manual SocioMoral Reasoning Aptitude Level Task (So Moral), (Beauchamp & Dooley, 2012).

A previously completed pilot study found that adolescents with a TBI were able to complete the So-Mature instrument but were reasoning at a lower level than those without a TBI; however, the difference was not significant (Dooley et al., 2010). A subsequent study found significant differences in moral reasoning maturity level of a TBI group and a healthy TD group (Beauchamp et al., 2013). Although the pilot study tested comprehension and familiarity with the dilemmas, and inter-rater reliability, it did not assess test-retest reliability or internal consistency, so these aspects are yet to be studied.

6.5.2 Behaviour. Behavioural difficulties were measured using the SDQ (Goodman, 1997; Goodman et al., 1998). The SDQ is a 25-item questionnaire comprised of five sub scales (emotional symptoms, conduct problems, hyperactivity/inattentions, peer relationship problems and prosocial behaviour). The subscales (excluding prosocial behaviour) are then added together to generate a total difficulties score. The total difficulties score can be categorised into one of four classifications, based on a large UK community sample: close to average, slightly raised, high or very high. The SDQ includes some antisocial behaviour such as "I take things that are not mine from home, school or elsewhere". The SDQ is a widely used measure and has been found to have good psychometric properties even though it is very brief (Goodman & Scott, 1999). A review found that the psychometric properties are strong and that it measures both problem behaviours and competencies at an early age use (Stone et al., 2010). The SDQ has previously been used with brain injury samples (Anderson et al., 2009; Tonks et al., 2007). The self-report and parent versions were both used in this study. All of the 20 ABI participants returned the parent booklets. Of the 20 NH participants, three parent booklets were unreturned, meaning that there were three missing parent SDQs for the NH group.

As an exploratory investigation into whether moral reasoning is related to offending behaviour in an ABI sample, all participants were also asked some short questions about police contact, which were included in the participant booklet. Participants were asked "Have you ever been in trouble with the police because of your behaviour?" If they answered no there were no further questions but if they answered yes there were follow up questions relating to if they had been arrested, cautioned or convicted. If they answered yes to any of these follow up questions they were asked for details on number of times and dates. Parents were also asked to answer the same questions about their child as part of the parent booklet.

6.5.3 General intellectual functioning. A measure of general intellectual functioning was administered to assess whether any differences found for moral reasoning levels between the ABI and NH group can be accounted for by differences in intellectual functioning. The WISC-IV (Wechsler, 2003) is designed to be used for ages 6-16 years. The WAIS-IV (Wechsler, 2008) is a measure of intellectual functioning designed to be used for ages 16 years and over. Both versions provide a measure of full scale IQ (FSIQ) as well as subscale scores (e.g. verbal comprehension, working memory). The WISC-IV has been shown to be valid in children with open and closed head injuries and Wechsler (2003) concludes that the WISC-IV is useful as part of a comprehensive assessment of children with TBI.

The participants aged between 11 years to 15 years and 11 months completed a WISC-IV while those aged 16-21 years completed a WAIS-IV, which took about 65-80 minutes to complete. Some participants (n=9) were recruited for this study via a linked study (see Chapters 5 and 6) and were already completing a two-subscale version of the WASI–II (Wechsler, 2011), so their scores from the WASI-II were used as an estimate of general intellectual functioning for the current study. The WASI-II is designed for use with ages 6-90 years and provides an estimate of FSIQ from the two subtests of vocabulary and matrix reasoning, and is comparable with the WISC-IV and WAIS-IV. Other NH participants recruited via the same routes as participants for the linked study also completed a WASI-II. Estimates of general intellectual functioning for the current study were based on the WISC-IV (n=13), the WAIS-IV (n=11) and the WASI-II (n=16). Three of the ABI group had completed a WISC-IV in the past year; in these cases, consent was sought to use their existing scores and the scores were obtained from the parent or relevant NHS service, rather than administering the measure of general intellectual functioning again.

6.5.4 Socioeconomic status. SES measures which ask adolescents about parental education and occupation have typically shown poor completion rates (Currie et al., 1997; Wardle et al., 2002) while studies which have asked adolescents about material indicators of SES have found good completion rates (Currie et al., 1997; Wardle et al., 2002). The Family Affluence Scale II (FAS-II) (Currie, et al., 1997, Currie, et al 2004) was used as a measure of SES status. This measure consists of four questions which ask adolescents how many cars are owned by their family, whether they have their own bedroom, how many family

holidays they have taken in the last 12 months and how many computers are owned by their family.

6.5.5 Social desirability. The social desirability bias is the tendency for respondents to answer in a manner that will be favourable to others. In this study, if social desirability correlates highly with the moral reasoning measures then the measures are less valid, as respondents are not responding in a true fashion. The Marlowe-Crowne scale (Crowne & Marlowe, 1960) is a frequently used measure of social desirability and was updated by Stöber (2001), as the original reflected social standards of the 1950s. Stöber's social desirability scale (SDS- 17) has shown a Cronbach's alpha of 0.72 and a test-retest correlation of 0.82, and a correlation of 0.74 with the Marlowe-Crowne scale (Stöber, 2001). The SDS-17 was originally developed to be used for people aged 18 and over but Johnson and Krettanauer (2011) administered the SDS-17 to 205 adolescents ranging in age from 11.33-19.08 years and found that the internal consistency was not lower for younger participants compared with the older adolescents. For the current study, the SDS-17 was used as a measure of social desirability. Some of the items were amended to match the age of the sample, resulting in 15 items, such as "I am always polite and considerate of others" and "I always eat a healthy diet". The SDS-17 was administered as part of a pen and paper booklet.

6.6 Data analysis

All data were entered into IBM SPSS Statistics Version 22. Data were checked for normality in three ways: 1) visual inspection of histograms and P-P plots, 2), converting skewness and kurtosis scores to z-scores, 3) running the Kolmogrov-Smirnov test. No variables departed substantially from normality.

Initial comparisons between the ABI and NH group on age, SES, social desirability and general intellectual functioning were made using an independent samples *t*-test. Analyses were then performed to explore the psychometric properties of the moral reasoning measures at Time 1 and Time 2. Internal consistency was examined by calculating Cronbach's alpha and test-retest reliability was examined by calculating the intraclass correlation coefficient (ICC; single measures). Convergent validity between the moral reasoning measures was explored by assessing the Pearson's correlation coefficients (two-tailed).

A paired samples *t*-test was performed to assess the effect of time for the ABI and NH group on SRM-SF and So-Mature scores. Pearson's correlations (two-

tailed) were calculated to assess the relationships between moral reasoning variables at Time 1 and general intellectual functioning, social desirability and SES, to assess any potential co-variates. An independent *t*-test was performed to assess differences in moral reasoning scores for the ABI and NH group. A series of ANOVAs and ANCOVAs were performed to assess differences in self and parent-reported behavioural difficulties for the ABI and NH group. Finally, Pearson's correlations were calculated to explore the relationships between SRM-SF and So-Mature scores and self and parent-reported behavioural difficulties. Exploratory analyses are also reported.

6.7 Results

6.7.1 Descriptive statistics. The descriptive statistics for the sample are displayed in Table 6.6. As expected, due to the groups being matched on age, there were no significant differences between the ABI and NH group on age (t (38) =.16, p=.87). There were also no significant differences between the ABI and NH group on social desirability (t (38) = -.28, p=.78) and SES (t (38) =-1.84, p=0.73). The ABI group had significantly lower general intellectual functioning than the NH group (t (38) = -3.01, p=.01) with a small effect size (r=.21). There were no significant differences between the TBI and nTBI subgroups for age at injury (t (18) = -.04, p=.97) or time since injury (t (18) =.83, p=.42). All 40 participants completed all measures, apart from the parent report SDQ, of which 3 were unreturned for the NH group.

Table 6.6 Descriptive statistics for the ABI and NH group.

	ABI (*n*=20)	NH (*n*=20)
Age (years)	15.48 (2.91)	15.33 (3.09)
General intellectual functioning	89.25 (11.62)	102.55 (15.96)
Gender	11 M, 9 F	11 M, 9 F
FAS-II	6.95 (1.47)	6.00 (1.78)
SDS-17	10.25 (3.28)	10.50 (2.31)
Parent report total difficulties SDQ	15.85 (9.59)	7.88 (6.22)
Self-report total difficulties SDQ	12.90 (5.46)	10.50 (4.76)
Time 1 So-Mature	48.81 (8.13)	55.53 (8.46)
Time 2 So-Mature	49.08 (7.49)	55.98 (9.82)
Time 1 SRM-SF	257.65 (35.51)	279.15 (36.85)
Time 2 SRM-SF	256.85 (41.51)	285.20 (32.28)

Note. Means and standard deviations (). Gender=numbers of male (M) and female (F) participants. Age calculated from age at first session. General intellectual functioning score from WISC-IV, WASI-IV or WAIS-II.

6.7.2 Psychometric properties of the SRM-SF. For the ABI group, the internal consistency of the SRM-SF was moderate at Time 1 (α=.49) and excellent at Time 2 (α =.85). For the NH group, internal consistency of the SRM-SF was substantial at both Time 1 (α =.80) and Time 2 (α =.77). For the groups combined, internal consistency of the SRM-SF was substantial at Time 1 (α =.74) and excellent at Time 2 (α =.85). Hypothesis 1, that the SRM-SF will show excellent internal consistency (.80 or above) was supported for the ABI group at Time 2, the NH group at Time 1 and for the groups combined at Time 2. The test-retest reliability of the SRM-SF was good for the ABI group (ICC =.75), the NH group (ICC =.74) and the groups combined (ICC =.77). Hypothesis 1, that the SRM-SF will show excellent test-retest reliability (.80 or above) was not met.

6.7.3 Psychometric properties of the So-Mature. For the ABI group, the internal consistency of the So-Mature was substantial at both Time 1 (α =.76) and Time 2 (α =.69). For the NH group, the internal consistency of the So-Mature was substantial at Time 1 (α =.79) and excellent at Time 2 (α =.83). For the groups combined, internal consistency of the So-Mature was substantial at Time 1 (α =.80) and excellent at Time 2 (α =.85).The test-retest reliability of the So-Mature was good for the ABI group (ICC=.68), excellent for the NH group (ICC=.84) and excellent for the groups combined (ICC=.81).

6.7.4 Convergent validity of the SRM-SF and So-Mature. There was no significant association between scores on the SRM-SF and the So-Mature for the ABI group at Time 1 (r=.16, p=.508) or Time 2 (r=.36, p=.124), suggesting little convergent validity. There were significant associations between scores on the SRM-SF and So-Mature for the NH group at Time 1 (r=.68, p=.001) and Time 2 (r=.47, p=.039). There was a significant association between scores on the SRM-SF and the So-Mature for the groups combined at Time 1 (r=.49, p=.001) and Time 2 (r=.48, p=.002), suggesting moderate convergent validity. Hypothesis 2, that the SRM-SF and So-Mature will correlate highly with each other (0.70 or above) was not supported, with the highest convergent validity being .68.

6.7.5 Assessing potential co-variates. A paired samples t-test revealed that there was no significant effect of time for the ABI group on SRM-SF scores (t (19) =.13, p=.897) or So-Mature scores (t (19) =-.19, p=.850). There was also no significant effect of time for the NH group on SRM-SF scores (t (19) = -1.1, p=.289) or So-Mature scores t (19) = -.39, p=.700). As there was no effect of time on moral

reasoning scores, and Time 2 data were only collected for test-retest reliability analysis, Time 1 moral reasoning scores will be used in subsequent analyses.

6.7.5.1 *Moral reasoning.* To assess whether any variables should be entered as co-variates in subsequent analyses comparing moral reasoning sores for the ABI and NH group, Pearson's correlations (two-tailed) were performed to explore relationships between moral reasoning scores and general intellectual functioning, social desirability and SES. For the ABI group, there was a significant relationship between SRM-SF scores at Time 1 and general intellectual functioning (*r*=.47, *p*=.035). There was no significant relationship between SRM-SF scores and SES (*r*=.06, *p*=.811) or social desirability (*r*=-.06, *p*=.792). There were no significant relationships between So-Mature scores at Time 1 and general intellectual functioning (*r*=.40, *p*=.083), SES (*r*=-.41, *p*=.073) or social desirability (*r*=.03, *p*=.197), although the relationship between So-Mature scores and general intellectual functioning neared significance.

For the NH group, there were no significant relationships between SRM-SF score and general intellectual functioning (*r*=.37, *p*=.107), SES *(r*=.09, *p*=.713) or social desirability (*r*=-.04, *p*=.855). There were no significant relationships between So-Mature scores at Time 1 and general intellectual functioning (*r*=.07, *p*=.786), SES (*r*=.09, *p*=.697) or social desirability (*r*=.04, *p*=.863). General intellectual functioning was related to SRM-SF scores for the ABI group but not the NH group. As general intellectual functioning significantly differs between the ABI and NH group, it is not appropriate to enter general intellectual functioning as a covariate. No covariates will be entered for the moral reasoning analyses.

6.7.5.2 *Behaviour.* To assess whether any variables should be entered as co-variates in subsequent analyses comparing behavioural difficulties for the ABI and NH group, Pearson's correlations (two-tailed) were performed to explore relationships between self and parent-report behavioural difficulties scores and general intellectual functioning, social desirability and SES. For the ABI group, there were no significant relationships between self-report behavioural difficulties and general intellectual functioning (r= -.29, p=.210), SES (r=-.19, p=.436) or social desirability (r= -.30, p=.205). There were also no significant relationships between parent-report behavioural difficulties and SES (r= -.38, p=.100) or social desirability (r= -.22, p=.359). There was a significant relationship between parent-report behavioural difficulties and general intellectual functioning (r= -.56, p=.010). As stated, as general intellectual functioning significantly differs between the ABI and NH group, it is not appropriate to enter this as a covariate.

For the NH group, there was no significant relationship between self-report behavioural difficulties and general intellectual functioning (r= -.03, p=.207) or social desirability (r= -.20, p=.395). There was a significant relationship between self-report behavioural difficulties and SES (r= -.51. p=.022). There were no significant relationships between parent-report behavioural difficulties and general intellectual functioning (r= -.38, p=.133) SES (r= -.31, p=.221) or social desirability (r= -.10, p=.717). For the analysis comparing self-report behavioural difficulties for the ABI and NH group, SES will be entered as a covariate.

6.7.6 Moral reasoning analysis. An independent *t*-test found no significant difference between the ABI and NH group on SRM-SF scores (t (38) =1.88, p=.068). The mean score for the ABI group on the SRM-SF was at transition Stage 3 (2) and the mean score for the NH group of the SRM-SF was at Stage 3. For the So-Mature, the ABI group scored significantly lower than the NH Group (t (38) = 2.56, p=.015). The mean score for the ABI group on the So-Moral was at the transition from Stage 2 to Stage 3, while the mean score for the NH group was at the transition from Stage 3 to Stage 4. Hypothesis 3, that the will be a significant difference in moral reasoning for the ABI and NH group was partially supported.

6.7.7 Behaviour analysis. Self and parent report behavioural difficulties were significantly related to each other for the ABI group (r=.51, p=.023) and the NH group (r=.74, p=.001). An initial one-way ANOVA found no significant difference between the ABI and NH group for self-reported behavioural difficulties (F (1, 38) = 2.20, p=.147). An ANCOVA controlling for SES revealed that the ABI group scored

significantly higher than the comparison group on self-report behavioural difficulties ($F_{(1, 37)}$ =4.57, p=.039). The mean estimates for both groups were close to average. Parent-reported behavioural difficulties were significantly higher for the ABI group compared to the NH group ($F_{(1, 38)}$ =8.63, p=.006). The mean score for the NH group was close to average and the mean score for the ABI group was slightly raised. Hypothesis 4, that the ABI group will display more behavioural difficulties than the NH group was supported.

6.7.8 Relationships between moral reasoning and behaviour. For the ABI group, there were no significant relationships between Time 1 SRM-SF scores and self-report behavioural difficulties (r=.13, p=.577) or parent-report behavioural difficulties (r= -.27 p=.254).There were no significant relationship between Time 1 SRM-SF scores and self-report behavioural difficulties (r= -.14, p=.562) or parent-report behavioural difficulties (r= -.36, p=.154) for the NH group. Hypothesis 5, that there will be a significant negative relationship between scores on the SRM-SF and behavioural difficulties for the ABI and NH group was not supported.

For the ABI group, Time 1 So-Mature scores were significantly related to self-report behavioural difficulties (r= -.52, p=.020) but not to parent-report behavioural difficulties (r= -.09, p=.712). Time 1 So-Mature scores did not correlate with self-report behavioural difficulties (r= -.04, p=.860) or parent-reported behavioural difficulties (r= -.25, p=.327) for the NH group. Hypothesis 6, that there would be a significant negative relationship between So-Moral scores and behavioural difficulties was partially supported for the ABI group but not for the NH group.

6.7.9 Exploratory analyses. Exploratory analysis was performed to explore differences in moral reasoning scores for the TBI and nTBI subgroups of the ABI group, and also to explore the effect of injury severity and age at injury An independent t-test found no significant difference between the TBI and non-TBI subgroups on SRM-SF scores ($t_{(18)}$ =.98, p=.448). There was no significant difference between the TBI and non-TBI subgroups on So-Mature scores ($t_{(18)}$ = .23, p=.393). Injury severity data was incomplete for the nTBI subgroup so could not be used for analysis. For the TBI subgroup (n=11), seven had a mild TBI, one a moderate TBI, two had a severe TBI and the severity was unreported for one participant. Comparing the mild (n=7) to moderate and severe TBIs (n=3), there were no significant difference between SRM-SF scores ($t_{(8)}$ =1.17, p=.393) or So-Mature scores ($t_{(8)}$ = .61 p=.322).

For the ABI group as a whole there was no significant relationship between age at injury and So-Mature scores at Time 1 ($r=-.03$, $p=.912$) or SRM-SF scores at Time 1 ($r=.43$, $p=.057$), although the latter neared significance. For the TBI subgroup there was no significant relationship between age at injury and So-Mature scores at Time 1 ($r=-.11$, $p=.753$) or SRM-SF scores at Time 1 ($r=.34$, $p=.309$). For the nTBI subgroup there was no significant relationship between age at injury and So-Mature scores at Time 1 ($r=.09$, $p=.829$) or SRM-SF scores at Time 1 ($r=.52$, $p=.154$).For the ABI group as a whole there was no significant relationship between time since injury and So-Mature scores at Time 1 ($r=.09$, $p=.706$) or SRM-SF scores at Time 1 ($r=-.19$, $p=.433$). For the TBI subgroup, there was no significant relationship between time since injury and So-Mature scores at Time 1 ($r= -.06$, $p=.853$) or SRM-SF scores at Time 1 ($r= -.40$, $p=.221$). For the nTBI subgroup, there was no significant relationship between time since injury and So-Mature scores at Time 1 ($r= .27$, $p=.489$) or SRM-SF scores at Time 1 ($r= -.16$, $p=.683$).

The police contact questions were added as exploratory variables. In total, three participants reported some police contact. These participants were all male, with an average age of 16 years (SD 2.15). Only one parent reported that their child had had some police contact, which was a parent of one of the three who self-reported police contact. The two participants who had self-reported police contact only were from the NH group. Both reported having been in trouble with the police for their behaviour, and one reported being cautioned once. The participant with self and parent-reported police contact was from the ABI group (TBI; severity unknown) and reported being in trouble with the police because of their behaviour, and arrested and cautioned once. The same information was reported by their parent. For this ABI participant, their SRM-SF score at Time 1 was 206 (Stage 2) which is a stage lower than the mean for the ABI group in this study (transition Stage 3 (2)). Their So-Mature score at Time 1 was 38 (transition from Stage 2-3), which matches the mean stage of the ABI group in this study.

6.8 Summary

The aims of this study were to a) examine the psychometric properties of two measures of moral reasoning, the SRM-SF and So-Mature, b) use these measures to compare moral reasoning levels of an ABI and NH group, and c) investigate how behaviour differs between the ABI and NH group, and whether low moral reasoning is related to behavioural difficulties.

Results indicated that the SRM-SF and So-Mature had satisfactory psychometric properties for the ABI and NH group. The test-retest reliability of the SRM-SF and So-Mature was good or excellent for both groups. Internal consistency of the SRM-SF was higher for the NH group than the ABI group, which was more inconsistent, being moderate at Time 1 and excellent at Time 2. This suggests that adolescents with ABI may be less consistent in their reasoning across different moral values (e.g. truth, affiliation, legal justice). Internal consistency of the So-Mature was overall higher than for the SRM-SF, ranging from substantial-excellent for the ABI and NH group. The So-Moral and So-Mature measures involve participants imagining they are in situations (presented on a computer screen), making a response decision and then explaining that decision. This may lead to more consistent reasoning compared to reasoning about a wide range of moral values on the SRM-SF, "e.g. why is it very important/important/not important for people to keep promises, if they can, to friends?" The SRM-SF and So-Mature showed convergent validity for the NH group but not for the ABI group. This suggests that for adolescents with ABIs, moral reasoning about values does not correlate with moral reasoning about response decisions they have made in certain situations. Again, this would suggest an inconsistency of moral reasoning across values and situations for adolescents with ABI. The ABI group had significantly lower general intellectual functioning than the NH group, which may impact on the ability to apply moral reasoning about values to specific situations.

The ABI group were on average reasoning at transition Stage 3 (2) and the NH group were on average reasoning at Stage 3 on the SRM-SF but the difference in score was not significant. A significant difference between groups was found for the So-Mature, with the ABI group reasoning at the transition from Stage 2-3 while the NH group were reasoning at the transition from Stage 3-4. Exploratory analysis found no significant differences between the TBI and nTBI subgroup on either the SRM-SF or So-Mature, suggesting that both TBIs and ABIs can have an effect on moral reasoning maturity. No significant differences were found between mild and moderate/severe TBIs, which is in line other studies (Beauchamp et al., 2012; Dooley et al., 2012) but may also be due to the small number of TBI participants with reported severity information (n=10). The sub-group analyses should be interpreted with caution as they were exploratory and may have been underpowered. The significant difference between the ABI and NH group for So-Mature but not SRM-SF scores suggests that reasoning about moral values is not as affected following an ABI than reasoning about moral response decisions.

Adolescents with ABIs may have difficulty with moral or social decision-making rather than an understanding and appreciation of moral values; they understand moral values but may struggle to apply them to their own decision-making. It has been found that how people act in moral dilemmas differs from how they say they will act in such situations (Patil, Cogoni, Zangrando, Chittaro, & Silani, 2014); this effect may be more pronounced in adolescents with ABIs, but further research is needed in this area.

In terms of behaviour, the ABI group displayed more behavioural difficulties than the NH group. The ABI group scored significantly higher on self-reported behavioural difficulties than the NH group, after controlling for SES. The ABI group also scored significantly higher on parent-reported behavioural difficulties than the NH group. Self-report difficulties were close to average for both groups but 'slightly raised' on the parent report for the ABI group, which may suggest a lack of insight into one's own behavioural difficulties among the ABI participants, which has been found following brain injuries (Ownsworth, McFarland, & Young, 2002; Sherer, Hart, & Nick, 2003). In addition, the self and parent report behavioural difficulties were more strongly related for the NH group than the ABI group. For the NH group, there were no relationships between moral reasoning and behaviour. For the ABI group, there was a significant negative relationship between self-report behavioural difficulties and scores on the So-Mature, but no relationship between behaviour and scores on the SRM-SF. The relationships between behaviour and So-Mature but not SRM-SF scores may reflect the fact that the So-Mature involves reasoning about response decisions made in everyday situations, so scores on this measure may more closely relate to behaviour, compared to reasoning about values measured in the SRM-SF. A lack of relationships between the So-Mature and behaviour for the NH group is in contrast to previous research which has found relationships between the So-Mature and aggressive behaviour for TD adolescents (Dooley et al., 2010).

Police contact questions were added as exploratory variables, as an initial investigation into whether moral reasoning scores are related to offending behaviour in an adolescent ABI sample. Only three of the 40 participants reported any police contact, with only one of these being from the ABI group. The moral reasoning scores for this participant was comparable with the mean scores for the ABI group on the So-Mature, but one stage lower than the mean for the ABI group on the SRM-SF. Future studies using samples of adolescents with ABIs who have been

involved in offending behaviour could further explore the relationship between moral reasoning and offending in this population.

Chapter 7: Discussion

7.1 Chapter overview

The overall objective of this thesis was to make some initial strides towards integrating aspects of developmental psychology and social neuroscience approaches to moral decision-making and development. This objective was addressed by (a) presenting a new theoretical framework; the SIP-MDM framework, which combines aspects from both disciplines, (b) conducting a systematic review and meta-analysis of neuroimaging research into moral decision-making, and (c) investigating a series of hypotheses generated using the SIP-MDM framework in TD adolescents and adolescents with ABIs. This discussion chapter will firstly summarise the SIP-MDM framework introduced in Chapter 3 before summarising the main findings of the systematic review and empirical studies. Clinical and theoretical implications will be discussed, followed by the strengths and limitations of the systematic review and meta-analysis, the TD studies and the ABI study. Finally, this chapter will suggest areas for future research before finishing with concluding remarks.

7.2 Summary of findings

7.2.1 A new theoretical framework. Within Chapter 3, the SIP-MDM theoretical framework was introduced, which incorporated aspects from developmental psychology and social neuroscience moral theories. In developing this framework, SIP theory was incorporated, while moral decision-making was placed alongside other types of decision-making, highlighting that moral decisions and behaviour are subject to contextual and situational influences. This framework can help to explain how real-time moral decisions occur, how they relate to behaviour, and how they mature over time. A developmental aspect was also added to ensure it was clear that the development of components was associated with increased efficiency of information processing and the capacity for making mature moral decisions. The SIP-MDM framework expanded the definition of moral development to incorporate the maturation of component skills and processes, along with the maturation of moral decision-making. The centre of all these developmental changes is the brain, and as such, this was added to the centre of the framework, as a component that affects all steps of processing and the development of other components, but it was acknowledged that this aspect could be expanded upon through further research into brain regions involved in moral

decision-making. Furthermore, research exploring hypotheses based upon the SIP-MDM framework may lead to support for the framework or arguments of reformulation.

7.2.2 The neural correlates of moral decision-making. A systematic review and meta-analysis was presented in Chapter 4, which aimed to review the neuroimaging research into MEs and MRDs. Findings from the ALE meta-analysis revealed that when making one's own moral decisions about what to do in a moral dilemma, there was increased activation of additional brain areas compared to when judging the moral actions of others, suggesting different processes may be involved. Making one's own decisions appears to involve an extended brain network, incorporating self-referential regions which do not show an increase in activation when making MEs. While the vmPFC has previously been implicated in moral decision-making, the results of this meta-analysis did not find a cluster of activation in the vmPFC for MRDs. This finding highlighted that previous conclusions about the brain regions involved in moral decision-making have been based on studies primarily using ME tasks, and that making your own decisions about what to do in a moral dilemma is different to judging the appropriateness of the actions of others or judging statements as right or wrong.

7.2.3 Exploring the SIP-MDM framework in typically developing adolescents. Within Study 1 presented in Chapters 5 and 6, the proposed relationships between components of the SIP-MDM framework were investigated with 80 TD adolescents, aged 11-18 years. Study 1 aimed to investigate relationships between cognitive and affective component processes of the SIP-MDM framework and moral reasoning, whether these components mature with age and whether moral reasoning relates to self-report or parent report behavioural difficulties. Findings indicated that working memory and moral reasoning correlated positively with age, but perspective taking, empathy and emotion recognition did not. Working memory correlated with moral reasoning but did not significantly predict moral reasoning after controlling for age and general intellectual functioning. There were no significant relationships between moral reasoning and perspective taking, empathy or emotion recognition. There were also no significant relationships between moral reasoning and behavioural difficulties.

Study 1 also aimed to investigate whether SIP abilities mature with age, and to explore relationships between components processes and steps of the SIP-MDM framework. While it was proposed that SIP skills develop with age, there is limited

research studying the typical developmental trajectory for SIP skills. Study 1 presented novel findings regarding how SIP skills relate to age in a TD sample of 11-18 year olds. It was hypothesised that components in the centre of the SIP-MDM framework (e.g. SES and moral reasoning) would correlate with proficiency at each SIP step, and that SIP steps would be predicted by components in the centre and components relevant at each step. It was found that only Steps 1 and 2, encoding and interpretation positively correlated with age. Steps 4 and 5, response access and response decision showed negative correlations with age, with older participants generating and selecting fewer prosocial responses. In terms of predictive relationships of the SIP-MDM framework, it was found that while working memory correlated with some variables at Steps 1 and 2, it did not predict scores at these steps. Moral reasoning also correlated with some variables at Steps 1 and 2 and significantly predicted the number of emotion, interpretation and total cues encoded, and the number of interpretation cues used when assessing intent. No relationships were found between any of the SIP steps and perspective taking, empathy, emotion recognition, SES or current mood.

7.2.4 Moral reasoning and behaviour in adolescents with acquired

brain injuries. Within Study 2, presented in Chapter 7, some aspects of the SIP-MDM framework were investigated with adolescents with ABIs by comparing moral reasoning and behaviour of an ABI group (aged 11-21 years, *n*=20) with a NH group (*n*=20), matched on age and gender. This study aimed to investigate the psychometric properties of two measures of moral reasoning, the SRM-SF and the So-Mature. Novel findings were presented, as the internal consistency and test-retest reliability of the SRM-SF have not previously been reported when used with ABI samples, and these psychometric properties of the So-Moral have not previously been reported for either ABI or non-ABI samples. These measures were used to compare moral reasoning maturity of the ABI and NH group. In addition, self-report and parent reported behavioural difficulties were compared for the groups, and relationships between moral reasoning maturity and behaviour were explored. Results indicated that the SRM-SF and So-Mature had satisfactory psychometric properties for the ABI and NH group, though internal consistency on the SRM-SF was only moderate at Time 1 for the ABI group, suggesting an inconsistency in reasoning about moral values among the ABI group. The ABI group were reasoning at a stage lower than the NH group on both measures, though the difference in reasoning score was only significant for the So-Mature. It was found that the ABI group displayed more behavioural difficulties

based on both the self-report and parent report questionnaires. No relationships were found between moral reasoning and behaviour for the NH group, but there was a significant negative correlation between self-report behavioural difficulties and scores on the So-Moral for the ABI group.

7.3 Theoretical and clinical implications

7.3.1 Towards an integrative theory of moral decision-making and development.

Developmental psychology and social neuroscience approaches to moral decision-making and development have developed separately, with different research methods and informed by separate theories. Theories and research have tended to focus on moral decisions rather than behaviour as the end point. There have also been divides within theories from these disciplines, such as whether moral decisions are driven by intuitions or reasoning. Furthermore, although many components have been proposed to be important for moral decision-making and development, these have not previously been integrated into one comprehensive theory, and research does not tend to measure multiple components to assess relationships between them. The SIP-MDM framework suggested in this thesis attempted to address these issues by demonstrating how suggested components from various moral theories can be integrated. This framework combined both automatic processes (somatic markers and schemas) and moral reasoning, showing how both can guide moral decisions and the end point of moral behaviour (Step 6).

The SIP-MDM framework was developed by expanding on previous integrations of moral theory with SIP, and incorporated other skills and processes theorised to be important for moral development. Looking to the future of moral theory development, the SIP-MDM framework offers promise that concepts from developmental psychology and social neuroscience can be incorporated into one integrative framework. This is a step towards a dynamic model of moral decision-making, which was suggested by Van Bavel and colleagues (2015) and shows how moral decisions are not just driven by automatic intuitive processes and/or slower reasoning processes, but that many other components and factors are involved. This framework included brain development but also referenced the rich tradition of developmental psychology. Using the term 'moral decision-making' places moral decisions alongside other types of decision-making, which can help in thinking about the general influences and processes that guide such decisions (e.g. situational factors), along with the morally specific processes, creating richer

explanations of decisions and behaviour. Predictions can be made based on the SIP-MDM framework, which can be tested in future research studies, leading to further clarification of the relationships between components and hopefully a thorough model which accurately predicts behaviour.

      7.3.2 Challenges to theoretical assumptions. The SIP-MDM framework is not at present a working model or theory but can be used to generate hypotheses to guide future research and theory development in this area. The empirical studies presented in this thesis attempted to explore some of the hypotheses of the SIP-MDM framework in TD adolescents and adolescents with ABIs, finding only limited support and highlighting some inconsistencies with theoretical assumptions of the framework and the moral theories it is derived from.

      Firstly, the components of the SIP-MDM framework are proposed to develop with age, but empathy, perspective taking and emotion recognition did not correlate positively with age, and only some encoding and interpretation variables correlated positively with age in Study 1. It may be that some of these processes do not show marked developmental changes between the ages of 11 and 18 years. Such an interpretation is inconsistent with what is known about adolescent brain development; the lack of relationships with age may therefore reflect issues with some of the measures used in Study 1, or it may be that there is large individual variability in the development of these components and the sample size was too small to detect a significant effect of age. Exploratory analyses revealed that for females, age was significantly related to working memory and emotion recognition, but these relationships were not significant for males. These differences may be due to sex-specific maturational changes of the developing brain (Giedd et al., 2006; Giedd et al., 1996; Lenroot & Giedd, 2010) or gender-related differences in the development of executive functions (Anderson, 2001; McClure, 2000), but these findings should be interpreted with caution as the analysis was only exploratory.

      Previous research has failed to find development of affective empathy during adolescence (Garaigordobil, 2009; Schwenck, Göhle, Hauf, Warnke, Freitag, & Schneider, 2014; Van der Graaff et al., 2014). A study using the ERT in 373 TD participants aged 8-75 years found that for the 8-17 year olds, happiness significantly correlated positively with age (r=.23) and anger showed a significant negative correlation with age (r=-.21) but fear, sadness, disgust and surprise did not show development effects for this age group (Kessels, Montagne, Hendriks, Perrett, & Haan, 2014). In terms of perspective taking development with age, Abell and

colleagues (2000) found that accuracy on the animated triangles task was equivalent for TD 8 year olds and adults. However, Schwenck et al. (2014), found that age accounted for 29.3% of the variance on the animated triangles task for TD participants aged 7-17 years, so the lack of correlation with age for Study 1 of this thesis is surprising. Another surprising finding of the empirical studies was that age was negatively correlated with prosocial first responses and prosocial decisions in Study 1, with older participants displayed less prosocial decision-making. These findings suggest that moral decision-making may follow a curvilinear pattern, as found for moral reasoning by Bear and Rhys (1994) and Langdon and colleagues (2001b).

Secondly, while a relationship was found between moral reasoning and working memory in Study 1, no relationships were found between moral reasoning and perspective taking, empathy or emotion recognition. The lack of correlation between moral reasoning and these cognitive and affective processes is inconsistent with theoretical assumptions, especially as perspective taking is the component most frequently cited as being important for moral development. There is a lack of research investigating the relationship between moral reasoning and perspective taking so before this theoretical assumption is rethought, future studies are needed to explore this relationship. Previous research into relationships between other cognitive and affective processes and moral reasoning is limited but Dooley et al (2010) found a significant positive correlation between empathy, as measured by the IECA, and moral reasoning, as measured by the So-Mature in TD adolescents. While Study 1 of this thesis also used the IECA as a measure of affective empathy, the SRM-SF was used a measure of moral reasoning; it may be that empathy correlates more with reasoning about moral response decisions than reasoning about moral values. However, relationships have been found between scores in the IECA and the SRM-SF in delinquent populations (Lardén, Melin, Holst, & Långström, 2006) and adults with intellectual disabilities (Langdon, Murphy, Clare, Steverson, & Palmer, 2011). Further research is needed into the relationships between affective empathy and moral reasoning in TD adolescents.

Finally, it was proposed that SIP steps within the SIP-MDM framework are influenced by components at each step and components in the centre of the framework. However, some components in the centre of the framework did not correlate with any of the SIP steps in Study 1, calling into question the hypothesised predictive relationships of the framework. Further research using larger samples

could look at potential mediating relationships of the framework, for example, whether moral reasoning mediates the link between working memory and SIP steps. There are many relationships between components proposed within the SIP-MDM framework which remain to be tested, such as whether attention is related to Step 1, and how parenting impacts on all steps. Further research exploring hypotheses of the SIP-MDM framework in TD and atypically developing samples of different ages is needed, and findings may call theoretical assumptions into question, leading to further theory development.

7.3.3 A moral brain? The three clusters of significant shared activation for MEs and MRDs found in the meta-analysis were the left MTG, left CG, and left MFG. These regions are also involved in other processes, so are not unique or specific to making moral decisions. All three significant clusters were found in the left hemisphere, which is involved in language (Springer et al., 1999) so this may reflect the fact that most of the tasks involve language processing. It has been found that perceptual decisions engaged the left hemisphere of the MFG (Talati & Hirsch, 2005) and that the MTG is involved in multimodal semantic processing (Visser, Jefferies, Embleton, & Ralph, 2012) with the left MTG being the core component of the semantic network (Wei et al., 2012). The cluster of activation in the CG was found in BA 31, which is part of the posterior cingulate cortex and has been found to show increased activation when judging the valence of emotional words (Maddock, Garrett, & Buonocore, 2003); increased activation of this area for MRD and ME tasks may therefore reflect processing of written emotional stimuli.

Neuroimaging and lesion research has implicated the vmPFC in moral decision-making. However, the majority of such studies use hypothetical dilemmas that involve judging the appropriateness of a protagonist's actions, rather than making a response choice about what you would do. The systematic review and meta-analysis presented in Chapter 4 highlighted the differences in ME and MRD tasks, and found that the vmPFC was not a significant cluster for MRDs. Relative to ME tasks, MRDs were found to additionally activate the left and right MTG and the right precuneus, suggesting that making one's own decisions about what to do in a moral dilemma is different to judging the appropriateness of the actions of other people and activates additional brain regions. While activation of the right precuneus in MRD tasks may reflect increased self-referential processing compared to when making MEs of other people's behaviour, it may just reflect differences between the moral task types. The right precuneus is associated with metaphor

comprehension (Mashal, Vishne, & Laor, 2014) and verbal creative thinking (Chen et al., 2015), so activation of this region during MRD tasks may reflect the fact that these tasks tend to involve dilemmas that are not typical to real life (e.g., choosing to kill one or five people), thus may require more abstract thinking about unfamiliar situations.

One surprising finding of the meta-analysis presented in this thesis was that the rTPJ, an area associated with ToM, showed increased activation for MRDs but not MEs, suggesting that ToM processes are even more involved when making one's own moral decisions than when making evaluations of others. One explanation for this finding may be the type of tasks used in experiments included in the systematic review. The hypothetical dilemmas used in the included MRD experiments involved other people, so participants may typically infer the mental states or possible mental states of others when deciding their response. Some of the included ME tasks did not reference other people, such as judging sentences as 'right' or 'wrong' so would not have led to participants inferring mental states of others. Contrary to the finding for this meta-analysis, Bzdok et al. (2012) found significant activation in the rTPJ for their moral cognition domain. However, experiments were only included in the moral cognition analysis if tasks involved participants making "appropriateness judgements on actions of one individual towards others" (p. 785) so always involved judging the actions of other people.

The results of the meta-analysis in Chapter 4 supported the view that there is no 'moral brain' (Fumagalli & Priori, 2012; Young & Dungan, 2012) i.e. no region or network uniquely involved in moral decision-making. This is in line with aspects of the SIP-MDM framework; real-time moral decision-making involves many different processes such as empathy, emotion recognition and working memory and so will activate various brain regions and networks to different extents, depending on individual and situational factors. Consistent with the SIP-MDM, damage to any region of the developing brain may impact on moral decision-making and development. Some support for this proposal was found in Study 2, which included a wide range of ABIs, including nTBIs, and found a significant difference between the ABI and NH group for moral reasoning on the So-Mature.

7.3.4 Explaining moral behaviour. Most moral theories and research in this area have focused on moral decisions, rather than behaviour as the end point. The SIP-MDM framework categorised Step 5 as moral response decisions, the step before behaviour enactment (Step 6). Other types of moral decision (judgements

and evaluations) are important at other steps of processing but moral response decisions are a proximal step before behaviour. The systematic review presented in this thesis highlighted that choosing what to do in a moral dilemma is different to making evaluations such as evaluating the actions of others or judging moral sentences as right or wrong, and that choosing what to do recruits additional brain regions. Study 2 found convergent validity between the SRM-SF and the So-Mature for the NH group, suggesting that reasoning about moral values, such as life and justice, correlates with reasoning about response decisions one has made in a hypothetical moral dilemma. Although different brain regions are activated for different types of moral decisions, there appears to be some relationships between an understanding of moral values and reasoning about moral response decisions for NH adolescents.

The lack of convergent validity between the SRM-SF and So-Mature for the ABI but not the NH group in Study 2 suggests that adolescents with ABIs may struggle to apply their understanding of moral values to their own decision-making. Further research is needed to confirm this interpretation of the novel finding of Study 2. Previous research has found that adults with TBIs and children with frontal lobe lesions do show developmentally delayed moral reasoning on the SRM-SF (Couper et al., 2002; Wigg, 2013). Before strong conclusions can be made about moral reasoning maturity in adolescents with ABIs, further research which includes different types and severity of ABIs and different age of injury and time since injury is necessary, as Study 2 of this thesis only included a sample of 20 adolescents with mostly mild ABIs and a mean age of injury of 11.39 years (4.38). If it is the case that adolescents with ABIs show delayed moral reasoning for their own response decisions but not for moral values, research could focus on exploring why this is true; for example, whether this is due to certain processes such as working memory and abstract reasoning being affected after ABI and limiting the ability to apply abstract moral values in real-life dilemmas. Such research could add to our understanding of the role of moral development in the relationship between brain injury and offending.

A significant relationship between self-reported behavioural difficulties and scores on the So-Mature was found for the ABI group in Study 2 of this thesis. However, no relationships were found between moral reasoning (as measured by the SRM-SF or So-Mature), and self or parent-reported behavioural difficulties for TD adolescents in Study 1 or NH adolescents in Study2. While some studies have

found relationships between moral reasoning and behaviour (Carlo et al., 2011; Dooley et al., 2010; Miller et al., 1996), there is limited research which has investigated this relationship using the SRM-SF in TD populations. Dooley and colleagues (2010) found a strong negative correlation between moral reasoning scores on the So-Mature and aggressive behaviours and oppositional defiant symptoms in TD adolescents using the parent-report version of the Child Behavioural Checklist (Achenbach & Rescorla, 2001) and the self-report Form of Aggression Scale (Little, Brauner, Jones, Nock, & Hawley, 2003). No significant relationships were found for scores on the So-Mature and either self or parent-reported behavioural difficulties as measured by the SDQ in Study 2. Further research is needed, using various behavioural measures, including measures of prosocial behaviour, before strong conclusions can be made about the link between moral reasoning and behaviour in TD adolescents. Recent social neuroscience research has attempted to shift the focus of study to moral behaviour by using virtual reality to measure moral response choices. Such studies have found that how people act in virtual reality moral dilemmas differs to how they say they would act in hypothetical text-based scenarios describing the same situations (Francis et al., 2016; Patil et al., 2014), highlighting that measuring moral decisions or reasoning alone is not sufficient to understand behaviour.

The major moral principles of a society are generally reflected in laws, so moral behaviour can in some cases also be referred to as rule-breaking or offending behaviour. As offending behaviour involves breaking moral rules of a culture or society, the SIP-MDM framework could be used to make predictions about offending behaviour. Palmer (2003) proposed placing moral reasoning within a wider explanation of offending behaviour, theorising that SIP mediates the link between parenting and offending (Palmer, 2000), while Gibbs (2013) proposed that antisocial behaviour can be explained as a developmental delay in moral judgement, along with self-serving cognitive distortions and deficiencies in social skills. Based on the SIP-MDM framework, offending behaviour could be explained as behaviour based on immature moral decision-making, which could either be the result of (a) developmental delay or deficiencies in one or more of the component processes such as perspective taking or working memory, or (b) due to an underdeveloped database (a lack of adaptive moral schemas or an understanding of moral necessities), or (c) it could be the result of poor information processing, such as a the misinterpretation of cues, or failing to recognise a situation as having moral rules attached. In addition, contextual and situational factors, such as the presence of

peers and current mood, can affect moral decision-making and behaviour, including offending behaviour. This fits with the Situational Action Theory of crime (Wikström, 2005; Wikström, Oberwittler, Treiber, & Hardie, 2012) which proposed that crimes are moral actions involving an interaction of personal and environmental factors, and that whether an individual views crime as a possible action in a situation is determined by their moral evaluation of action alternatives.

7.3.5 Interventions. It may be possible to increase moral or prosocial behaviour and reduce antisocial behaviour by training individuals in some of the components of the SIP-MDM framework. The EQUIPping Youth to Help One Another training program (EQUIP) aims to address deficits in social skills, moral judgement and cognitive distortions in young people with antisocial behavioural problems (Gibbs, Potter, & Goldstein, 1995). A systematic review found that while EQUIP had a significant effect on sociomoral development in juvenile delinquents it did not have a significant effect on recidivism (van Stam et al., 2014). It may be that more specific interventions which target components of the SIP-MDM framework that an individual has difficulties in can impact on behaviour. A study which trained perspective taking abilities in preschool children found that training increased visual, cognitive and affective perspective taking, and that these increases were related to increased prosocial behaviour and decreases in aggressiveness (Cigala, Mori, & Fangareggi, 2015). Interventions which aim to enhance SIP skills may help to reduce aggressive behaviour. Dodge, Godwin, and The Conduct Problems Prevention Research Group (2013) found that long-term positive effects of the 'Fast Track' intervention on reducing antisocial behaviour in adolescence was partially accounted for by improvements in SIP skills such as attributions, response generation and evaluations. The 'Making Choices' school-based intervention to reduce aggression in children by strengthening social-cognitive and emotion regulation skills has been found to relate to improved response decisions and lower hostile intent attribution, but have no significant effect on encoding (Terzian, Li, Fraser, Day, & Rose, 2015). The lack of effect on encoding may suggest that other related skills, such as attention may need to be targeted in order to increase encoding skills.

In Study 2 of this thesis it was found that the ABI group were reasoning at a significantly lower level than an age and gender-matched NH comparison group on the So-Mature but not on the SRM-SF. These findings suggest that adolescents with ABIs may have difficulty with moral or social decision-making rather than

difficulties understanding moral values, i.e. they understand moral values but may struggle to apply them to their own decision-making. Further research is needed to establish the mediating factors in the relationship between understanding moral values and applying them in real-life moral decision-making, which could then inform interventions. For example, if abstract reasoning and memory are required to apply moral values across different situations, interventions could target the training of these skills and processes. Interventions which help adolescents with ABIs understand the moral rules attached to situations they may frequently encounter may also be of benefit.

Screening some of the component skills of the SIP-MDM framework in atypically developing individuals, or those at risk of engaging in antisocial behaviours could allow for targeted interventions which may prove more useful than general interventions. For example, people with ABIs and also offender populations have been found to have deficits in facial emotion recognition (Croker & McDonald, 2005; Robinson et al., 2012). If an individual has deficits in emotion recognition, the SIP-MDM framework would suggest that they will have problems encoding this information, which may potentially bias subsequent processing and moral decisions and behaviour. Teaching generic social problem solving skills may be of limited utility in such a case, as in a real-life situation the individual will still struggle to use information from other people's facial expressions in their moral decision-making. It has been found that modification training, to encourage the perception of happiness over anger in ambiguous facial expressions, results in a decrease in self-reported anger and aggression in TD adults and adolescents at risk of engaging in offending behaviour (Penton-Voak, Thomas, Gage, McMurran, McDonald, & Munafò, 2013). Further investigation of how components relate to behaviour can help to determine which component processes it would be most useful to help train and improve.

7.4 Strengths and limitations

7.4.1 Systematic review. The systematic review and meta-analysis presented in Chapter 4, is, as far as the author is aware, the first systematic review of moral decision-making to explicitly acknowledge the different types of moral decisions, and to compare brain activity for the two main types, MRDs and MEs. This review also performed quality assessment of the included experiments, something which is not normally carried out for neuroimaging systematic reviews. The novel method of ALE analysis was employed to perform the meta-analysis. This analysis allowed for an assessment of which brain areas consistently show

increased activation for MRDs and MEs, and also for conjunction and contrast analyses to be performed to explore similarities and differences of brain activation for these two types of moral decisions. Findings from this analysis can be used to expand on the 'brain development' component of the SIP-MDM as it indicates which regions are particularly involved when making real-time MEs and MRDs.

There are several limitations to this systematic review. Firstly, only 10 MRD experiments were identified from the literature, and 15 is the minimum recommended number of experiments for ALE contrast analysis (Laird et al., 2010; Lancaster et al., 2007). While significant clusters were still found for MRD's and ME's, and the findings are novel, the results should be interpreted with caution as the MRD clusters are only based on 10 experiments. Secondly, there were some experiments where it was ambiguous as to whether the task was a MRD or ME task. Experiments were categorised based on the authors' claims, and the type of question participants responded to (evaluation or response decision), but difficulty categorising some of the experiments highlights the lack of consistency among moral tasks used in fMRI experiments. Thirdly, some of the tasks appeared to lack ecological validity as they did not seem to reflect how moral decisions are made in real life situations. Also, to ensure comparability across studies, adolescents were excluded so the conclusions drawn, therefore, only apply to adults.

Due to the wide range of moral tasks were used in the included experiments, it is important to acknowledge that differences in brain activation may reflect differences in the tasks used across studies, in terms of modality and content of the moral stimuli, and the nature of the control task. The presentation modality varied, and while most tasks used written stimuli presented on screens for participants to read, some experiments, such as Bahnemann et al. (2010) used animated stimuli, with participants being asked to judge if the protagonist in the animations is violating a norm. Also, there were differences in the content and amount of detail of moral stimuli across moral tasks. Bahnemman and colleagues' (2010) animations featured a social violation where a protagonist is punching the other person in the face. While this is a real life social and moral (harm) violation, it could be argued that this scenario is not as emotive as scenarios involving life or death decisions. Differences in emotional engagement, paying more attention to out of the ordinary stimuli, or having to think more about scenarios not previously encountered are likely to contribute to differences across experiments.

Another limitation of some of the included experiments was the nature of the task that was used as a comparison to the moral task. For some experiments, participants were asked to respond similarly across control and experimental conditions, while the stimuli varied. For example, in Parkinson et al. (2011), participants judged whether a character's actions were right or wrong within neutral or moral tasks. Differences in brain activity may therefore have been partially accounted for by differences in reading and processing moral, compared to neutral scenarios, rather than for making a moral compared to a neutral evaluation decision, which the authors did acknowledge (p. 3166). Similar issues exist across other experiments (Harenski et al., 2012; Harenski et al., 2014; Han et al., 2014; Moll, Eslinger & de Oliveira-Souza, 2001; Moll et al., 2002; Reniers et al., 2012). Several of the included experiments used the same moral task, classified as a MRD task, where participants were asked "would you do X?" after reading a scenario about Mr Jones' dilemma (Harrison et al., 2012; Pujol et al., 2008; Verdejo-Garcia et al., 2014). For the control condition, participants were asked to recall the correct answer to the non-dilemma vignette, which they had been familiarised with before the scanner task, e.g., "will he go to the beach?" The control task used in these experiments was, therefore, a recall rather than a decision task, thus the results show brain activation differences for recall vs. a MRD, rather than brain activation for making a moral as opposed to a non-moral decision. For some of the included experiments, the control task may not have been an appropriate comparison for moral tasks, so the moral decision-making peak coordinates from these experiments should be interpreted with caution.

7.4.2 Typically developing study.

7.4.2.1 *Design and procedure* Study 1 was a theoretically driven empirical study, based on testing hypotheses generated using the SIP-MDM framework and the moral theories the framework drew upon. Although moral theories have proposed cognitive and affective processes thought to be involved in moral development, there is a lack of research which measures such processes alongside moral reasoning. Study 1 measured multiple components of the SIP-MDM in order to explore relationships between components. These studies employed a cross-sectional design and all measures were administered at one timepoint. Ideally, in order to measure developmental relationships between components of the SIP-MDM, a longitudinal study would be conducted. This would allow measures to be administered at different ages, and predictive developmental relationships between components to be explored, for example, whether working memory at age 11 years predicts moral reasoning maturity in older adolescence.

7.4.2.2 *Participants.* A priori sample size calculations were performed and the required sample size of 80 was achieved. Participants were recruited from schools and colleges in Norwich and Devon, and via media advertisements at the University of East Anglia. At school assemblies, all participants were invited to take part and to take a letter about the study home to their parents, but there may have been some self-selection bias in that those who decided to take part in the study differed to those who did not take part. Study 1 involved 80 participants. There was also some overlap of participants with Study 2, with some taking part in Study 1 and being in the NH group for Study 2. This was only the case for 9 participants, so the empirical studies included in this thesis involved 111 adolescents, making a total of 120 participants. Ethnicity was not recorded in the studies of this thesis but participants were mainly recruited from schools and colleges in Norwich and Devon so findings may not be generalizable to all adolescents. The age range of the sample for Study 1 was 11-18 years but the mean of 14.05 (2.25) years suggests that the sample were more slightly in the younger range. Of the 80 TD participants, 46 were aged 11-14 years (57.5%), and 34 were aged 15-18 (42.5%). More relationships between age and variables measured in these studies may have been evident if there had been more participants in the older age range.

7.4.2.3 *Measures.* There may have been problems with some of the measures selected for this study, in terms of sensitivity and construct validity. For example, no significant relationships were found for age and perspective taking on the triangles measure used in this study, yet previous research using different measures has found that perspective taking does develop with age (Dumontheil et al., 2010; Vetter et al., 2013). Measures for Study 1 were selected based on their suitability of use for this age range (11-18 years), their psychometric properties (where reported), and the resources available. Length of the overall testing session was also taken into account when choosing appropriate measures. For example, the two-subtest version of the WASI-II was used rather than a WISC-IV or WAIS-IV as the WASI-II takes just 15 minutes to administer, compared to 90 minutes. The empirical studies of this thesis may have benefited from also measuring executive functions such as abstract reasoning, but this would have made the overall testing sessions too long. There is a need for a set of brief measures, validated for use with adolescents, in order to fully measure the cognitive and affective processes thought to be important for moral development.

Some of the measures across the two TD studies were self-report and included in a participant booklet: the IECA (empathy), FAS-II (SES), SDS-17 (social desirability), the PANAS (current mood) and the self-report SDQ (behaviour). For behaviour, the parent and teacher versions of the SDQ were also administered. There was a low response rate of teacher reported SDQs, partly due to a low return rate from teachers asked to complete an SDQ and also because not all participants were recruited from schools. Teacher SDQs were therefore not used in analyses. However, parent report SDQs were returned for the majority of the 80 participants in Study 1 (n=62) so were used in the analysis for behavioural difficulties, alongside self-report SDQs. Social desirability was also explored as a covariate for analyses and entered where appropriate, to control for socially desirable responding to self-report measures.

The SRM-SF was used as a measure of moral reasoning in this study, as moral schemas are proposed to be relevant for all steps of the SIP-MDM framework, and moral reasoning is proposed to be important at Step 5. The SRM-SF was chosen because it is a widely used instrument and has been shown to have excellent levels of test-retest reliability (.88) and internal consistency (.92) (Gibbs et al., 1992). It has been argued that the SRM-SF measures higher level moral reasoning skills and may therefore offer limited insight into moral reasoning skills that guide daily social behaviour (Dooley et al., 2010). An instrument that is based on a SIP approach and uses dilemmas containing moral issues may have yielded clearer findings for Study 1, but as far as the researcher is aware such an instrument has not yet been developed. A SIP instrument, such as the SIPT, which uses hypothetical but everyday moral dilemmas to measure SIP skills but can also elicit and score moral reasoning maturity levels would allow for the relationships between moral reasoning and SIP skills to be more effectively studied. The SIPT, used to measure SIP skills in Study 1, presented situations as cartoons and drawings, which may have limited the extent to which they elicited empathy and related to emotion recognition abilities. The SIPT is a Dutch measure which was translated into English after being sent to the researcher. There are video vignettes which can be used as part of the SIPT but it was unfeasible to translate these into English for Study 1. Future studies may benefit from using video vignettes rather than drawings to measure SIP skills

7.4.3 Data analysis. Many of the variables in Study 1 showed significant departures from normality so bootstrapping with 5000 samples was performed and

bias corrected and accelerated confidence intervals were calculated, which is a robust method for dealing with non-normally distributed data. The only missing data for these studies were some parent SDQs (*n*=18). Teacher SDQs were not used in analyses due to low response rate. While the required sample size was obtained for the TD studies, a larger sample size would have allowed for more complex data analysis, such as mediation analysis, or structured equation modelling. Such analyses would have enabled a more detailed exploration of relationships between components of the SIP-MDM.

7.4.4 Acquired brain injury study.

7.4.4.1 *Design and procedure.*The NH group was matched on age and gender to the ABI group and matching was done in pairs rather than at the group level. However, there were a few cases where age-matching differed by a year, e.g. a 13 year-old female was matched to a 14 year-old female. Also, the groups were not matched on general intellectual functioning. General intellectual functioning differed significantly between the groups and matching groups on this variable would have allowed for general intellectual functioning to be entered as a covariate for relevant analyses. Another limitation of this study is that there was no pre-injury data for any of the measures, so it could be the case that differences in moral reasoning between the ABI and NH group could be due to another factor which is inherently different between the groups. However, a longitudinal study measuring moral reasoning before and after an ABI in the same individuals would be unfeasible.

The relationships between the So-Mature scores at Time 1 and some potential covariates neared significance for the ABI group. Some previous studies have found a significant relationship between general intellectual functioning and scores on the So-Mature for ABI and TD adolescents (Beauchamp et al., 2013; Vera-Estay, Dooley, & Beauchamp, 2015) while others have failed to find a significant relationship (Vera-Estay et al., 2016). It is possible that the small sample size of the ABI study increased the probability of Type II errors, failing to find a relationship between general intellectual functioning and So-Mature scores. Future studies should continue to assess general intellectual functioning alongside moral reasoning measures as a potential covariate. The relationship between age at injury and SRM-SF scores also neared significance, with older age at injury related to higher moral reasoning scores. Again, a larger ABI sample may have elicited significant relationships between age at injury and moral reasoning scores.

A priori sample size estimations were performed and the desired sample size was reached. Sample size estimations were based on findings for similar studies but methods have been proposed to estimate the required sample size for clinical reliability studies (Charter, 1999; Shoukri, Asyali, & Donner, 2004; Zou, 2012). Such methods propose that a minimum of 400 subjects are required (Charter, 1999), which would have been unfeasible for this study. Charter (1999) noted that smaller sample sizes may need to be used if, for example, the study is of a rare population such as people with brain lesions, or if the tests are solely for research purposes; both of which apply to the ABI study in this thesis.

7.4.4.2 *Recruitment.* There are challenges in recruiting participants with ABIs, which were experienced in this study. Separate R&D applications are required to cover different NHS Trusts, which adds additional time following the main NHS ethics approval before recruitment can begin. In certain regions of the UK there are multiple studies recruiting children and adolescents with ABIs, causing a high demand for participants. This high demand means that brain injury charities only advertise a limited number of studies and brain injury services may already be supporting recruitment for a number of studies. In order to overcome these issues, the ABI group were recruited from services across England, national adverts via the Encephalitis society website and an advert on the University of Exeter's Get Involved pages. While this ensured that ABI participants came from a wide range of counties across England (South Yorkshire, Derbyshire, Lincolnshire, Norfolk, Cambridgeshire, Somerset, Wiltshire and Gloucestershire) there was a time and travel burden on recruitment and data collection.

The researcher is not a clinician and so did not have direct access to individuals with ABI and their families at NHS services. Potential participants were identified by clinicians working at each service, based on the inclusion and exclusion criteria, and contact was then made with the researcher. It cannot be ruled out that there was selection bias in recruitment, with clinicians not asking all potentially eligible participants about the study. There may also have been some self-selection bias in that the families or participants who took part in the study may differ to those who chose not to. Whether some individuals were asked about the study by clinicians but declined to take part is not known the by researcher, as only the details of those who wanted to take part were passed on, due to ethical considerations.

7.4.4.3 *Participants.* Previous research into moral reasoning in adolescents with ABIs has included samples with TBIs and frontal or temporal lobe lesions. Study 2 of this thesis included adolescents with nTBIs in the ABI group. Additionally, there was heterogeneity of cause of injury for TBIs and nTBIs. As this study found significant differences in moral reasoning maturity on the So-Mature for the ABI and NH group, this may suggest that damage to any part of the developing brain, either through TBIs or nTBIs can impact on moral reasoning maturity. This would fit with the SIP-MDM framework, which proposes that many processes are involved in moral decision-making and so moral development may be underpinned by various brain regions and networks.

Although injury severity details were collected from parents and from medical records for the ABI group, incomplete data meant that injuries were unable to be classified as mild, moderate or severe. While all but one of the TBI participants (n=10) had GCS scores, there is not a single scale that is used to assess the severity of nTBIs so this information was unreported for five of the nine participants in the nTBI subgroup. nTBIs are currently under researched as most studies use TBI samples to explore the effects of brain injury on development. The severity of TBIs can be classified using the GCS and it has been found that the severity of TBIs can affect outcomes (Ryan et al., 2016). A scale which categorises the severity of nTBIs would allow researchers to study how the severity of ABIs affects outcomes. The effects of injury severity on moral reasoning scores were explored for the TBI subgroup only, finding no significant difference between mild and moderate/severe TBIs, but this was exploratory analysis only and based on small numbers.

The only types of injury that were excluded were where the participant lacked the physical, cognitive or communication ability to engage in the assessments, as this was one of the exclusion criteria for all participants, and ABI participants had to be at least 6 months post injury or diagnosis. From the GCS scores available, the majority of the ABI group (n=11) had a mild brain injury, three had a moderate or severe brain injury and six had no severity information. If the sample had included more moderate and severe ABIs, significant differences may have been found for SRM-SF scores between the ABI and NH group. The findings of this study may not be generalizable to moderate or severe ABIs, although it is possible that the six ABI participants with no severity data had moderate or severe brain injuries.

There are many factors that influence outcomes following ABIs, including injury-related factors (e.g. age at injury and injury severity) and non-injury factors (e.g. family functioning and SES), and these factors interact with each other to determine the extent of post-injury recovery (Anderson, Spencer-Smith, & Wood, 2011; Kline et al., 2017; Li, Fraser, & Wike, 2013). Therefore, it is difficult to generalise findings from ABI studies, particularly from studies with small samples, due to the heterogeneity among participants with ABIs in terms of pre and post injury factors. Brain injuries that occur during neurodevelopmental sensitive periods can impact on developmental trajectories. While some functions recover with time (Anderson et al, 2005), deficits may also emerge over time (Chapman, Wade, Walz, Taylor, Stancin, & Yeates, 2010; Li et al., 2013; Ryan et al., 2015). A brain injury that occurs during infancy, when skills are emerging, can have widespread implications for the development of all skills (Anderson et al., 2010; Anderson et al., 2011) and adolescence is a sensitive period for the development of social-cognitive skills (Blakemore & Choudhury, 2006). A brain injury that occurs during infancy or adolescence may therefore particularly impact on the development of skills and processes required for moral development, but the effect of a brain injury on moral development will depend on a variety of factors and interaction between these factors.

Some studies investigating the social, cognitive or emotional effects of a TBI have used an OI group as a comparison, in order to compare the effects of a TBI to other traumatic injuries which do not damage the brain (e.g. Janusz et al., 2002; Yeates et al., 2013). However, for the ABI study presented in this thesis, nTBIs such as encephalitis and brain tumour were included in the ABI group, so it would have been difficult to find a suitable injury comparison group. Also, while OI groups are used as comparison groups to control for factors which may relate to both TBIs and OIs (such as risk-taking behaviour), there are no known common factors related to increased incidence of nTBIs. Furthermore, a recent study found that children with OIs and non-injured TD children did not significantly differ on a range of demographic variables relating to pre-injury and post-injury characteristics (Beauchamp, Landry-Roy, Gravel, Beaudoin, & Bernier, 2017). NH adolescents, with no incidence of ABIs were therefore used as a comparison group in Study 2. Such comparison groups have also been used in other studies of moral reasoning after brain injury (Beauchamp et al., 2013; Chiasson et al., 2017a; Wigg, 2013).

7.4.4.4 *Measures.* Some self-report measures were used in this study, such as the FAS-II (SES), SDS-17 (social desirability) and the self-report SDQ. For behavioural difficulties, the parent report SDQ was also administered. There was a high return rate of parent SDQs, with only three missing for the NH group. Social desirability was also investigated as a covariate to control for socially desirable responding on self-report measures. Estimates of general intellectual functioning were based either on the WISC-IV (*n*=12) or the WAIS-IV (*n*=8) for the ABI group. Three ABI participants had completed a WISC-IV in the past year so this was not administered again by the researcher. For the NH group, the two-subtest WASI-II was used for the majority of participants (*n*=16) due to practical reasons and time constraints of testing participants during the school day. While the WASI-II is linked to the WISC-IV and WAIS-IV (Wechsler, 2008), it may be the case that differences in general intellectual functioning between the ABI and NH group were due to the different measures used.

One aim of this study was to investigate the psychometric properties of two measures of moral reasoning when used with an ABI sample. The SRM-SF and So-Mature were chosen as the most appropriate measures, as the SRM-SF is widely used in developmental psychology and has previously been used with brain injury samples, and the So-Moral was designed to be used by adolescents with brain injuries. The SRM-SF scores justifications given for evaluations of moral values. The authors excluded hypothetical dilemmas from this measure for practical reasons, (to make administration and scoring quicker and easier), due to criticisms of artificial dilemmas, and argued that moral evaluation questions are sufficient for moral reflection (Gibbs et al., 1992). The So-Mature on the other hand, scores the justifications given for response decisions made in hypothetical moral dilemmas. While this measure uses everyday dilemmas relevant to adolescents (e.g. whether or not to tell the teacher that your friend is cheating on an exam), the scoring is based on Kohlberg's theory, which has received some notable criticisms and been subject to revisions (Gibbs, 2013; Gibbs et al., 1992; Rest et al., 1999). As one aim of Study 2 was to compare moral reasoning about values to moral reasoning about response decisions, and as no production measure using dilemmas employs neo-Kohlbergian theory for scoring, these two measures were the most appropriate.Exploratory analysis was performed in this study to explore levels of offending behaviour, and relations to moral reasoning for the ABI group compared to the NH group. This was explored because there appears to be a relationship between both brain injury and offending and low moral reasoning and offending.

The analysis was only exploratory as low levels of offending behaviour were expected due to the small sample size and participants being recruited from the general population rather than prison or young offenders institutions. A self-report measure of delinquency would have made the overall testing session too long and this question was not a main aim of the study, so participants were instead asked if they had ever been in trouble with the police because of their behaviour. The questions were short and provided some information about offending behaviour. As expected, offending rates were low with only three participants reporting any police contact so no conclusions about the link between moral reasoning, offending and ABIs could be made. Ideally, in a larger study investigating the links between moral reasoning and offending behaviour in adolescents with ABIs, a validated self-report measure of delinquency would be used to capture offending behaviour which has not led to police contact.

7.5 Future directions

7.5.1 Developmental research. Study 1 found limited support for aspects of the SIP-MDM framework for TD adolescents so future research is needed to confirm or reject proposals of this integrative framework, which can aid the development of theory. Study 2 was a first step towards investigating some aspects of the SIP-MDM framework in adolescents with ABIs by investigating the psychometric properties of a measure of moral reasoning to use with this population. Further studies need to investigate psychometric properties of other measures such as empathy and SIP when used with adolescents with ABIs. Future studies can then measure components of the SIP-MDM framework and relationships between components in ABI samples, to explore whether difficulties in one component impact on other components.

There appears to be a link between ABIs and offending, with high rates of TBI among offender populations (Farrer & Hedges, 2011; Hughes et al., 2015; Shiroma et al., 2010; Williams et al., 2010) and a study finding that a community sample of children and adolescents with ABIs reported to have committed multiple offences (Luiselli et al., 2000). There is also a strong link between low moral reasoning and adolescent offending (Nelson et al., 1990; Stams et al., 2006). It may be the case that moral development mediates or moderates the relationship between ABIs and offending behaviour, through the impact that damage to the brain has on moral maturity. An ABI may affect moral development in many ways, either through damage to the brain regions required for real-time moral decision-making or

due to the impact of brain damage on the maturation of component processes of the SIP-MDM framework. An ABI may also limit social participation and interaction with peers, which in turn can impact on opportunities for role-taking, affecting the development of perspective taking. The ABI study in this thesis was unable to address the link between moral reasoning and offending behaviour but future studies using larger samples could aim to establish whether (a) nTBIs are related to offending behaviour as TBIs have found to be, and (b) the role of moral maturity in the relationship between ABIs and offending.

The relationship between moral reasoning and behaviour in TD adolescents remains unclear. Future research could focus on behaviour as the end product, assessing whether there are processes which mediate the link between moral reasoning and behaviour, and exploring the influence of different situational factors on moral behaviour. Future studies measuring moral reasoning alongside different behavioural measures can assess the link between reasoning maturity and behaviour. The So-Moral/So-Mature has the potential to be used to measure how different situational factors impact on moral response choices and moral reasoning. The So-Moral presents hypothetical dilemmas of real life situations, presented in the first person via static photographs on a laptop. Respondents are required to choose between two response options and then explain their decision. For example, one situation depicts a woman dropping her purse, you (the viewer) and your friends picking it up and you then decide whether or not to keep it. When this measure was used for Study 2, some participants provided justifications for not keeping it such as "because she's right there, she'd know it was me". While such answers may have indicated perspective taking, they also reference situational factors, which are currently not explicitly scored, according to the So-Mature manual.

The influence of situational factors on moral response decisions and moral reasoning could be investigated by using situations with the same moral value attached but with modified situational factors, for example peers present or not present, an authority figure present or not present. In the purse example, the majority of respondents may say they would return the purse but this may be different if the person who dropped the purse was not present in the situation, although the moral value remains the same. It could also be assessed whether situational factors affect moral decision-making differently depending on the individual's highest capacity for reasoning, for example, are individuals reasoning at lower stages more influenced by situational factors? After dilemmas are first

presented on the So-Moral, respondents are asked to explain what is happening in the situation. This question is asked to determine if the respondent understands the situation, before then asking how they would respond and why. However, this first question could be used to assess whether a respondent recognises the situation as being in the moral domain, by scoring whether they reference moral values such as fairness or harm. Whether recognising a situation as being in the moral domain influences the reasoning that then occurs can then be investigated.

7.5.2 Neuroscience research. Most neuroimaging and lesion research into moral decision-making has focused on MEs, but the incorrect use of moral terms has led to the misleading conclusion that there is strong evidence of which brain regions are involved in all types of moral decisions. Researchers across disciplines use different moral terms interchangeably leading to confusion about what each term means, or what is actually being studied. Decety and Cowell (2014) made a sound argument that the concept of empathy refers to many distinct phenomena and it would be useful if scholars used more specific terms such as emotional sharing, empathic concern and perspective taking rather than the catch all term of empathy. However, while making this argument in relation to understanding the relationship between empathy and morality, the authors used the catch all term 'morality' to refer to moral cognition, moral reasoning and moral judgements. Clearer definition of moral terms will hopefully lead to consensus among researchers, making it clearer what concept/process is actually being studied.

While we may have a wealth of evidence from fMRI studies of which brain areas are involved when judging the moral permissibility or appropriateness of another's actions (MEs), there is much less evidence of brain areas involved when making a decision about what you would do in a moral dilemma (MRDs). Furthermore, studies which measure MRDs tend to use life or death scenarios, which do not reflect the everyday moral decisions of most people and so may lack ecological validity. Future research could focus on assesing the neural correlates of everyday moral decision-making, by using more real life scenarios for assessing moral decision-making (e.g. the So-Moral, or virtual reality moral tasks). Further developmental fMRI studies would help to assess how brain activation patterns for different types of moral decisions change with age, which can help our understanding of moral decision-making development.

While this thesis has attempted to bring together social neuroscience and developmental psychology approaches to moral decision-making and behaviour,

this integration could be taken further. Developmental fMRI or structural MRI studies could measure the neural correlates of everyday moral decision making, alongside measuring moral reasoning maturity (e.g. using the SRM-SF or So-Mature) to see whether there are any relationships between age-related brain activation patterns or structural changes, and developmental levels of moral maturity. Research measuring brain development from infancy to adulthood, alongside measuring moral reasoning, moral decision-making and related components such as perspective taking would provide a fuller picture of the brain networks required for moral decision-making. Such research would allow the 'brain development' of the SIP-MDM framework to be greatly expanded upon, pinpointing which brain regions are most important for the maturation of moral decision-making, and highlighting developmental windows of importance which can be useful in training to enhance moral decision-making.

7.6 Conclusion

Developmental psychology and social neuroscience approaches to moral decision-making and development have developed mostly in isolation, informed by separate theories and leading to differing research focuses. This thesis has taken some initial strides towards bridging the gap between these disciplines. Within this thesis, the SIP-MDM framework was proposed, which brought together aspects from various theories into one descriptive SIP framework. Tentative support was found for some of the hypotheses generated by this framework in TD adolescents, but hypotheses relating to some predictive relationships were not supported. Additionally, no relationships were found between moral reasoning and perspective taking, empathy and emotion recognition, calling into question long-held but largely untested theoretical assumptions.

The systematic review presented in this thesis added to our knowledge of brain regions involved in making moral decisions and highlighted that making one's own moral decisions activates additional brain regions compared to making moral evaluations such as judging the permissibility of other people's actions. The ABI study found that adolescents with ABIs showed delayed moral reasoning relating to moral response decisions but not for moral reasoning relating to moral values, suggesting that they may understand moral values but struggle to apply them to everyday moral decision-making. The empirical studies presented in this thesis confirmed that the relationship between moral reasoning and behaviour remains unclear for TD adolescents, while a link was found between delayed moral

reasoning about response decisions and behavioural difficulties for adolescents with ABIs. The SIP-MDM framework can be used to generate hypotheses, guiding further research and theory development in this area. It is hoped that such future integrative work will lead to better predictions of moral behaviour and identify where interventions can be targeted for those at risk of atypical moral development or engaging in antisocial behaviour.

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Appendices

Appendix A: Quality assessment checklist for systematic review

Quality assessment table

Are these criteria reported in the study?

1=sufficient evidence reported. 0=no evidence reported/unclear/not explicit

Reference………………………………………………………………………………………
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Total scores: 0-10=low quality, 11-20=medium quality, 21-30=high quality.

		Examples/notes	Reported?
Experimental design	Number of blocks, trials or experimental units per session/subject		
	Length of each trial and interval between trials	*Both must be reported*	
	Total (out of 2)		
Task specification	Describes what subjects were asked to do	*E.g. Subjects read statements and instructed to press button to indicate if they agreed or disagreed*	
	Stimuli- describes what they were and how many	*E.g. 24 scenarios, 12 moral and 12 non moral. Explanation or example of content*	
	Total (out of 2)		
Subjects	Number of subjects		
	Age (mean and range)	*Both must be reported*	
	Handedness		
	Number of males/females		
	Inclusion/exclusion criteria	*Explicit inclusion and exclusion criteria, not just description of participant characteristics*	
	States which IRB approved the protocol	*Mark as not reported if just states 'local ethics committee' without giving name/institution*	
	Total (out of 6)		
Data acquisition *(these details need to be reported for functional imaging not*	MRI system manufacturer, field strength (Tesla), model name	*Only give point if all info reported*	
	MRI acquisition (number of experimental sessions and volumes acquired per session)	*Needs to report both no. of volumes and sessions*	

just structural)	Field of view, matrix size, slice thickness	*All 3 must be reported*	
	Pulse sequence type	*E.g. gradient/spin echo, EPI/spiral*	
	TE/TR/flip angle	*All 3 must be reported*	
	Total (out of 5)		
Data pre-processing	Name and version number of pre-processing software used	*E.g. SPM5*	
	Specifies order of pre-processing operations	*If in list format, assume that is order*	
	Motion correction details *(not just stating that motion correction was performed)*	*E.g. Head motion corrected with FSL's MCFLIRT by maximizing the correlation ratio between each time point and the middle volume, using linear interpolation*	
	Slice timing correction (reference type of slice and interpolation)	*E.g. Slice timing correction to the first slice as performed, using SPM5's Fourier phase shift interpolation*	
	Size and type of smoothing kernel	*E.g 8mm FHWM Gaussian*	
	Total (out of 5)		
Analysis	Brain image template space, name, modality and resolution	*E.g. SPM2s MNI grey matter template 2x2x2mm' (not just MNI/Talairach space- see below)*	
	Coordinate space	*Reports if coordinates are reported as MNI or Talairach, not just which template normalised to (see above). In text not just tables*	
	Specifies exactly which conditions were subtracted from which condition		
	Statistical model reported	*E.g. Multiple regression, ANOVA, t-test*	
	Estimation method reported	*GLS or OLS. Tick as reported if e.g. 'A regression using 3dREMLfit in ANFI', as this is software for GLS or explicitly states 'according to*	

		SPM8s GLM '(uses OLS)	
	Inference type	Mixed or random effects	
	Cluster-wise threshold and significance level details	E.g. Group activation contrasts (uncorrected <.05 with a cluster-size threshold of 50 voxels)	
	Total (out of 7)		
Tables	Labelled with coordinate space		
	Thresholds used to create tables	P value/cluster threshold	
	Statistics for each cluster in tables	Must report X, y, z co-ordinates, cluster size and either a z or t value	
	Total (out of 3)		
	OVERALL TOTAL (out of 30)		

Appendix B: Quality assessment results for systematic review

Quality assessment results

Author	Year	Experimental design (/2)	Task specification (/2)	Subjects (/6)	Data acquisition (/5)	Data pre-processing (/5)	Analysis (/7)	Tables (/3)	Total (/30)	Descriptive category
Avram et al	2013	2	2	3	4	3	3	2	19	Medium
Avram et al	2014	2	2	5	4	3	4	2	22	High
Bahnemann et al	2010	2	2	4	2	4	5	3	22	High
Borg et al	2006	2	2	5	3	1	5	2	20	Medium
Chiong et al	2013	2	2	3	4	3	5	2	21	High
de Achaval et al	2013	2	2	4	4	4	5	1	22	High
FeldmanHall et al	2014	2	2	4	3	4	4	3	22	High
Han et al	2014	2	2	5	5	3	6	3	26	High
Harada et al	2009	2	2	4	5	2	7	2	24	High
Harenski et al	2014	2	2	5	4	4	4	1	22	High
Harenski et al	2008	1	2	3	5	3	6	1	21	High
Harenski et al	2012	2	2	5	4	4	4	3	24	High
Harrison et al	2012	2	2	6	5	4	5	2	26	High
Heekeren et al	2003	2	2	3	5	2	5	2	21	High
Heekeren et al	2005	2	2	3	5	5	7	2	26	High
Moll et al	2001	2	1	3	5	2	6	1	20	Medium
Moll et al	2002	2	2	4	3	2	4	3	20	Medium
Parkinson et	2011	1	2	2	4	3	6	2	20	Medium

al									
Prehn et al	2008	2	2	3	3	4	5	3	22	High
Pujol et al	2012	1	2	6	4	4	6	2	25	High
Reniers et al	2012	2	2	5	4	5	5	2	25	High
Roberston et al	2007	2	2	5	3	3	4	3	22	High
Schleim et al	2011	2	2	3	4	3	6	3	23	High
Schneider et al	2012	2	2	5	4	4	5	3	25	High
Sommer et al	2010	2	2	3	4	3	4	2	20	Medium
Sommer et al	2014	1	2	4	4	3	6	2	22	High
Takahashi et al	2008	2	2	2	4	4	5	1	20	Medium
Verdejo-Garcia et al	2012	1	2	4	5	2	3	2	19	Medium

Appendix C: Ethics documentation

NRES Committee East of England - Essex

London REC Office
Health Research Authority
Ground Floor, Skipton House
80 London Road
London
SE1 6LH

Telephone: 020 797 22587

21 October 2013

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
IRAS project ID:	**123083**

Thank you for your letter of 16 October 2013, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Vice-Chair.

We plan to publish your research summary wording for the above study on the NRES website, together with your contact details, unless you expressly withhold permission to do so. Publication will be no earlier than three months from the date of this favourable opinion letter. Should you wish to provide a substitute contact point, require further information, or wish to withhold permission to publish, please contact the REC Manager Miss Kate Donaldson, NRESCommittee.EastofEngland-Essex@nhs.net.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

This Research Ethics Committee is an advisory committee to London Strategic Health Authority

The National Research Ethics Service (NRES) represents the NRES Directorate within the National Patient Safety Agency and Research Ethics Committees in England

Ethical review of research sites

NHS sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Non-NHS sites

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

The Committee was not content with Q2 in the Participant Booklet asking for the age in years and months. It was agreed that it is not appropriate to ask for age in years and months in these very small groups as this would allow easy identification of individuals. The Committee request that

1. 'Months' is removed

   Or

2. The researcher provides significant justification as to why this degree of participant identifiable data is needed.

You should notify the REC in writing once all conditions have been met (except for site approvals from host organisations) and provide copies of any revised documentation with updated version numbers. The REC will acknowledge receipt and provide a final list of the approved documentation for the study, which can be made available to host organisations to facilitate their permission for the study. Failure to provide the final versions to the REC may cause delay in obtaining permissions.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publically accessible database within 6 weeks of recruitment of the first participant (for medical device studies, within the timeline determined by the current registration and publication trees).

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non clinical trials this is not currently mandatory.

If a sponsor wishes to contest the need for registration they should contact Catherine Blewett (catherineblewett@nhs.net), the HRA does not, however, expect exceptions to be made. Guidance on where to register is provided within IRAS.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	Version	Date
Advertisement: Recruitment Poster to advertise for participants at UEA	1	10 May 2013
Advertisement: Recruitment Poster to advertise for ABI group 11-16 (poster for parents)	1	10 May 2013
Advertisement: Recruitment poster to advertise for ABI group 16-21	1	10 May 2013
Evidence of insurance or indemnity: Zurich Municipal Policy Number NHE-09CA01-0013		22 May 2013
GP/Consultant Information Sheets: Letter for clinicians or charities		10 May 2013
GP/Consultant Information Sheets: Letter for schools	1	10 May 2013
GP/Consultant Information Sheets: Letter for colleges	1	10 May 2013
Investigator CV: Beverley Garrigan		10 May 2013

Letter from Sponsor: Letter from UEA Sue Steel		09 July 2013
Letter of invitation to participant: Letter for parents of potential participants recruited from schools	1	10 May 2013
Letter of invitation to participant: Info for clinicians to give to potential participants aged 16-21	1	10 May 2013
Letter of invitation to participant: Info for clinicians to give to potential participants aged 11-16	1	10 May 2013
Letter of invitation to participant: Information for schools to give to potential participants	1	10 May 2013
Letter of invitation to participant: Information summary sheet for colleges to give to potential participants	1	10 May 2013
Other: Academic Supervisor CV: Dr Peter Langdon		13 September 2011
Other: Academic Supervisor CV: Dr Anna Adlam		
Other: Email from Peter Langdon - Scientific Critique		07 August 2013
Other: Information Summary Sheet for Colleges to give to Potential Participants	1	18 September 2013
Other: Information for Schools to give to Potential Participants	1	18 September 2013
Other: Debriefing Sheet for Under 16 year olds	1	18 September 2013
Other: Debriefing Sheet for Parents of Under 16s	1	18 September 2013
Other: Debriefing Sheet for Over 16s	1	18 September 2013
Other: Email from Dr Jerosch-Herold: Peer Review		20 September 2013
Other: Checklist for home visits	1	23 September 2013
Other: Covering letter for parents, to include with parent booklet	1	18 September 2013
Other: Debriefing Sheet for Parents	1	18 September 2013
Participant Consent Form: Consent to contact form for participants age 16-21	1	10 May 2013
Participant Consent Form: Consent to contact form for participants age 11-16	1	10 May 2013
Participant Consent Form: for Parents	2	18 September 2013
Participant Consent Form: for Comparison Group age 16-21	2	18 September 2013
Participant Consent Form: for Comparison Group Parents to give Consent for Child	2	18 September 2013
Participant Consent Form: Assent Form for Comparison Group age 11-16	2	18 September 2013
Participant Consent Form: Assent form for ABI group age 11-16	3	15 October 2013
Participant Consent Form: for ABI group age 16-21	3	15 October 2013
Participant Consent Form: for ABI group parents to give consent for child	3	15 October 2013
Participant Information Sheet: for Parents	2	18 September 2013
Participant Information Sheet: for Parents of Comparison Children	2	18 September 2013

Participant Information Sheet: for Comparison Group Age 16-21	2	18 September 2013
Participant Information Sheet: for ABI group 16-21	2	18 September 2013
Participant Information Sheet: for Parents of ABI Children	2	18 September 2013
Participant Information Sheet: Comparison Group age 11-16	2	18 September 2013
Participant Information Sheet: ABI Group age 11-16	2	18 September 2012
Protocol	2	08 September 2013
Questionnaire: Parent/Caregiver Booklet ABI group	1	10 May 2013
Questionnaire: Parent/Caregiver Booklet Comparison Group	1	10 May 2013
Questionnaire: Participant Booklet	3	15 October 2013
REC application	123083/484298/1/918	18 July 2013
Response to Request for Further Information: Letter from Beverley Garrigan		02 October 2013
Response to Request for Further Information: Email from Beverley Garrigan		16 October 2013

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

This Research Ethics Committee is an advisory committee to London Strategic Health Authority
The National Research Ethics Service (NRES) represents the NRES Directorate within
the National Patient Safety Agency and Research Ethics Committees in England

Further information is available at National Research Ethics Service website > After Review

13/EE/0289	**Please quote this number on all correspondence**

We are pleased to welcome researchers and R & D staff at our NRES committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

With the Committee's best wishes for the success of this project.

Yours sincerely
pp

[signature]

Niki Bannister
Vice-Chair

Email:NRESCommittee.EastofEngland-Essex@nhs.net

Enclosures: "After ethical review – guidance for
                     researchers" *SL-AR2*

Copy to: *Mrs Sue Steel*

NRES Committee East of England - Essex

12 November 2013

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
Amendment number:	**Minor Amendment 01**
Amendment date:	**07 November 2013**
IRAS project ID:	**123083**

Thank you for your letter of 07 November 2013, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Notification of a Minor Amendment (Email from Beverley Garrigan)		07 November 2013
Participant Booklet	5	07 November 2013
Injury Characteristics	1	04 November 2013

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

13/EE/0289:	**Please quote this number on all correspondence**

Yours sincerely

[signature: Kate Donaldson]

Miss Kate Donaldson
REC Manager

E-mail: NRESCommittee.EastofEngland-Essex@nhs.net

Copy to: *Mrs Sue Steel*

NRES Committee East of England - Essex

London REC Office
Health Research Authority
Ground Floor, Skipton House
80 London Road
London
SE1 6LH

Tel: 020 797 22560

29 November 2013

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
Amendment number:	**Minor Amendment 02 to Protocol and Consent Forms**
Amendment date:	**28 November 2013**
IRAS project ID:	**123083**

Thank you for your letter of 28 November 2013, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Participant Consent Form: Consent Form for ABI group age 16-21	5	28 November 2013
Participant Consent Form: Consent Form for comparison group age 16-21	3	28 November 2013
Protocol	3	28 November 2013
Notification of a Minor Amendment (Email from Beverley Garrigan)		28 November 2013
Participant Consent Form: Assent Form for ABI group age 11-16	5	28 November 2013

This Research Ethics Committee is an advisory committee to London Strategic Health Authority

*The National Research Ethics Service (NRES) represents the NRES Directorate within
the National Patient Safety Agency and Research Ethics Committees in England*

Participant Consent Form: Assent Form for comparison group age 11-16	3	28 November 2013

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

13/EE/0289:	**Please quote this number on all correspondence**

Yours sincerely

Miss Kate Donaldson
REC Manager

E-mail: NRESCommittee.EastofEngland-Essex@nhs.net

Copy to: *Mrs Sue Steel*

NHS
Health Research Authority

NRES Committee East of England - Essex

London REC Office
Health Research Authority
Ground Floor, Skipton House
80 London Road
London
SE1 6LH

Tel:
Fax:

02 May 2014

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
Amendment number:	**Minor Amendment for information only**
Amendment date:	**02 May 2014**
IRAS project ID:	**123083**

Thank you for your email of 02 May 2014, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees.   The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Participant Information Sheet: ABI group aged 11-15	4	02 May 2014
Participant Consent Form: for ABI group aged 16-21	6	02 May 2014
Participant Information Sheet: for clinicians to give to potential participants aged 11-16	2	02 May 2014
Participant Consent Form: Parents go give consent for child	5	02 May 2014

Participant Information Sheet: for clinicians to give to potential participants aged 16-21	2	02 May 2014
Participant Information Sheet: Parents of ABI children	4	02 May 2014
Participant Consent Form: Assent Form for ABI group aged 11-16	6	02 May 2014
Notification of a Minor Amendment	email from Beverley Garrigan	02 May 2014
Participant Information Sheet: ABI group aged 16-21	4	02 May 2014

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

13/EE/0289:	**Please quote this number on all correspondence**

Yours sincerely

Alison O'Kane

Mrs. Alison   O'Kane
Committee Co-ordinator

Copy to: *Mrs Sue Steel*

NRES Committee East of England - Essex
Health Research Authority
Ground Floor, Skipton House
80 London Road
London
SE1 6LH

Tel:
Fax:

25 July 2014

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
Amendment number:	**Minor amendment for information only**
Amendment date:	**24 July 2014**
IRAS project ID:	**123083**

Thank you for your letter of 24 July 2014, notifying the Committee of the above amendment. It is noted you would like to add that participants (over 16), or parents (of the participants under 16) can also request a report of their/their child's scores on standardised measures used in the study, which are the IQ measure (WISC/WAIS) and the behaviour measure (SDQ).

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Notice of Minor Amendment [email]		24 July 2014
Participant consent form [ABI group parents to give consent for child]	7	24 July 2014
Participant consent form [Comparison group]	5	24 July 2014

Participant consent form [ABI Group aged 16-21]	8	24 July 2014
Participant consent form [Comparison group parents to give consent for child]	4	24 July 2014
Participant information sheet (PIS) [Parents of ABI group]	6	24 July 2014
Participant information sheet (PIS) [ABI group aged 16-21]	6	24 July 2014
Participant information sheet (PIS) [Comparison group age 16-21]	4	24 July 2014
Participant information sheet (PIS) [ABI group aged 11-15]	6	24 July 2014
Participant information sheet (PIS) [Parents of comparison children]	4	24 July 2014
Participant information sheet (PIS) [Comparison group aged 11-16]	4	24 July 2014
Research protocol or project proposal	5	24 July 2014

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

13/EE/0289:	**Please quote this number on all correspondence**

Yours sincerely

Alison O'Kane

Mrs. Alison   O'Kane
REC Manager

E-mail: nrescommittee.eastofengland-essex@nhs.net

Copy to:

Mrs   Sue Steel

14 July 2014

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
Amendment number:	
Amendment date:	**14 July 2014**
IRAS project ID:	**123083**

Thank you for your letter of 14 July 2014, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees.   The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

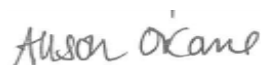| Document	Version	Date
Notice of Minor Amendment [email]		14 July 2014
Participant consent form [comparison group parents to give consent for child]	3	11 July 2014
Participant consent form [ABI group parents to give consent for child]	6	11 July 2014
Participant consent form [comparison group age 16-21]	4	11 July 2014
Participant information sheet (PIS) [parents of comparison children]	3	11 July 2014
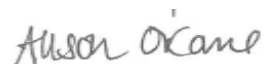
Participant information sheet (PIS) [ABI group age 11-15]	5	11 July 2014
Participant information sheet (PIS) [comparison group age 16-21]	3	11 July 2014
Participant information sheet (PIS) [comparison group age 11-16]	3	11 July 2014
Participant information sheet (PIS) [ABI group 16-21]	5	11 July 2014
Participant information sheet (PIS) [parents of ABI children]	5	11 July 2014
Research protocol or project proposal	4	11 July 2014

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

13/EE/0289:	**Please quote this number on all correspondence**

Yours sincerely

Alison O'Kane

Mrs. Alison O'Kane
REC Manager

E-mail: nrescommittee.eastofengland-essex@nhs.net

Copy to:

> *Mrs   Sue Steel*

NRES Committee East of England - Essex

The Old Chapel
Royal Standard Place
Nottingham
NG1 6FS

Tel: 0115 8839697

18 November 2014

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan,

Study title:	Understanding how brain injury affects development.
REC reference:	13/EE/0289
Amendment date:	14 November 2014
IRAS project ID:	123083

Thank you for your letter of 14 November 2014, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Notice of Minor Amendment		14 November 2014

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

13/EE/0289:	Please quote this number on all correspondence

Yours sincerely,

Ms Rachel   Nelson
REC Manager

E-mail: nrescommittee.eastofengland-essex@nhs.net

Copy to: *Mrs Sue Steel*

East of England - Essex Research Ethics Committee

The Old Chapel
Royal Standard Place
Nottingham
NG1 6FS

18 February 2016

Miss Beverley Garrigan
PhD Student
University of East Anglia
Department of Psychological Sciences
Norwich Medical School, University of East Anglia
Norwich Research Park, Norwich
NR4 7TJ

Dear Miss Garrigan

Study title:	**Understanding how brain injury affects development.**
REC reference:	**13/EE/0289**
Amendment number:	**Extend study & shorter IQ test**
Amendment date:	**06 February 2016**
IRAS project ID:	**123083**

Thank you for your letter of 06 February 2016, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Notice of Minor Amendment [2016.02.08 13EE0289 Minor Amendment notice - email from CI]	Extend study & shorter IQ test	06 February 2016
Participant information sheet (PIS) [Participant info sheet Comparison 11-16]	5	05 February 2016
Participant information sheet (PIS) [Participant Information Sheet Comparison 16-21]	5	05 February 2016
Participant information sheet (PIS) [Participant Information Sheet for parents of comparison children under 16]	5	05 February 2016

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

Yours sincerely

Adam Garretty
REC Assistant

Email: NRESCommittee.EastofEngland-Essex@nhs.net

Copy to: *Mrs Sue Steel*

Faculty of Medicine and Health Sciences Research Ethics Committee

Beverley Garrigan
MED

2 March 2015

Dear Beverley

Project Title: Moral development and social information processing: relationships with empathy, working memory and perspective taking.
Reference: 2014/2015 – 15

The amendments to your above proposal have been considered by the Chair of the Faculty Research Ethics Committee and we can confirm that your proposal has been approved.

Please could you ensure that any further amendments to either the protocol or documents submitted are notified to us in advance and also that any adverse events which occur during your project are reported to the Committee. Please could you also arrange to send us a report once your project is completed.

Yours sincerely,

Mark Wilkinson
Chair FMH Research Ethics Committee

Cc
Dr Peter Langdon (University of Kent)
Dr Anna Adlam (University of Exeter)

Faculty of Medicine and Health Sciences Research Ethics Committee

Beverley Garrigan
MED

13th August 2015

Dear Beverley

Moral development and social information processing: relationships with empathy, working memory and perspective taking – 20142015-15

Thank you for your e-mail dated 10th August 2015 notifying us of the amendments you would like to make to your above proposal. These have been considered and we can now confirm that your amendments have been approved.

Please can you ensure that any further amendments to either the protocol or documents submitted are notified to us in advance, and also that any adverse events which occur during your project are reported to the Committee.
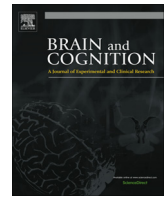
Please can you also arrange to send us a report once your project is completed.

Yours sincerely,

Mark Wilkinson
Chair FMH Research Ethics Committee

Appendix D: Published and submitted work

CrossMark

The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decision judgements

Beverley Garrigan [a], Anna L.R. Adlam [b], Peter E. Langdon [c,d,∗]

[a] Department of Clinical Psychology, Norwich Medical School, University of East Anglia, United Kingdom
[b] School of Psychology, College of Life and Environmental Sciences, University of Exeter, United Kingdom
[c] Tizard Centre, University of Kent, United Kingdom
[d] Hertfordshire Partnership University NHS Foundation Trust – Norfolk, United Kingdom

ABSTRACT

The aims of this systematic review were to determine: (a) which brain areas are consistently more active when making (i) moral response decisions, defined as choosing a response to a moral dilemma, or deciding whether to accept a proposed solution, or (ii) moral evaluations, defined as judging the appropriateness of another's actions in a moral dilemma, rating moral statements as right or wrong, or identifying important moral issues; and (b) shared and significantly different activation patterns for these two types of moral judgements. A systematic search of the literature returned 28 experiments. Activation likelihood estimate analysis identified the brain areas commonly more active for moral response decisions and for moral evaluations. Conjunction analysis revealed shared activation for both types of moral judgement in the left middle temporal gyrus, cingulate gyrus, and medial frontal gyrus. Contrast analyses found no significant clusters of increased activation for the moral evaluations-moral response decisions contrast, but found that moral response decisions additionally activated the left and right middle temporal gyrus and the right precuneus. Making one's own moral decisions involves different brain areas compared to judging the moral actions of others, implying that these judgements may involve different processes.
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1. Introduction

Over the past decade, functional magnetic resonance imaging (fMRI) has increasingly been used to measure the neural correlates of moral decision-making, adding to our understanding of the cognitive and affective processes involved. Nevertheless, there are issues with a lack of consistency amongst studies (Christensen & Gomila, 2012); a variety of different tasks have been used, and there are no agreed definitions, meaning that moral terms such as judgement, reasoning, sensitivity and moral cognition are all used differently across experiments. For the purpose of this study, we define moral judgements from a developmental psychology perspective; a moral judgement can refer to any judgement made within the moral domain, i.e. judgements relating to moral principles such as harm, justice, and fairness (Smetana, 2006; Turiel, 1983). Moral judgements can either be response decisions about what to do in a moral dilemma (self), or can be judgements of others, including judging individuals, groups, institutions or moral principles. The distinction between different types of moral judgement has not been explicitly recognised amongst cognitive neuroscientists, with recent meta-analyses in this field grouping all task types together when analysing the neural correlates of moral decision-making. Task-type may influence the results, and whether moral judgements related to the self involve different processes, and different brain areas relative to moral judgements about others has not yet been considered in previous systematic reviews.

The moral tasks used in fMRI experiments which involve an active judgement (as opposed to passive judgements) can be grouped into two categories: (a) moral response decision tasks, where an individual is asked to make a decision (judgement) about what they would do in a hypothetical moral dilemma; and (b) moral evaluation tasks, where an individual is asked to judge the appropriateness or moral permissibility of another's actions, or asked to identify or judge a moral issue or violation. Moral response decisions require an individual to think about what they would do in a moral dilemma, whereas moral evaluations require judging the moral permissibility or appropriateness of the actions of others in a moral dilemma. Discrepancy has been found for answers to moral response questions ("Would you do X?") and moral evaluation questions ("Is it wrong to do X?") in moral

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dilemmas (Tassy, Oullier, Mancini, & Wicker, 2013); "it seems that deciding *what to do* is not processed in the same way as deciding whether an action is *right or wrong*, and that in moral dilemmas it is the first that matters" (Christensen, Flexas, Calabrese, Gut, & Gomila, 2014, p. 5). A systematic review of moral decision-making which compares brain activation patterns for moral evaluations and moral response decisions can help to address whether these different questions are indeed processed in different ways in the brain. We hypothesised that making one's own decisions about what to do in a moral dilemma and judging the moral actions of others will show increased activation of different brain areas, with response decisions showing greater activation in self-referential regions and evaluations showing greater activation in theory of mind (ToM) regions.

There appears to be no evidence for a uniquely "moral brain" (Young & Dungan, 2012), as brain areas that show increased activation during moral tasks are also involved in other functions. However, the brain region which appears to be of particular importance for morality, based on neuroimaging and lesion studies, is the ventromedial prefrontal cortex (vmPFC Blair, Marsh, Finger, Blair, & Luo, 2006; Fumagalli & Priori, 2012; Marazziti, Baroni, Landi, Ceresoli, & Dell'Osso, 2013; Raine & Yang, 2006). The vmPFC is thought to be involved in emotion regulation, and activation during moral decision-making tasks is seen as evidence of the involvement of emotion processes in making moral judgements (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). Reviews of moral neuroimaging evidence have also suggested that ToM is a key cognitive input to moral judgement because ToM brain regions show increased activation when making moral judgements (Blair et al., 2006; Young & Dungan, 2012). However, this conclusion may have been overstated because most neuroimaging experiments utilise moral evaluation tasks, where participants are asked to evaluate the actions of *others*. So while ToM is likely to be involved in judging the moral permissibility or appropriateness of others' actions, it remains to be seen whether ToM brain regions are as active when making one's own moral response decisions.

Two recent meta-analyses have been conducted on brain areas consistently showing increased activation in moral decision-making studies. Bzdok et al. (2012) performed an activation likelihood estimate (ALE) analysis of morality, empathy and ToM and found overlap in activation for ToM and morality. Experiments were only included in the 'moral cognition' domain, which they defined as a "reflection of the social appropriateness of people's actions" (p. 789) if the task required participants to make judgements of other people's actions. It is, therefore, not surprising that there was overlap with ToM brain activation, as moral evaluation tasks require thinking in the third person to evaluate the actions of others, which may include inferring others' intentions to judge the permissibility of their actions. It remains to be investigated whether such an overlap with ToM regions would occur for moral response decision tasks. Sevinc and Spreng's (2014) recent systematic review of brain processes underlying moral cognition found activation in the default mode network. They compared brain activity for active vs. passive judgements and found that active judgements showed more activity in the temporoparietal junction (TPJ), angular gyrus, and temporal pole compared to passive viewing. Within the active domain however, they did not distinguish between moral response decision judgements and moral evaluation judgements, so it still remains to be investigated whether brain activity differs between these two types of moral decisions.

The aims of the current systematic review and meta-analysis are twofold: (a) to investigate which brain areas consistently show increased activation when making (i) moral response decisions (MRD), or (ii) making moral evaluations (ME) compared to non-moral or neutral decisions or evaluations; and (b) to compare brain activation patterns for these two types of moral judgements to

determine shared or significant differences in brain activation. A quality assessment of the included experiments was also undertaken, something which is often omitted from ALE studies.

All neuroimaging experiments of any type of moral decision-making were systematically searched and retrieved. Eligible experiments were categorised as either response decisions, or evaluations. ALE analysis was used to assess brain areas significantly more activated for both types of moral judgement, while conjunction and contrast analyses were performed to determine areas of significant difference. This allowed for the potential discrepancy in brain activation between task-type to be considered.

2. Method

2.1. Search strategy

A systematic search was conducted to identify all neuroimaging experiments of moral decision-making. Three databases, PubMed, PsycInfo and Web of Science were searched up to March 2015 using the terms "Moral" AND "Neuroimag* OR neural OR fMRI OR functional magnetic resonance OR PET OR positron emission tomography OR MEG OR magnetoencephalography OR brain". Where the database allowed, results were limited to humans, English language and full text articles (excluding letters, editorials etc.). This search returned 3563 results (2521 after duplicates removed) which were exported to EndNote X7. A title screen was performed to remove those obviously irrelevant, followed by an abstract screen (see Fig. 1 for PRISMA flowchart). One hundred and twenty-one references remained for full text screening, which was performed based on the eligibility criteria (Table 1). The reference list of recent systematic reviews (Bzdok et al., 2012; Sevinc & Spreng, 2014) were also screened for additional references. The initial search, title and abstract screen was carried out by BG. Full text screening was carried out by BG and PL independently and decisions were compared. Where there was a disagreement, these were discussed with reference to the inclusion criteria and a joint decision was reached.

Data extraction was performed by BG for the included experiments. Details of task type and description were extracted, along with relevant foci co-ordinates for the ALE analysis. Experiments were either categorised as MRDs or MEs based on task design. Coordinates of moral vs. non-moral/neutral conditions were extracted into an Excel file and any coordinates reported in Montreal Neurological Institute (MNI) space were converted to Talairach using the icbm2tal transformation in GingerAle 2.3.4 (Laird et al., 2010; Lancaster et al., 2007). Where an experiment did fit the inclusions criteria but did not report coordinates of moral vs. non-moral/neutral conditions, the main author was contacted via email to request these data. If there was no response after three weeks, the experiment was excluded due to lack of appropriate data to extract for ALE analysis. Where an experiment included a sample of non-typically developing adults, it was only included if coordinates for the comparison group were presented separately, and only these data were extracted for analysis. For some experiments, there was more than one moral condition (e.g., moral personal and moral impersonal) and these were collapsed together to make moral vs. non-moral for extraction purposes. Where there was more than one comparison condition to a moral condition, data were extracted for moral vs. the most neutral condition (i.e., if there was a non-moral and a neutral condition, the moral vs. neutral comparison was extracted). Different experiments had different thresholds for significant clusters, but for each experiment, coordinates were extracted for moral vs. non-moral or neutral if they met the whole brain threshold set by the authors. In some papers, authors reported coordinates under the threshold because
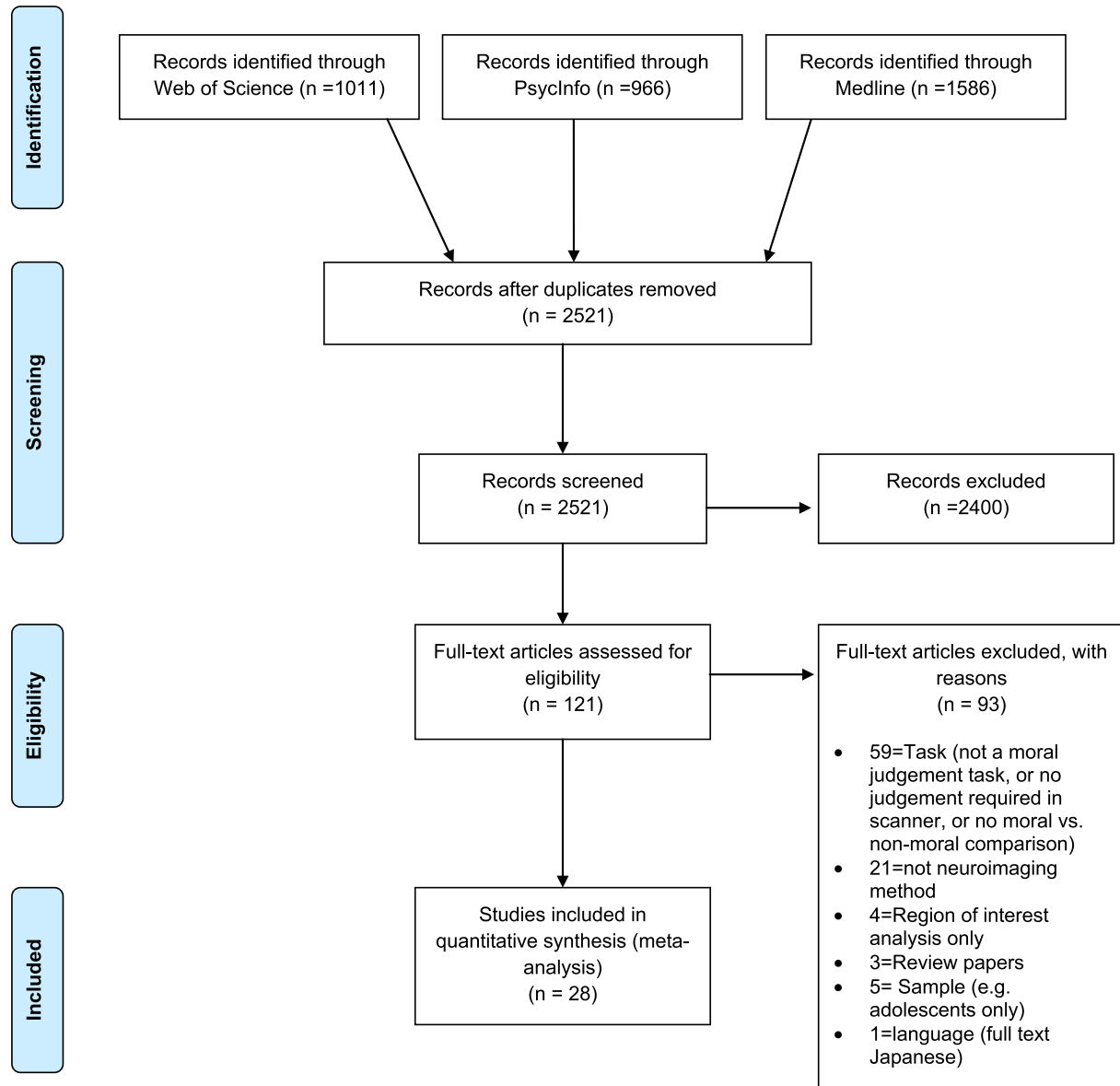
Fig. 1. PRISMA flowchart (from Moher, Liberati, Tetzlaff, & Altman, 2009).

they related to an a priori hypothesis or region of interest; these coordinates were not extracted for meta-analysis.

Table 1
Inclusion and exclusion criteria for experiments.

Inclusion criteria	Exclusion criteria
Moral decision-making task with active judgement required (response decision or evaluation)	Not moral task, or passive moral task (e.g. just viewing moral stimuli with no judgement required)
Neuroimaging method	No neuroimaging method used
Talairach or MNI coordinates reported for whole brain analysis	No coordinates reported, or region of interest analysis only
Moral task activation compared to non-moral or neutral task activation	No control task, or no moral vs. non-moral/neutral comparison coordinates reported
Typical/healthy adult subjects. (If experiment also includes non-typical participants, data for comparison group must be reported separately)	Subjects with developmental or neurological disorder, psychopathy, drug dependency or children/adolescents (can include if comparison group/adult data reported separately)
English language paper	Not English language

A quality assessment tool was developed by BG and PL, based on guidelines for reporting an fMRI study (Poldrack et al., 2008), using a binary scale (1 = evidence reported, 0 = no evidence reported/unclear/not explicit; see Supplementary Material). Experiments scoring 0–10 were classed as low quality, 11–20 classed as medium quality and 21–30 classed as high quality. BG performed quality assessment for all included experiments and PL performed quality assessment on 20% of included experiments independently.

2.2. Analysis

ALE analysis is a commonly used method for coordinate based meta-analysis. This method assesses the patterns of activation foci reported in different experiments, to establish where in the brain convergence is higher than would be expected if foci were normally distributed throughout the brain (Eickhoff, Bzdok, Laird, Kurth, & Fox, 2012; Eickhoff et al., 2009; Turkeltaub et al., 2012), taking sample sizes of experiments into account. ALE analysis was performed using GingerAle 2.3.4 on the x, y, z coordinates of moral vs. non-moral or neutral conditions. Firstly, ALE analysis

was performed for all ME experiments and then for all MRD experiments. A conjunction analysis was then performed to find shared brain activation for ME and MRD judgements. Contrast analyses were performed to assess differences in brain activation (MRD-ME and ME-MRD).

Conjunction analysis comparing the results of the present ALE to results from recent ALE systematic reviews was not possible without knowledge of exactly which foci had been extracted for each included experiment of previous reviews, and was also not practical due to differences in inclusion and exclusion criteria. The results of the present ALE were instead compared visually with results from two recent reviews (Bzdok et al., 2012; Sevinc & Spreng, 2014) where appropriate, and outlined in the discussion. Results from these previous reviews were reported in MNI coordinates, so for an easier comparison with our results we transformed their reported coordinates to Talairach coordinates using the using the icbm2tal transformation in GingerAle 2.3.4 (Laird et al., 2010; Lancaster et al., 2007) and then labelled the areas using Talairach client (Lancaster et al., 1997, 2000).

3. Results

After full text screening, 28 separate experiments were eligible for inclusion, with a total of 271 foci from 642 participants. All experiments used fMRI, 10 used a MRD task and 18 used a ME task. Table 2 shows the main characteristics of the included experiments.

ALE analysis was performed for all ME experiments and all MRD experiments, *cluster-level* = 0.05, 1000 *permutations*, *p* = 0.001. Conjunction and contrast analyses were then performed, *p* = 0.01, 1000 *permutations*, *minimum cluster* = 200mm^3, to assess shared and divergent brain activation between the two task types. Table 3 shows the results of ALE analysis, and Fig. 2 shows the largest significant clusters of brain activation found for each ALE analysis. All coordinates are reported in Talairach space.

Six significant clusters of activation were found across the ME experiments (18 experiments, 174 foci, 383 participants): two in the left medial frontal gyrus (MFG), the left superior temporal gyrus (STG), left cingulate gyrus (CG), right STG and right MFG. Six significant clusters were found across the MRD experiments (10 experiments, 97 foci, 259 participants): left middle temporal gyrus (MTG), left precuneus, right MFG, right MTG, right inferior frontal gyrus (IFG) and left caudate. Conjunction analysis revealed three clusters of shared activation for both moral task types: the left MTG, left cingulate gyrus and left MFG. A contrast analysis of MEs-MRDs did not find any significant clusters. However, a contrast analysis of MRDs-MEs found three significant clusters: the right MTG, right precuneus, and left MTG.

Quality assessment indicated that 20 experiments were high quality, eight were medium quality and none were low quality (see Supplementary Material). The medium quality experiments did not report as much information as the high quality experiments. Analyses included all experiments regardless of quality, but issues regarding the quality of included experiments are outlined in the discussion and should be taken into consideration when interpreting the results. Agreement between BG and PL for quality assessment was k = 1 (p = 0.14), ICC = 0.88 (p = 0.005).

4. Discussion

4.1. Interpretation of significant clusters of activation

This systematic review and meta-analysis builds on previous reviews in the field by differentiating between MRD judgements and ME judgements, to assess similarities and differences in

Table 2
Characteristics of included experiments.

Reference	Subjects	Conditions	No. foci	Moral stimuli	Moral task instructions/response format
Moral response decisions					
Borg, Hynes, Van Horn, Grafton, and Sinnott-Armstrong (2006)	24	Moral vs. non-moral	7	Written moral scenarios	Yes/No button press to "Is it wrong to do it?" and "Would you do it?" after each scenario
Chiong et al. (2013)	16	Moral personal vs. non-moral	3	Modified Greene (2001) dilemmas presented as written text and also audible narration	Yes/No button press to "Would you do X in order to X?" after each dilemma
FeldmanHall, Sokol-Hessner, Van Bavel, and Phelps (2014)	38	Moral (difficult and easy) vs. non-moral (difficult and easy)	10	Written moral scenarios	Yes/No button press to "Do you do (proposed response)?" after each scenario
Han et al. (2014)	16	Moral (personal and impersonal) vs. neutral	28	Modified Greene et al. (2001) dilemmas, moral-personal and moral-impersonal, presented as text	Yes/no button press to "Is it appropriate for you to do (proposed solution)?"
Harrison et al. (2012)	73	Moral vs. nondilemma	11	Vignettes of modified Greene et al. (2001) dilemmas. Participants familiarised with vignettes within 1 week of scanning session using illustrations and examiner-read descriptions. Voice-prompts in scanner	Yes/no finger raise to "Would you do X?" after each dilemma
Pujol et al. (2012)	22	Moral vs. nondilemma	14	As Harrison et al. (2012)	As Harrison et al. (2012)
Schneider et al. (2012)	28	Moral vs. baseline	4	Written moral dilemmas. Social-ethical dilemmas and individual gain vs. collective losses	Agree or disagree with proposed solution using button press after each dilemma
Sommer et al. (2010)	12	Moral vs. neutral	6	Written stories describing moral conflict	"What should I do?" Choose between two response alternatives after each dilemma with a button press
Sommer et al. (2014)	16	Moral vs. social	6	As Sommer et al. (2010)	As Sommer et al. (2010)
Verdejo-Garcia et al. (2014)	14	Moral vs. nondilemma	8	As Harrison et al. (2012)	As Harrison et al. (2012)

Table 2 (continued)

Reference	Subjects	Conditions	No. foci	Moral stimuli	Moral task instructions/response format
Moral evaluations					
Avram et al. (2013)	16	Moral vs. esthetic	8	Written moral statements	Decide whether each moral statement could be considered 'right' by pressing button
Avram et al. (2014)	16	Moral (1st and 3rd person) vs. non-moral	10	Written moral statements	Rate each statement as 'right' or 'wrong' using button press
Bahnemann et al. (2010)	25	Moral vs. physical	10	Animated stimuli of two people in a social interaction. Protagonist's behaviour was either in accordance with or in violation of a social norm	Yes/no button press to "Is the protagonist violating a norm?" after each moral dilemma
de Achával et al. (2013)	13	Moral vs. non-moral	6	Modified version of Moral Dilemmas Test (Greene et al., 2001) presented as text	Yes/ no button press to "Would you consider it appropriate to…?" after each dilemma
Harada et al. (2009)	18	Moral vs. gender judgement	9	Written stories of protagonist performing good or bad deed	Yes/no button press to "Is the protagonist's behaviour morally bad?"
Harenski, Antonenko, Shane, and Kiehl (2008)	28	Moral vs. non-moral	15	Moral pictures from IAPS and media, depicting unpleasant social scenes indicating a moral violation	Determine if the picture represented a moral violation and rate the severity of the violation on scale of 1–5 using button press to stop rating bar
Harenski et al. (2012)	36	Moral vs. neutral	7	Moral pictures from IAPS and media, depicting unpleasant social scenes indicating a moral violation	Rate moral violation severity of picture on scale of 1–5 using button press to stop rating bar
Harenski et al. (2014)	46	Moral vs. neutral	23	Moral pictures from IAPS and media, depicting unpleasant social scenes indicating a moral violation	Rate severity of moral transgression in pictures from 1 to 5 using button press to stop rating bar
Heekeren, Wartenburger, Schmidt, Schwintowski, and Villringer (2003)	8	Moral vs. semantic	9	Written sentences (German)	Judge whether actions described in sentences were "appropriate" or "inappropriate" with button press
Heekeren et al. (2005)	12	Moral vs. semantic	8	Written sentences (German) containing bodily harm or not	Judge if actions described in moral sentences were "appropriate" or "inappropriate" with button press
Moll et al. (2001)	10	Moral vs. factual	10	Moral sentences presented aurally	Think about each statement and judge whether they are 'right' or 'wrong'. No overt judgement in scanner
Moll et al. (2002)	7	Moral vs. non-moral neutral	2	Written moral statements	Covertly judge each sentence as 'right' or 'wrong'. No overt judgement in scanner
Parkinson et al. (2011)	30	Moral (harmful, dishonest and disgust) vs. neutral	30	Written moral scenarios	Decide if main character's actions were 'wrong' or 'not wrong' with button press
Prehn et al. (2008)	23	Socio-normative vs. grammatical	6	Written sentences	Decide if action described was a social norm violation or not with yes/no button press
Reniers et al. (2012)	24	Moral vs. non-moral	6	Written scenarios of moral decision-making	Yes/no to "Is it ok for X to do this?" using button press
Robertson et al. (2007)	16	Moral (care/justice) vs. neutral nonmoral	5	Written business case scenario describing workday of a fictional marketing research analyst	Press button when identify an important point or issue
Schleim, Spranger, Erk, and Walter (2011)	40	Moral vs. personal	6	Written stories adapted from moral issues in media	Had to judge if behaviour in stories was right from a moral point of view. Decide between 'yes, rightly' and 'no, not rightly' using button press
Takahashi et al. (2008)	15	Moral (beauty and depravity) vs. neutral	4	Written sentences (Japanese)	Read sentences silently and rate according to how moral/ immoral or praiseworthy/blameworthy the events were (no overt judgement in scanner)

Number of subjects is the number included in the analysis that was extracted for this review (e.g., number of subjects in control group sample) not necessarily the total number of subjects in the experiment. Harenski et al. (2014) coordinates for control group were sent by main author after email request.

Table 3
Significant clusters of activation for moral evaluations, moral response decisions, and conjunction and convergence analysis.

	#	Volume (mm³)	X	y	z	Cerebrum	Label	Brodmann area
Moral evaluations	1	3296	−6	44	20	Left	MFG	9
	2	2176	−44	−56	18	Left	STG	39
	3	2024	−2	−56	26	Left	CG	31
	4	744	50	6	−20	Right	STG	38
	5	384	2	54	2	Right	MFG	10
	6	296	−4	48	−6	Left	MFG	10
Moral response decisions	1	1968	−44	−64	20	Left	MTG	39
	2	1928	−2	−60	30	Left	Precuneus	7
	3	1512	2	44	36	Right	MFG	6
	4	1248	44	−60	24	Right	MTG	39
	5	296	36	28	−12	Right	IFG	47
	6	264	−12	4	12	Left	Caudate	–
Conjunction of moral evaluations and moral response decisions	1	712	−44	−60	18	Left	MTG	19
	2	680	−2	−56	28	Left	CG	31
	3	312	−6	44	40	Left	MFG	8
Moral response decisions-moral evaluations	1	904	42.8	−56	21	Right	MTG	39
	2	408	3	−64	30	Right	Precuneus	31
	3	264	−40	−66	16	Left	MTG	39

X, y, z coordinates are reported in Talairach space and refer to the maximum value of each cluster. Moral evaluation and moral response decision ALE analyses performed using cluster-level = 0.05, 1000 permutations, p = 0.001. Conjunction and contrast analysis performed using p = 0.01, 1000 permutations, minimum volume = 200 mm³. Labels and Brodmann areas generated by GingerAle 2.3.4. MFG = medial frontal gyrus, STG = superior temporal gyrus, CG = Cingulate gyrus, MTG = middle temporal gyrus, IFG = inferior frontal gyrus.

patterns of brain activation between these two types of moral decisions. The ALE analyses found three significant clusters of shared brain activation for both task types: the left MTG, CG and MFG. Contrast analysis revealed that MRDs additionally activated the right MTG, right precuneus and left MTG. These findings show that making one's own moral judgements about what to do in a moral dilemma is associated with increased activation of differing brain areas, as we predicted.
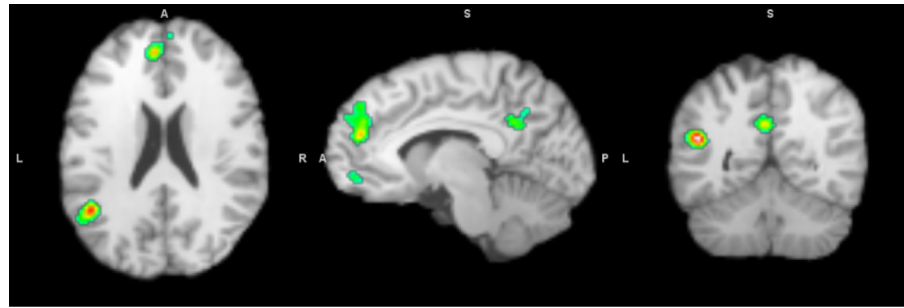
The brain region which has been most commonly implicated in moral decision-making, based on neuroimaging and lesion studies is the vmPFC. This region is not precisely defined in the literature but usually refers to any brain areas in the ventromedial frontal lobe, and BA's 10, 11, 24, 25 and 32 (Nieuwenhuis & Takashima, 2011). We only found a significant cluster of activation of this region for MEs (cluster 5 and 6, MFG BA 10) and also the adjacent BA 9 (cluster 1, MFG), rather than MRDs, and this region did not remain significant in the conjunction analysis, probably because it was the smallest of the clusters found for MEs. The lack of a significant cluster of activation in the vmPFC for MRDs highlights that most previous conclusions about brain activation for moral decision-making have been made based on ME tasks; further research on the involvement of this region for MRDs is needed, as the current review only identified 10 relevant MRD experiments.

The three clusters of significant shared activation for both moral task type (ME and MRD) - the left MTG, left CG, and left MFG - are also involved in other processes, so are not unique or specific to making moral judgements. Such a view that there is no 'moral brain' suggests that many processes such as attention, working memory, emotion recognition, empathic arousal and retrieval of relevant schemas may be involved when making moral judgements, thus many brain areas related to various domains are likely to be recruited. All three significant clusters were found in the left hemisphere, which is involved in language (Springer et al., 1999) so this may reflect the fact that most of the tasks involve language processing. It has been found that perceptual decisions engaged the left hemisphere of the MFG (Talati & Hirsch, 2005) and that the MTG is involved in multimodal semantic processing (Visser, Jefferies, Embleton, & Ralph, 2012) with the left MTG being the core component of the semantic network (Wei et al., 2012). The cluster of activation in the cingulate gyrus was found in BA 31,

which is part of the posterior cingulate cortex and has been found to show an increase in activation when judging the valence of emotional words (Maddock, Garrett, & Buonocore, 2003); increased activation of this area for both types of moral task may reflect processing of written emotional stimuli.

Relative to ME tasks, MRDs were found to additionally activate the left and right MTG and the right precuneus. These findings support our hypothesis that MRDs will show increased activation of more self-referential brain areas. The precuneus, a brain region more highly developed in humans than other animals, is involved in higher order cognitive processes including self-processing and consciousness (Cavanna & Trimble, 2006) and egocentric spatial processing (Freton et al., 2014). The MTG also showed an increase in activation for MRDs but not MEs, suggesting it may play a role in making one's own decisions, particularly the right MTG which was not a significant cluster in the conjunction analysis. While activation of the right precuneus in MRD tasks may reflect increased self-referential processing compared to when making MEs of other's behaviour, it may just reflect differences between the moral task types. The right precuneus is associated with metaphor comprehension (Mashal, Vishne, & Laor, 2014) and verbal creative thinking (Chen et al., 2015), so activation of this region during MRD tasks may reflect the fact that these tasks tend to involve dilemmas that are not real life (e.g., choosing to kill one or five people), thus may require more abstract thinking about unfamiliar situations.

We hypothesised that the ME tasks would show increased activation of more ToM related areas than MRD tasks, as they involve thinking about the mental states of others to judge moral behaviour. This hypothesis was not supported, as the contrast analysis for MEs-MRDs did not reveal any significant clusters. The right temporoparietal junction (rTPJ) has been suggested as an area important for ToM (Saxe & Powell, 2006). The rTPJ is a vaguely defined area but is also referred to as Brodmann Area (BA) 39 (Bzdok et al., 2013). Contrary to our hypothesis, the ALE analysis revealed that the rTPJ (BA 39, MTG) showed significantly increased activation across the MRD tasks (cluster 4) but not across the ME tasks. The surprising finding of significant activation of this area for MRDs but not MEs suggests that ToM processes are even more involved when making one's own moral decisions than when making evaluations of others. One explanation may be that when

Moral evaluation clusters
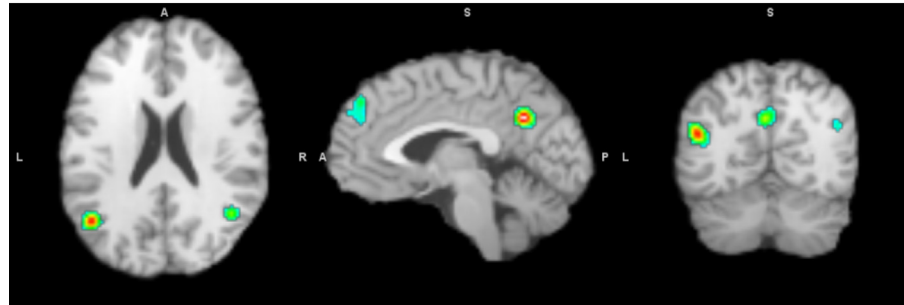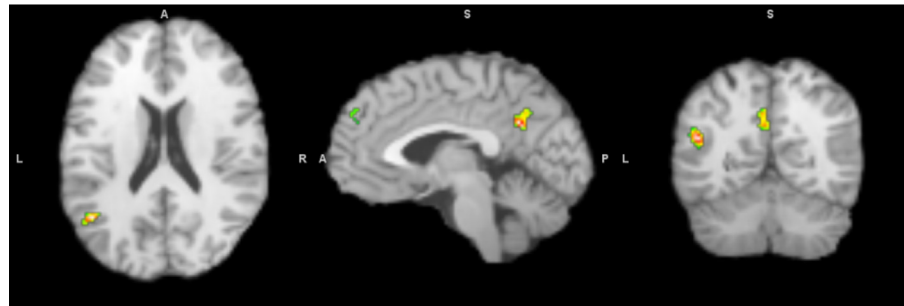
Moral response decision clusters

Conjunction analysis: Shared activation for moral evaluation and moral response decisions

Contrast analysis: Moral response decisions-moral evaluations

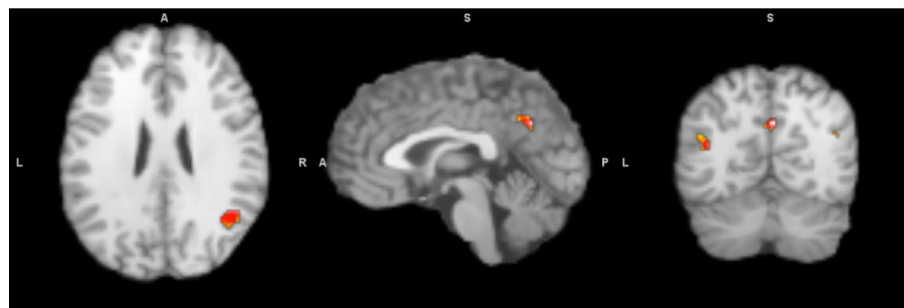**Fig. 2.** Brain activation maps showing significant clusters of activation. Images created in GingerAle 2.3.4, overlaid onto Colin 2 × 2 × 2 template in Mango (Lancaster & Martinez 2006–2015). Brain images are axial, sagittal and coronal view of main clusters of activation for each ALE analysis. Image labels: L = left, R = right, P = posterior, A = anterior, S = superior.

thinking about what to do in a moral dilemma, individuals think about the consequences of their possible actions for others, e.g. "would my actions upset/harm someone?" ToM abilities develop with age (Wellman, Cross, & Watson, 2001) and the perspectives of others are taken into account more as egocentric bias decreases (Gibbs, 2013), and this may reflect the increased activation of the rTPJ for MRDs amongst adults found in this meta-analysis. Harenski, Harenski, Shane, and Kiehl's (2012) ME study which we

included in our meta-analysis also included an adolescent sample, and they found that involvement of the rTPJ while viewing moral pictures increased with age. Developmental fMRI studies of MRDs are needed, to establish whether the involvement of ToM regions when making one's own moral decisions increases with age. The hypothetical dilemmas used in the included MRD experiments involved other people, so participants may typically infer the mental states or possible mental states of others when deciding their

response. Some of the included ME tasks used did not reference other people, such as judging sentences as 'right' or 'wrong' so would not have led to participants inferring mental states of others. Contrary to our finding, Bzdok et al. (2012) found significant activation in the rTPJ for their moral cognition domain. However, experiments were only included in their moral cognition analysis if they involved participants making "appropriateness judgements on actions of one individual towards others" (p. 785) so always involved other people. The lack of rTPJ involvement for MEs in this meta-analysis may reflect the type of evaluation tasks used. Our finding suggested that not all types of moral decision-making involve ToM processes - it depends on whether the dilemma or stimuli involves other people, which can lead individuals to infer the mental states of others when considering the possible consequences of their decisions. Real life moral dilemmas are likely to involve other people, so ToM processes are likely to be involved in such decisions, and involvement may change with age.

We compared our findings to those of two recent systematic reviews of moral decision-making, Bzdok et al. (2012) and Sevinc and Spreng (2014). As previously stated, the criteria for Bzdok et al.'s (2012) moral cognition domain was that participants were required to make appropriateness judgements, which is what we have termed moral evaluations. We, therefore, compared our ALE analysis results for MEs to Bzdok et al.'s (2012) results for the moral cognition domain. Our results are fairly comparable to Bzdok et al.'s (2012) with both finding activation in the left and right MFG (BA 10, labelled by Bzdok et al. as vmPFC) and the right STG (BA 38, labelled by Bzdok et al. as the right temporal pole). In line with Bzdok et al.'s (2012) analysis, we also found a cluster of activation in the left STG (labelled by Bzdok et al. as left TPJ), though in our analysis this was BA 39 and from their analysis it was BA 22, although these are adjacent areas. As previously stated, Bzdok et al. (2012) found a cluster of activation in the rTPJ (BA 39), which we did not find. Another discrepancy between our ME activation clusters and Bzdok et al.'s (2012) for moral cognition are that they found a cluster of activation in the left amygdala, which we did not find. Also, Bzdok et al. (2012) reported activation in the precuneus, which was not found to be a cluster of significant activation for the ME experiments in our analysis, although our results did reveal activation in the adjacent cingulate gyrus. Differences between our findings and Bzdok et al.'s (2012) may be partly due to discrepancies between Talairach labels and the SPM anatomy toolbox, and also due to the differences of tasks for the included experiments; Bzdok et al. (2012) included only experiments where participants were required to make appropriateness judgements on the actions of one individual towards others while we included any ME judgement, including tasks where participants had to judge moral sentences. Our ALE analysis results for MRDs are not comparable with Bzdok et al.'s (2012) moral cognition results, supporting the finding that judging the appropriateness of others actions increases activation of different brain regions compared to when making one's own moral response decisions.

Sevinc and Spreng's (2014) systematic review compared brain activation for active and passive moral tasks. As our review only included tasks that required an active decision, we compared our findings for MRDs and MEs to Sevinc and Spreng's (2014) findings for active tasks. Our ALE results for MEs are fairly comparable to Sevinc and Spreng's (2014) ALE results for active tasks, with both finding clusters of activation in the left MFG (BA 9, labelled by Sevinc & Spreng as medial PFC and anterior superior frontal sulcus), right MFG (BA 10, labelled by Sevinc & Spreng as vmPFC and superior temporal sulcus), right STG (BA 38, labelled by Sevinc & Spreng as MTG) and the left cingulate gyrus (BA 31, labelled by Sevinc & Spreng as posterior cingulate cortex). Comparing our results for MRDs to Sevinc and Spreng's (2014) active results, there is no direct overlap but there are some similarities. Sevinc and Spreng (2014) found a cluster of activation in the left MTG, BA 22, whereas our ALE analysis for MRDs revealed a cluster in the left MTG BA 39, adjacent to BA 22. Sevinc and Spreng (2014) found activation in the left IFG whereas we found activation in the right IFG for MRDs. Again, differences may be due to discrepancies between Talairach and MNI labelling and also differences between tasks of the included experiments. For Sevinc and Spreng's (2014) active domain, four of the included experiments were also included in our MRD domain, but we included an additional six MRD experiments, and the majority of the active experiments in Sevinc and Spreng (2014) were MEs.

4.2. Quality assessment and critique of tasks used in included experiments

As far as we are aware, this review is the first ALE meta-analysis to report on the quality of included experiments. In the absence of a pre-existing standardised quality assessment tool for an ALE systematic review, the quality assessment tool was adapted from guidelines for reporting fMRI studies (Poldrack et al., 2008). Future reviews could use this checklist, or similar quality assessment tools, and should exclude low quality experiments from ALE analysis. While the majority of included experiments in this systematic review were found to be of high quality, based on the adapted checklist, there were issues with some of the tasks used.

Firstly, there was a wide range of moral tasks used across the included experiments, and it is important to acknowledge that differences in brain activation may reflect differences in the tasks used across studies, in terms of modality and content of the moral stimuli, and the nature of the control task. The presentation modality varied, and while most tasks used written stimuli presented on screens for participants to read, some experiments, such as Bahnemann, Dziobek, Prehn, Wolf, and Heekeren (2010) used animated stimuli, with participants being asked to judge if the protagonist in the animations is violating a norm. Also, there were differences in the context and amount of detail of moral stimuli across moral tasks. Bahnemann et al.'s (2010) animations featured a social violation where a protagonist is punching the other person in the face. While this is a real life social and moral (harm) violation, it could be argued that this scenario would be more emotive if the victim was murdered. Differences in emotional engagement, paying more attention to out of the ordinary stimuli, or having to think more about scenarios not previously encountered (such as many of the life and death choices presented in moral tasks) are likely to contribute to differences across experiments.

One limitation of some of the included experiments is the nature of the task that was used as a comparison to the moral task. For some experiments, participants were asked to respond similarly across control and experimental conditions, while the stimuli varied. For example, in Parkinson et al. (2011), participants judged whether a character's actions were right or wrong within neutral or moral tasks. Differences in brain activity may therefore have been partially accounted for by differences in reading and processing moral, compared to neutral scenarios, rather than for making a moral compared to a neutral evaluation judgement, which the authors did acknowledge (p. 3166). Similar issues exist across several other experiments (Harenski et al., 2012; Harenski, Edwards, Harenski, & Kiehl, 2014; Han, Glover, & Jeong, 2014; Moll, Eslinger, & de Oliveira-Souza, 2001; Moll et al., 2002; Reniers et al., 2012). Several of the included experiments used the same moral task, classified as a MRD task, where participants were asked "would you do X?" after reading a scenario about Mr. Jones' dilemma (Harrison et al., 2012; Pujol et al., 2008; Verdejo-Garcia et al., 2014). For the control condition, participants were asked to recall the correct answer to the non-dilemma vignette, which they had been familiarised with before the scanner task, e.g., "will he go

to the beach?" The control task used in these experiments was, therefore, a recall rather than a decision task, thus the results show brain activation differences for recall vs. a MRD judgement, rather than brain activation for making a moral as opposed to a non-moral decision. For some of the included experiments, the control task may not have been an appropriate comparison for moral tasks (i.e., not a non-moral or neutral judgement task), so we should be cautious about the significant moral decision-making peak coordinates from these experiments.

4.3. Limitations

There are several limitations to this review and meta-analysis. Firstly, only 10 MRD experiments were identified from the literature, and 15 is the minimum recommended number of experiments for ALE contrast analysis (Laird et al., 2010; Lancaster et al., 2007). While significant clusters were still found for MRD and ME judgements, and the findings are novel, the results should be interpreted with caution as the MRD clusters are only based on 10 experiments. Secondly, there were some experiments where it was ambiguous as to whether the task was a MRD or ME task. We categorised the experiments based on the authors' claims, and the type of question participants responded to (evaluation or response decision), but difficulty categorising some of the experiments highlights the lack of consistency amongst moral tasks used in fMRI experiments. Thirdly, some of the tasks appeared to lack ecological validity as they did not seem to reflect how moral decisions are made in real life situations. We recommend that future neuroimaging experiments use more real life scenarios for assessing moral decision-making, for example, everyday scenarios that people are more likely to encounter than life or death situations. Finally, to ensure comparability across studies, adolescents were excluded. The conclusions drawn, therefore, only apply to adults. Further neuroimaging studies focusing on children and adolescents would help answer questions about moral development and the developmental pattern of the neural correlates of moral decisions.

5. Conclusion

This is the first systematic review of moral decision-making to explicitly acknowledge the different types of moral decisions, and to compare brain activity for the two main types, MRDs and MEs. Findings from the ALE analysis show that making one's own moral judgements about what to do in a moral dilemma involves increased activation of additional brain areas compared to judging the moral actions of others, suggesting different processes may be involved. Making one's own decisions appears to involve an extended brain network, incorporating self-referential regions which do not show an increase in activation when making moral evaluations of others. Most previous conclusions about moral decision-making have been based on moral evaluation tasks; further neuroimaging studies employing moral response decisions tasks of real life scenarios are needed before we can be confident about which brain areas are needed for making one's own, every day moral response decisions.

Conflict of interest

All authors declare they have no conflict of interest.

Acknowledgements

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.bandc.2016.07.007.

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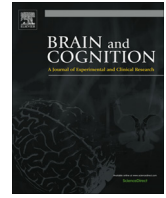
Corrigendum

Corrigendum to "The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decision judgements" [Brain Cogn. 108 (2016) 88–97]

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A cluster-level thresholding error in the version of GingerALE software used by the authors (version 2.3.4) was reported by Eickhoff et al. (2016) recently. The authors subsequently re-ran the ALE analysis using version 2.3.6 of GingerALE. This resulted in a change to the meta-analysis clusters, with the two smallest clusters for moral evaluations (ME) and moral response decisions (MRD) being no longer being significant. There was no change to the conjunction analysis, or to the ME-MRD contrast (still no significant clusters). The results for the MRD-ME contrast are slightly different after re-running the analysis, although the area labels remain the same. Table 1 below shows the corrected results obtained from re-running the analysis in GingerALE version 2.3.6

and Fig. 1 displays the brain activation maps for MEs, MRDs and the MRD-ME contrast based on the revised analysis.

We stated in our original paper that "six significant clusters of activation were found across the ME experiments (18 experiments, 174 foci, 383 participants): two in the left medial frontal gyrus (MFG), the left superior temporal gyrus (STG), left cingulate gyrus (CG), right STG and right MFG. Six significant clusters were found across the MRD experiments (10 experiments, 97 foci, 259 participants): left middle temporal gyrus (MTG), left precuneus, right MFG, right MTG, right inferior frontal gyrus (IFG) and left caudate." (p. 91). After re-running the analysis in GingerALE 2.3.6, only four significant clusters of activation were found for ME and MRD

Table 1
Significant clusters of activation for moral evaluations, moral response decisions, and conjunction and convergence analysis.

	#	Volume (mm^3)	X	y	z	Cerebrum	Label	Brodmann area
Moral evaluations	1	3296	−6	44	20	Left	MFG	9
	2	2176	−44	−56	18	Left	STG	39
	3	2024	−2	−56	26	Left	CG	31
	4	744	50	6	−20	Right	STG	38
Moral response decisions	1	1968	−44	−64	20	Left	MTG	39
	2	1928	−2	−60	30	Left	Precuneus	7
	3	1512	2	44	36	Right	MFG	6
	4	1248	44	−60	24	Right	MTG	39
Conjunction of moral evaluations and moral response decisions	1	712	−44	−60	18	Left	MTG	19
	2	680	−2	−56	28	Left	CG	31
	3	312	−6	44	40	Left	MFG	8
Moral response decisions-moral evaluations	1	896	42.9	−56.9	23.4	Right	MTG	39
	2	328	2	−61	31	Right	Precuneus	7
	3	280	−39	−64.5	16.5	Left	MTG	39

X, y, z coordinates are reported in Talairach space and refer to the maximum value of each cluster. Moral evaluation and moral response decision ALE analyses performed using cluster-level = 0.05, 1000 permutations, p = 0.001. Conjunction and contrast analysis performed using p = 0.01, 1000 permutations, minimum volume = 200mm^3. Labels and Brodmann areas generated by GingerAle 2.3.6. MFG = medial frontal gyrus, STG = superior temporal gyrus, CG = Cingulate gyrus, MTG = middle temporal gyrus.

Moral evaluation clusters

Moral response decision clusters

Conjunction analysis: Shared activation for moral evaluation and moral response decisions

Contrast analysis: Moral response decisions-moral evaluations

Fig. 1. Brain activation maps showing significant clusters of activation. Images created in GingerAle 2.3.6, overlaid onto Colin 2 2 2 template in Mango (Lancaster & Martinez, 2006–2015). Brain images are axial, sagittal and coronal view of main clusters of activation for each ALE analysis. Image labels: L = left, R = right, P = posterior, A = anterior, S = superior.

experiments, with the two smallest clusters for each type being no longer significant. There were no longer significant clusters for MEs in the left and right MFG, Bro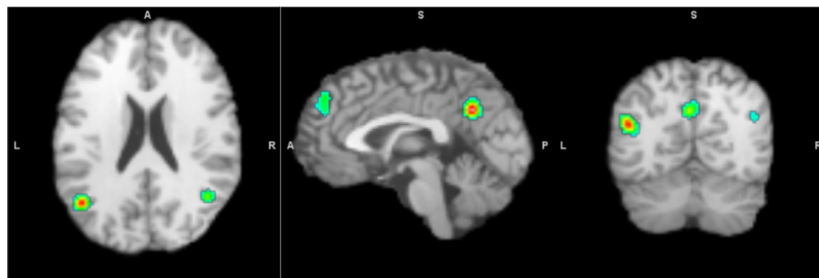dmann area (BA) 10, although the largest cluster for MFG, BA 9 remained. For MRDs, there was no longer a significant cluster in the right IFG, BA 47 or the left caudate. The number of experiments, foci and participants remained the same.

　　In terms of how the new results affected the discussion within our original paper, we had stated that we found significant clusters of activation in the ventromedial prefrontal cortex (vmPFC) for MEs: cluster 5 and 6, MFG BA 10. However, clusters 5 and 6 for MEs were no longer significant after we re-ran the analysis, due to the cluster-level threshold bug in GingerALE 2.3.4. Our

meta-analysis therefore only found one cluster (cluster 1 for MEs; MFG, BA 9) adjacent to the regions commonly referred to as the vmPFC. This further strengthens the argument that although the vmPFC has traditionally been the brain region most commonly implicated in moral decision-making, further research is needed to establish whether this brain region is involved for different types of moral evaluation tasks, and when making your own moral decisions.

　　In our comparison of our ME results with Bzdok et al.'s (2012), we previously said that we both found activation in the left and right MFG, BA10, while our revised findings indicated significant activation of the left MFG, BA9 only. Comparing our ME results

with that of Sevinc and Spreng (2014), we had previously stated that we both found activation in the right MFG, BA 10 but this cluster was no longer significant in our revised analysis. In the comparison of our MRD results with that of Sevinc and Spreng (2014) we also previously stated that while they found activation in the left IRF, we found activation in the right IFG, but this region is no longer significant in our revised analysis.

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Social Problem-Solving and Moral Development: New Perspectives

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Chapter 17

In

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Research, Training and Practice

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Abstract

This chapter reviews models of social problem-solving and makes links with social neuroscience, moral development and social information processing (SIP) theories in relation to people with intellectual disabilities (IDs). These differing theoretical perspectives are drawn together into a single, unified framework: the Social Information Processing-Moral Decision-Making (SIP-MDM) framework. Research into some of the aspects of this framework in children and adults with IDs is then briefly reviewed. The chapter concludes with a consideration of theoretical and clinical implications for people with IDs.

Keywords

Introduction

D'Zurilla and Nezu (2001, p. 212) defined problem-solving as "the self-directed cognitive-behavioural process by which a person attempts to identify or discover effective or adaptive solutions for specific problems encountered in everyday living." Inherently, and diagnostically, people with intellectual disabilities (IDs) have difficulties with adaptive behaviour (World Health Organisation, 1994), and as a consequence, it will not be surprising that many people with IDs will also have difficulties with problem-solving, including social problem-solving (Ferretti & Cavalier, 1991). Within this chapter, we will review models of *social* problem solving, making links with social information processing, moral development, and social neuroscience, drawing these related theoretical perspectives together in a single unified framework of social information processing and decision making. The implications for people with IDs, both theoretical and clinical, will be considered.

Theoretical Perspectives

Social Problem-Solving. There have been several attempts to characterise the process of problem-solving, from a cognitive perspective. Belmont, Butterfield and Ferretti (1982) argued that there were six component processes: (a) goal definition, (b) strategy selection, (c) goal monitoring, (d) strategy evaluation, and (e) strategy revision; although these were in reference to successful self-management. D'Zurilla and Goldfried (1971) suggested that problem-solving comprised five stages or steps: (a) general-orientation, (b) problem definition and formulation, (c) generation of solutions or alternatives, (d) decision-making, and (e) solution implementation or verification, and went on to develop a model of *social* problem-solving which they defined as, "…the process of problem solving as it occurs in the natural environment or "real world" (D'Zurilla, Nezu, & Maydeu-Olivares, 2004, p. 11).

D'Zurilla *et al*. (2004, p. 11) further commented that this included, "…all types of problems that might affect a person's functioning, including impersonal problems…personal or intrapersonal problems…interpersonal problems…as well as broader community and society problems."

    D'Zurilla *et al*. (2004)'s model comprised two components: (a) problem orientation, and (b) problem-solving skills, also referred to as "problem-solving proper or style".   Problem orientation was said to be a meta-cognitive process, involving schema, while problem-solving skills were seen as the activities that occur when attempting to solve a problem. They outlined four "skills," which were (a) problem definition and formulation, (b) generative of alternative solutions, (c) decision-making, and (d) solution implementation and verification.   They argued that individuals may have a positive or a dysfunctional problem orientation. A positive problem orientation was seen when problems were viewed as "challenges", with optimism about solvability, chances of success, and ability, and an understanding that problem-solving is effortful, but should be tackled quickly. An avoidant, or a dysfunctional problem orientation, was associated with seeing problems as threatening, with little optimism about one's ability, coupled with a tendency to become frustrated when faced with problems. Linked to this, people have several different problem-solving styles which were (a) rational, defined as the "…rational, deliberate and systematic application of effective problem-solving skills" (D'Zurilla *et al.*, 2004, p. 15) (b) impulsivity-carelessness, defined as "…narrow, impulsive, careless, hurried, and incomplete" (D'Zurilla *et al.*, 2004, p. 15) problem-solving, or (c) avoidant, "…characterised by procrastination, passivity or inaction, and dependency" (D'Zurilla *et al.*, 2004, p. 15).

Social Information Processing. While many are likely to make use of several multiple problem-solving styles at various points, effective social information processing is a necessity for solving problems within the social domain. The well-known social information processing model of Crick and Dodge (1994; 1996; Dodge, 1986; Dodge & Price, 1994), while developed in order to explain behavioural disorders in children, shares similarities with D'Zurilla *et al*. (2004)'s model. Crick and Dodge (1994; 1996) argued that behaviours are a function of the processing of contextual cues, but also biological determined capabilities and stored information regarding past experiences. Social information processing was said to involve six steps: (a) encoding of cues, (b) interpretation of cues, (c) clarification of goals, (c) response access or construction, (d) response decision, and (e) behavioural enactment. The steps occur rapidly and in parallel, and are influenced by stored information (social schema, acquired rules, and social knowledge), while processing can modify this stored information, and these changes occurred with development and experience, along with developmental shifts in cognitive functioning.

Integrating Social Problem-Solving, Social Information Processing and Moral Development. While Crick and Dodge (1994; 1996) attempted to explain the cognitive processes involved in social information processing, Lemerise and Arsenio (2000) attempted to expand the model to include emotion recognition and regulation. Temperament and emotion were seen as key influences on each step of processing, along with past experience, stored in the form memories, or in other words, latent mental structures. Arsenio and Lemerise (2004) integrated moral domain theory and social information processing, stating that both models emphasised the role of peer interactions and the formation of social knowledge. Moral domain theory, also referred to as social domain theory, makes the important distinction between the personal, moral and social domains

(Smetana, 1999; Turiel, 1983, 2002), and Arsenio and Lemerise (2004) argued that moral

domain theory provided a description of latent mental structures, while social information

processing theory described online information processing. Although, Arsenio and Lemerise

(2004) considered the domain model to be a primary approach in the field of moral

development, this is not entirely the case, as other models are relevant, especially

considering that some incorporate emotion and latent mental structures, or schema, rather

well (Gibbs, 2003, 2010, 2013; Haidt, 2008; Hoffman, 2000; Rest, Narvaez, Bebeau, &

Thoma, 1999).

Others have argued that moral psychology and social-cognitive theories can be readily

integrated, and differences in social experience, age and personality lead to individual

differences in the accessibility or availability of schemas (Lapsley & Narvaez, 2005), including

moral schemas, all of which are highly relevant to the process of social problem-solving.

Although there have been some attempts to integrate social problem-solving and moral

development (Arsenio & Lemerise, 2004; Lapsley & Narvaez, 2005; Lemerise & Arsenio,

2000), further consideration regarding the role of emotion and findings from social

neuroscience is needed.

The Role of Affect

Social intuitionist perspectives on moral development have argued (Haidt, 2001) that

moral judgements are a matter of affective intuition and moral reasoning is carried out post

hoc in order to justify a previously made decision. Haidt (2001b) suggested that the

important distinction between intuition and reasoning is that intuition occurs quickly,

effortlessly and automatically, while reasoning is slow and requires more effort. However,

Turiel (2006) argued that reasoning can be immediate and rapid and that you cannot

distinguish intuitions from reasoning on the basis of speed. Linked to intuitionist

perspectives of moral development, Damasio (1994) viewed somatic markers as a special

instance of feeling generated by secondary emotions, which resulted in a 'gut feeling' which

helped drive decision-making. The somatic marker hypothesis proposed that when we think

of a bad outcome connected with a given response option, we experience an unpleasant gut

feeling which forces our attention onto the negative outcome and may lead to rejection of

this option. Damasio (1994) argued that this is an automatic step that helps to narrow

down the number of response options, and that this process occurs before reasoning,

increasing the accuracy and efficiency of the decision process.

Important within all these theoretical perspectives is affect, especially empathy,

along with perspective taking, which has been considered by several theorists (Eisenberg,

Carlo, Murphy, & Court, 1995; Eisenberg, Eggum, & Edwards, 2010; Eisenberg, Spinrad, &

Sadovsky, 2006; Flavell, Flavell, Green, & Moses, 1990; Fonagy, Gergely, Jurist, & Target,

2002; Hoffman, 2000; Premack & Woodruff, 1978; Selman, 1976, 1980). Hoffman (2000)

argued that cognition is used to make sense of emotion, and emotional responses become

"paired" or "bonded" with cognition, such that both may determine behaviour. There

clearly are similarities with the work of Haidt (2001b) and Damasio (1994), and there are

implications for the understanding of social problem-solving. This was recognised by

Arsenio and Lemerise's (2004), and they incorporated aspects of affect, specifically

emotional regulation, into their integrated model of moral domain theory and social

information processing.

Social Neuroscience – A New Framework

However, social neuroscience has been overlooked within many of these developmental theories. Several attempts have been made to consider moral development within the context of social neuroscience (Baird, 2008; Kagan, 2008; Taber-Thomas & Tranel, 2012; Yeates *et al.*, 2007), including our understanding of the various brain regions involved (Garrigan, Adlam, & Langdon, 2016, 2017) but it is apparent that these theories have at times also overlooked developmental psychology. Aspects of cognitive development, including attentional control, cognitive flexibility, and goal setting, or in other words, executive functions, are important for socialisation, including moral development and decision-making, and this has been recognised and argued by many (Anderson & Beauchamp, 2012; Gibbs, 1979, 2003, 2010, 2013; Hoffman, 2000; Hoffman, 1977; Johnson, 1962; Kohlberg, 1969, 1976; Piaget, 1932; Taber-Thomas & Tranel, 2012; Tomlinson-Keasey & Keasey, 1974). However, one of the difficulties within this area is that moral development theory, neuroscience and neuropsychology, along with social problem-solving theory and social information processing have not been integrated effectively into a developmental theory that is dynamic and recursive, and context-dependent, such that it should effectively predict behaviour. In order to achieve this, and directly building on the work of Arsenio and Lemerise (2004), we wish to propose an integrated framework of moral development that incorporates and combines social information processing theory, moral development theory and associated theories, such as perspective-taking, along with constructs from neuroscience and neuropsychology (Figure 17.1).

FIGURE 17.1 ABOUT HERE

Within the framework proposed in Figure 17.1, the inner circle depicts the distal constructs that change over time, as a consequence of development (e.g. maturation of

brain regions, moral schema, and emotion regulation) or directly have an impact upon development (e.g. social participation, socioeconomic status). Together, these constructs affect each other in a dynamic and recursive manner, developing as a consequence of maturation and socialisation. Developmental changes to moral schema occur within the database, and this can be characterised by any of the various theoretical perspectives regarding moral development, although invariant and hierarchal assumptions are not necessary, which avoids some of the difficulties pointed out by others with traditional moral-cognitive developmental theory (Krebs & Rosenwald, 1977; Krebs & Denton, 2005; Krebs, Vermeulen, Carpendale, & Denton, 1991; Wark & Krebs, 1997). However, traditional stage-theories, although problematic, have strengths in that they characterise developmental maturation into broad age-trends which facilitate comparisons between different groups.

Maturation of the brain is vital, and the "social brain" includes areas such as the fusiform face area, posterior superior temporal sulcus, hippocampus, amygdala, temporoparietal junction, cingulate cortex, medial frontal cortex, and the anterior gyrus (Heyes, Sebastian, & Kadosh, 2012; Yeates *et al.*, 2012). It has also been suggested that moral development depends upon a fronto-limbic network (Taber-Thomas & Tranel, 2012), and many factors such as environment, nutrition and substance abuse can affect the maturation of the adolescent brain (Arain *et al.*, 2013). Maturation of the prefrontal cortex (PFC) takes longer and continues to mature during adolescence (Arain *et al.*, 2013), and has been linked to increased abilities in various components of our framework: abstract reasoning, attention, inhibition and processing speed (Arain *et al.*, 2013; Yurgelun-Todd, 2007). The PFC is also thought to be involved in the processing of secondary emotions and

the acquisition of somatic markers (Damasio, 1994), as well as the development of executive

functioning (Anderson, 2002).

Emotion regulation is partly based on the neurophysiological components that

develop during the first year of life and provide the basis for more complex forms of

emotional management (Thompson, 1994). We hypothesise that the maturation of the

brain (and maybe the "social brain" network in particular) directly maps onto the

components of our framework, resulting in an increased efficiency of social information

processing, moral development, and problem-solving. "Although morality is a social

construct, it would not exist without the brain" (Tancredi, 2005, p. 34), and increasing

maturation, leads to the building of connections between cognition and affect, similar to the

relationship discussed by Hoffman (2000). For a typically developing individual, social

information processing becomes more efficient and elaborate with age due to maturation of

skills and increasing social experience, considering that the human brain is still developing

into the mid-twenties (Blakemore, 2008).

The outer circle within the framework (Figure 17.1) represents the proximal

processes that occur when an individual has to deal with a problem, and is strongly affected

by contextual cues. Some of the constructs that affect each step are listed within the

framework, while the steps and processes are taken from Crick and Dodge (Crick & Dodge,

1994; Crick & Dodge, 1996; Dodge, 1980, 1986), and again are dynamic and recursive, but

mature over time, and moral development, including maturation of somatic or emotional

markers, are vital for effective social problem-solving.

Steps within the Framework

Step 1 is the encoding of cues. Emotion recognition is important at this step (Lemerise &

Arsenio, 2000) so that others' emotions can be correctly encoded and then processed when

making a moral judgement. Hoffman (2000) argued that one of the requirements for mature

empathic distress is the knowledge that facial expressions can reflect or mask feelings.

Other components of step 1 are situational cues and attention. Situational cues partially

determine what is encoded, for example, certain cues may trigger emotions (background

feelings) which then determine which cues are encoded, while previous experience may bias

encoding. Attention is important as individuals need to be able to pay attention to relevant

multiple features of a situation, so divided and selective attention is of particular

importance, as attention deficits may lead to biased encoding of cues, affecting later

processing steps.

Step 2 is the interpretation of cues, and Crick and Dodge (1994) suggested that

interpretation may consist of one of more independent processes. One such process is

making inferences about the perspectives of others in the situation, including attributions of

intent. This requires perspective taking and relies on Theory of Mind (ToM) or mentalisation

ability as an individual must be able to take another's perspective in order to infer their

beliefs and intentions, something which is also necessary for moral development. ToM

ability develops with age (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999) and the

medial prefrontal cortex has been suggested to be involved in mentalising ability (Frith &

Frith, 2006). Other skills such as working memory, attention and face processing have also

been linked to ToM (Korkmaz, 2011), which also appears within the framework as a distal

construct. As the brain develops, ToM skills (and related sub skills) develop, which affects

the interpretation of cues via the ability to make inferences about the perspectives of others

in a situation, resulting in less egocentric processing, a process that is an integral part of

moral development.

According to Crick and Dodge (1994), other processes that may be involved in

interpretation of cues are the evaluation of past performance, self-evaluations and other

evaluations. This is similar to Baird's (2008) focus on self-perception, other perception and

the integration of past and present, which are facilitated by the maturation of the

adolescent brain (Baird, 2008). Such evaluations require working memory capacity, which

develops with age (Gathercole, 1998) and has been linked to the development of the

superior frontal and intraparietal cortex (Klingberg, Forssberg, & Westerberg, 2002).

Step 3 is clarification or selection of a goal. Crick and Dodge (1994) defined a goal as

a focused arousal state that functions as an orientation toward producing (or wanting to

produce) a particular outcome, which is related to problem orientation within the model

developed by D'Zurilla et al., (2004). Crick and Dodge (1994) proposed that individuals bring

goal orientations to a social situation but also revise these and construct new goals in

response to the immediate stimuli. Therefore, situational factors are important at this step,

as the immediate situation can influence the goals that are constructed. An individual must

be able to think of a goal which they may not have previously experienced, which would

draw on abstract thinking, which increases with age as the PFC matures (Yurgelun-Todd,

2007). Arousal regulation, including empathic responses, are also involved at step 3, and

refers to the ability of an individual to regulate the arousal elicited by the current situation,

which may be influenced by temperament and personality factors. Empathic arousal is also

important during Step 3, as it can be a motivator of moral behaviour (Eisenberg *et al.*, 1995;

Eisenberg *et al.*, 2010; Eisenberg *et al.*, 2006; Hoffman, 2000) and will determine goals.

Individuals with greater empathic arousal should set more pro-social goals within problematic social situations.

Step 4 is response access or construction, where an individual accesses from memory possible responses to the situation, or constructs new behaviours if the situation is novel. Abstract thought is important as individuals may need to construct a response with which they have no prior experience, or imagine the ideal response. The somatic marker hypothesis (Damasio, 1994) is also relevant at Step 4 as it may automatically lead to the rejection of some outcomes. Damasio (1994) stated that the PFC is critical to the acquisition of somatic markers, and individuals with PFC damage may be unable to filter out some responses that are accessed at step 4, which may impair their reasoning and decision making. Situational factors may influence, and bias, the responses that are generated at step 4. The responses accessed or constructed at step 4 are influenced by other steps of processing (e.g. the goal(s) set) and can also be influenced by information stored in the database and emotion processes occurring (e.g. certain moods may bias responses that are constructed). The responses which were not automatically rejected at step 4, are then subject to deliberation at step 5.

In our framework, step 5 is described as moral response decision, rather than response decision as described by Crick and Dodge (1994). A moral response decision is a decision about how to act in a situation in the moral domain (Smetana, 2006; Turiel, 1983) i.e. decisions regarding moral issues such as justice, harm, fairness and life. Arguably, judgements within the social and personal domain may also feature here, and there is likely to be mixing of moral, social and person domain judgements (see Turiel, 1998 for more about domain theory). Moral reasoning is one process that can guide moral decisions at this

step and it differs from other forms of reasoning because it is guided by morally relevant

rules, knowledge and understanding, stored in memory as moral schemas. We would argue

that moral reasoning is the process by which a moral decision is made, but agree that this

can occur *post hoc* in order to evaluate and modify judgements, as suggested by Haidt

(2001a). Some initial judgements may arise rapidly as a consequence of cognitive and

emotive processes, or intuitions, at step 4, but reasoning, which incorporates emotion, is

required to confirm, reject or reformulate this into a moral judgement, and reasoning at

step 5 can either confirm or lead to the reformulation of a moral decision accessed or

constructed at step 4. Moral reasoning is determined by moral schema, the morally

relevant rules and knowledge, and by moral emotions (e.g. empathy and guilt), and these

processes mature with age, facilitated by the development of skills such as logical inference,

moral emotions, and by the refinement and increased accessibly of the moral schema.

However, in some situations, context may activate different moral schema, and therefore

moral reasoning associated with higher or lower developmental stages may be seen within

the same person, and this will be determined by processing at other steps of the

framework, and to what extent the situation activates different moral schema.

Step 5 requires decision making skills and individuals need to be able to inhibit

inappropriate responses. Decision making abilities and inhibition both develop with age as a

result of maturation of the PFC (Yurgelun-Todd, 2007), and Couper, Jacobs, and Anderson

(2002) found that children with frontal lobe lesions had lower levels of moral maturity.

Step 5 involves evaluations, so as with step 2, working memory is important for such

evaluations, as are situational factors, and particularly an individual's evaluation of their

self-efficacy to carry out their chosen response in a given situation. Hoffman (2000) argued

that the expectation of guilt can motivate empathic responding, which would be activated at step 5 through the evaluation of emotion expectancies and drawing on memory of previous experiences, particularly affect-event links (i.e. when guilt may have been experienced in the past). Guilt has been found to be associated with activation of the medial prefrontal cortex, left posterior superior temporal sulcus and visual cortex (Takahashi *et al.*, 2004), suggesting that damage to these areas may affect the expectation of guilt, which would affect moral reasoning, judgement and development. There has been some research suggesting that mood can affect brain activity for emotion expectancies (Chung *et al.*, 1996), and Ueda et al. (2003) found that the expectancy of emotional stimuli is mediated by the prefrontal and dorsolateral cortex; they also suggested that the amygdala and anterior cingulate cortex play an important role in the expectancy of unpleasant stimuli. Damage to these brain areas may affect emotion expectancies, but further research is needed in order to establish the relationship with moral reasoning, judgement and development. Perspective taking, or theory of mind are also important for step 5, as taking into account how others may respond can influence how an outcome is evaluated.

Step 6 is behaviour enactment. The behavioural response is theoretically based upon the moral decision made during step 5, Although many factors are involved in determining behaviour, the actual behavioural act is preceded by a decision- making process which serves as the proximal control mechanism (Burks, Laird, Dodge, Pettit, & Bates, 1999) and will usually be enacted at step 6, unless factors intervene to override the decision made. For example, a sudden strong emotional feeling (e.g. somatic marker) may cause an

individual to change their chosen course of action, or at step 5 they may have

overestimated their self-efficacy to enact their chosen behavioural response, and the

process of social problem-solving may continue.   One of the premises of this framework is

that the sequence of steps is not entirely linear as individuals may shift back and forth, or

skips steps, depending upon the context, their past experience, evaluations and moral

judgements.

This theoretical framework is based upon the work of Arsenio and Lemerise (2004),

although we are not as prescriptive with respect to the inclusion of moral domain theory,

and instead adopt the view that cognitive-developmental moral theories (e.g. Gibbs, 2013)

provide an excellent account of the developmental changes that occur to moral schema

over time, and such changes should correlate with neuroplasticity. As a consequence,

social-problem solving and the associated descriptive processes, and the developmental

changes, as described in Figure 17.1, allow for the prediction of behaviour, and inherently,

the development of intervention programmes.

People with Intellectual Disabilities

The framework described clearly has implications for people with IDs, simply

because people with IDs have a developmental disability. Within the framework, it is not

inevitable or destined, that certain groups of people have "inappropriate" social problem-

solving skills.   The framework would predict that there would be inherent differences

between typical and atypically developing populations, and such differences would indicate

avenues for intervention and support, which could be within the social, psychological, or

biological domains as described within the framework.

Children with Intellectual Disabilities. Is there any evidence that aspects of this framework may help understand the social problem-solving of children who have IDs? Several authors have attempted to look at individual aspects of the framework with people who have IDs. For example, Herman and Shantz (1983) investigated the social problem-solving abilities of children with IDs, concluding that they were poorer than their typically developing counterparts, and this related to maternal directiveness, which was thought to discourage reflection within the child, suggesting that socialisation was an important factor for the development of social problem-solving.

There is support for aspects of our framework within the literature about children with IDs who have behavioural problems. For example, children with IDs, as compared to children without IDs, tended to encode more negative cues within social vignettes in one study (van Nieuwenhuijzen, Orobio de Castro, Wijnroks, Vermeer, & Matthys, 2004a), while more recently, van Nieowenhuijzen *et al.* (2012) reported that working memory, perspective taking and facial emotional recognition ability all predicted the encoding of emotional cues amongst children with IDs. There is also evidence that children with IDs tended to generate more submissive responses to social problems, while appraising aggressive and submissive responses more favourably than children without IDs (van Nieuwenhuijzen *et al.*, 2004a; van Nieuwenhuijzen, Orobio de Castro, Wijnroks, Vermeer, & Matthys, 2004b). The authors reported that some of the differences between children with and without IDs could be accounted by intellectual functioning and aggressive behaviour, after age, sex, and internalising behaviour were controlled (van Nieuwenhuijzen *et al.*, 2004a). van Nieuwenhuijzen and Vriens (2012) reported that difficulties with inhibition predicted hostile attributions amongst children with IDs. They also found that emotional

recognition, and interpretation of problems, predicted response generation and selection.

There is also evidence to suggest that neuropsychological functioning, including impulse

control, has an important impact upon social information processing in children with IDs

(van Nieuwenhuijzen, Orobio de Castro, van Aken, & Matthys, 2009).

Adults with Intellectual Disabilities. The literature involving adults has been

inconsistent. Pert, Jahoda and Squire (1999) reported that adults with IDs who had a history

of aggression did have an hostile attributional bias within ambiguous situations, but both

aggressive and non-aggressive people with IDs were able to generate assertive and passive

solutions to problems. The authors suggested that problem-solving difficulties may not

relate to propensity to engage in aggressive behaviour amongst this population.   In a later

study, Jahoda, Pert and Trower (2006b) reported that there was no differences between

aggressive and non-aggressive adults with IDs on an emotional-recognition task, while

aggressive individuals appeared to be better at aspects of the perspective-taking task. They

suggested that "cognitive-deficits" inherent with having IDs cannot explain the differences

between aggressive and non-aggressive people with IDs, and suggested that the differences

may be associated with a bias held by people who have a history of engaging in aggressive

behaviour. This conclusion would be consistent with socialisation affecting the "database",

or schema of these individuals, leading to biased processing.

In a third study, Jahoda, Pert and Trower (2006a) went on to demonstrate that

individuals with IDs who have a history of aggressive behaviour did attribute more hostility

to characters in stories where hostility was directed at participants, but not so when

hostility was directed towards another character in the story.   However, this hostile

attributional bias was not present when intent was ambiguous, but those with a history of

aggression tended to generate a higher number of aggressive responses.   Others have also reported that offenders with IDs do indeed appear to have a hostile attributional bias and social-problem solving difficulties, as would be predicted by our theory (Basquill, Nezu, Nezu, & Klein, 2004), although again, this has not always been consistent (Fuchs & Benson, 1995).

Although there is some inconsistency amongst these studies, there is evidence to suggest that both children and adults with IDs who have a history of aggression process information differently, and as a consequence, may choose different behavioural responses. Some of these differences may be explained by the ability of the experimental tasks to tug or activate desired schema, or possibly, the inability of tasks to activate emotions or "somatic" markers which affect processing. There is supportive evidence that offenders with IDs tend to endorse a larger number of distorted, offence-supportive beliefs, consistent with biased information processing (Broxholme & Lindsay, 2003; Langdon, Murphy, Clare, Steverson, & Palmer, 2011b; Langdon & Talbot, 2006; Lindsay & Michie, 2004; Lindsay *et al.*, 2006), but some of the inconsistencies across studies may be explained further by giving consideration to psychological development.

Specifically, moral development is dependent upon perspective taking, along with cognitive development and social role taking opportunities (Gibbs, 1979, 2003, 2010, 2013; Hoffman, 2000; Kohlberg, 1958, 1969, 1976; Piaget, 1932). There is evidence that emotion-recognition, perspective-taking and empathy may vary with intellectual ability (Moffatt, Hanley-Maxwell, & Donnellan, 1995), but several have shown that offenders with IDs are actually better or no different than non-offenders on empathy and other tasks associated with perspective taking (Langdon *et al.*, 2011b; Proctor & Beail, 2007; Ralfs & Beail, 2012),

but this is not always consistent (Hockley & Langdon, 2015; Langdon & Hockley, 2012). One

of the reasons for these findings is that offenders with IDs may actually be developmentally

more "mature" than non-offenders with IDs, as a consequence of development within other

domains, which will have been brought about by socialisation, but at the same time may

have led to biased cognitive and affective processing. Langdon, Clare and Murphy (2011a)

argued this, highlighting the relationships between intelligence, moral development and

behaviour.

Intervention Programmes

There is much work to do in order to further examine whether our theorising has validity

for offenders with IDs. Nevertheless, there are several intervention programmes that

should be mentioned, as they appear linked or related to our theory. Trying to teach social

problem-solving skills to people with IDs is not a new idea, and several authors have

covered this elsewhere, often commenting that it is likely to aid community integration

(Loumidis, 1992; Loumidis & Hill, 1997a). Others have reported that social problem-solving

training is efficacious for people with IDs, as it is associated with reductions in aggressive

behaviour, and distress, as well as improvements in adaptive behaviour (Castles & Glass,

1986; Loumidis & Hill, 1997b; Nezu, Nezu, & Arean, 1991), while Ailey, Friese and Nezu

(2012) helpfully developed and piloted a social problem-solving programme jointly with

people with IDs.

However, many of these studies have not included adequate randomisation or blinding,

and many people with IDs who have been invited to take part in these studies are not

convicted offenders. There is some emerging evidence that cognitive-behavioural

interventions are effective for people with IDs, and within this literature anger-management

training, which traditionally has a problem-solving component, currently has a large effect

size of, *Hedges g* = 0.827, *95% CI* [0.508; 1.146] (Vereenooghe & Langdon, 2013). Several

authors have attempted to develop or adapt programmes that aim to address problem-

solving directly with offenders with IDs. Lindsay *et al.* (2010) developed and piloted an

impressive programme called the Social Problem Solving and Offence Related Thinking

(SPORT) programme within forensic mental health services for offenders with IDs, reporting

improvements in problem-solving skills following treatment. Lindsay *et al.* (2010)

commented that the intervention was designed to teach effective problem-solving skills

which related to the social problem-solving steps, incorporating cognitive restructuring, role

play, along with sessions designed to improve problem-recognition, response and solution-

generation, and effective appraisal of the consequences of choosing various solutions.

Within the wider treatment literature pertaining to offenders, there are various

intervention programmes which aim to improve social problem-solving skills, and

restructure problematic cognitive distortions and schema, addressing "moral developmental

delays". These include Moral Reconation Therapy (MRT; Little & Robinson, 1988), Anger

Replacement Training (ART; Goldstein & Glick, 1994; Goldstein, Glick, & Gibbs, 1998), along

with Reasoning and Rehabilitation (R&R) groups (Ross, Fabiano, & Ewles, 1988), which

shares similarities with the Enhanced Thinking Skills (ETS) Programme common within

criminal justice settings within the United Kingdom.   Lipsey, Landerberger and Wilson

(2007) undertook a meta-analysis of cognitive-behavioural programmes for use with

offenders, reporting that treatment programmes reduced recidivism by about 25%, with

few differences between programmes. However, while Lipsey et al. (2007) also found that

the moral reasoning interventions did not improve treatment outcome, van Vugt (2011) also

undertook meta-analytic work (N = 15 992), and reported that there was a significant

relationship between moral development and recidivism, which was better explained by

moral cognition, rather than moral emotion. There is also similar supportive evidence for

the link between moral reasoning and offending behaviours from the literature involving

young offenders (Stams *et al.*, 2006).

There are others reviews of treatment programmes that include social problem-solving

components. Wilson, Bouffard and Mackenzie (2005) concluded that MRT reduced

recidivism rates between 10 to 20%, while R&R reduced recidivism by 7 to 33%. Pearson,

Lipton, Cleland and Yee (2002) reported that the effect size for R&R was small, while Joy,

Tong and Farrington (2006) reported a larger effect size which varied according to risk and

whether the programme was undertaken within the community or prison. R&R has been

piloted in the United Kingdom with offenders with mental health problems detained within

hospital settings (Young, Chick, & Gudjonsson, 2010), and there is evidence that it leads to

improvements in social problem solving, attitudes and coping skills (Yip *et al.*, 2013).

More recently, and relevant to our integrated framework Langdon, Murphy, Clare,

Palmer and Rees (2013) piloted the Equipping Youth to Help One Another Programme

(Potter, Gibbs, & Goldstein, 2001) with offenders with intellectual and developmental

disabilities. This programme was designed to target moral reasoning, distorted cognitions,

and both social skills and social problem-solving ability. The programme has roots in ART,

and positive-peer culture (Vorrath & Brendtro, 1985), and is a multicomponent programme

comprising two types of treatment sessions: a) Mutual Help Meetings, and b) Equipment

Meetings. Mutual Help Meetings provide a forum for participants to discuss their

difficulties within a framework that allows for an appropriate resolution, and aims to

encourage problem-solving. Equipment Meetings are "active treatment" meetings comprising three different types of sessions: a) anger management and thinking error correction, b) social skills training, and c) social decision-making training.   Social decision-making aims to enhance perspective taking through a process of guided discussion and debate about problem situations.   Detailed information about the treatment programme can be found in Potter et al. (2001) and Gibbs et al. (1995).

Langdon et al. (2013) suggested that the programme is likely to have a positive impact upon the culture of services, because of the creation of a positive-peer culture, but the wider evidence for EQUIP, excluding MRT and R&R, suggests that it is effective at reducing recidivism and improving social skills amongst young offenders without IDs (Leeman, Gibbs, & Fuller, 1993). There is also evidence that it can improve cognitive distortions amongst young offenders (Brugman & Bink, 2010; Nas, Brugman, & Koops, 2005), although there is also evidence that it may not improve moral development and social skills (Brugman & Bink, 2010; Nas *et al.*, 2005). Although, in some of these studies, treatment fidelity may have been an issue.   Although there have been no large trials of EQUIP, as a treatment, it is theoretically robust. This is because it is multicomponent in nature, including anger management, cognitive restructuring, problem-solving, and interventions that target moral development, all of which link to criminal offending behaviour. However, there is clearly a need for much larger studies with offenders with IDs, as EQUIP and other programmes, such as MRT, are likely to be helpful.   Excluding anger-management treatment, there is insufficient evidence to allow for the conclusion that psychological interventions for offenders with IDs, such as R&R, MRT, EQUIP, or other related programmes are empirically validated.

Conclusions

In an attempt to further understand social problem-solving, we have tried to integrate social information processing, developmental psychology, and social neuroscience into a comprehensive framework. This suggested conceptual framework is not a working model but aims to serve as an illustration that the various components of moral development suggested by different theories could be incorporated into one integrative model of moral decision-making, showing how moral decisions can be guided by both emotional and cognitive factors, intuitions and reasoning. Such an approach can help to place moral decision-making alongside other types of decision-making, which could lead to better prediction of moral or antisocial behaviour. There appears to be some tentative supportive evidence for aspects of this theory from studies involving children and adults with IDs. However, the broader landscape of supportive evidence from studies involving people with IDs is weak, and further research is clearly needed in order to refine, develop and consider our approach further. There are immerging clinical interventions which are based upon social problem-solving and moral development for offenders with IDs, but there is little in the way of evidence that can be using to empirically validate these treatments. While treatments are further developed and tested, it is important to ensure that their theoretically underpinnings are robust and valid for people with IDs, and it is hoped that our framework can be used in this manner, once further supportive evidence has been generated.

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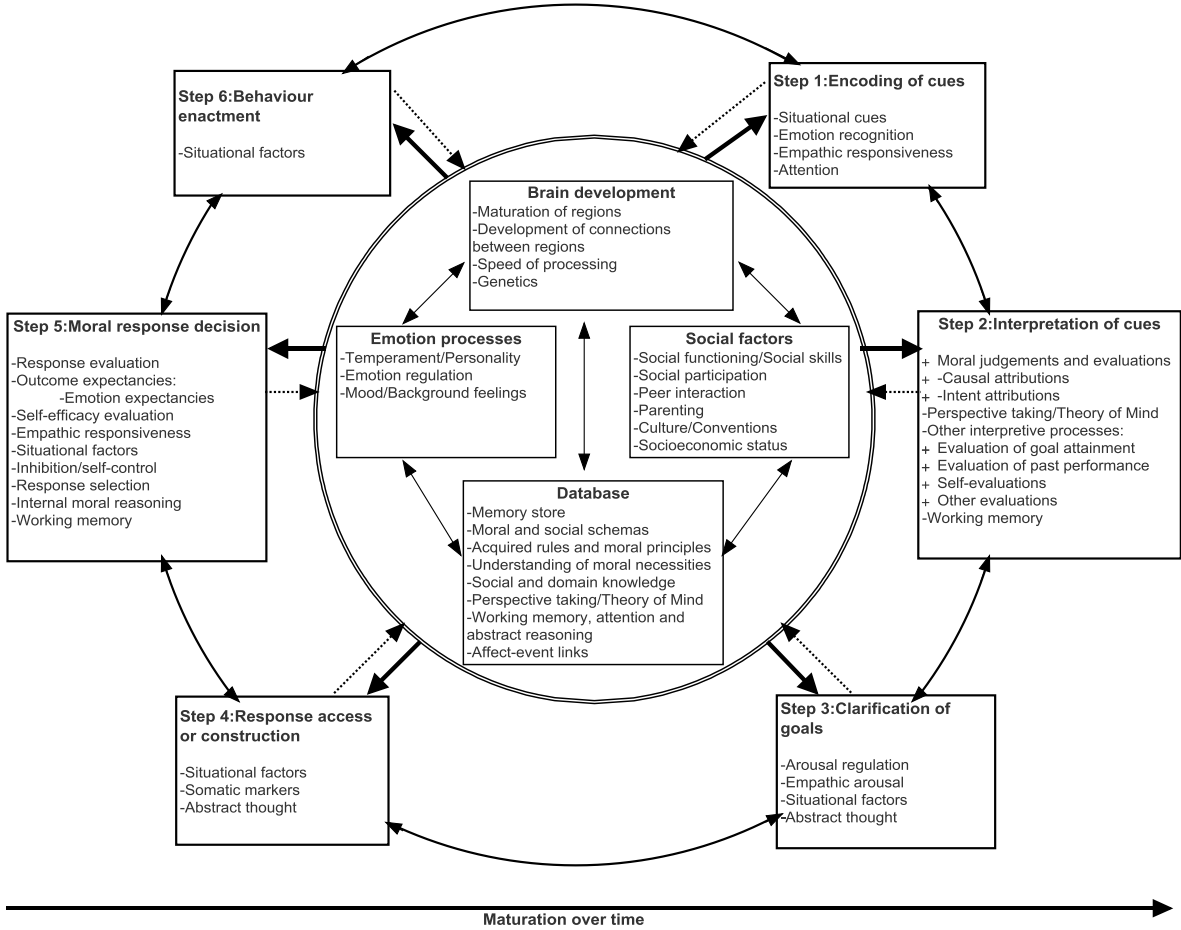
Figure 17.1. A Social Information Processing Framework of Moral Decision-Making (SIP-MDM)

Moral decision making: what develops and how? Toward an integrative developmental framework

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Abstract

Traditionally, psychological theories of moral development have focused on either the cognitive or affective skills required for the development of moral maturity, such as empathy or working memory. While some have emphasised the role of emotional intuitions, others have focused the cognitive reasoning as the driver of moral decisions. At times, theoretically divisions have hampered both research and the further development of theory. More recent theories have attempted to integrate affect and cognition, and other components thought to be relevant to moral decision making, such as personality and social information processing, but have not always sufficiently explained *development*. There is, to date, no comprehensive developmental theory incorporating all of the components or processes suggested to be involved in moral decision making and behaviour. Such a theory would help to bridge the gap between traditional developmental theories and more recent social neuroscience perspectives and move the field forward. This paper aims to: a) review traditional and more recent theories of moral development and decision making, b) highlight the components that may be involved in moral development and discuss research into the development of these components, and c) integrate these components into an illustrative framework which can be used as a starting point for building an integrative theory of moral development.

Keywords: Moral decision making, moral development, moral reasoning, perspective taking, social information processing

Abbreviations: SIP: social information processing; ToM: theory of mind; PFC: prefrontal cortex; vmPFC: ventromedial prefrontal cortex;

Introduction

The terms 'moral judgement', 'moral reasoning', and 'moral cognition' are often used interchangeably, and with differing definitions. This paper will use the broader term moral decision-making to refer to any decision, including judgements, evaluations, and response choices, made within the 'moral domain' (Smetana, 2006; Turiel, 1983) i.e. decisions regarding moral issues such as justice, harm, fairness and life. A moral decision can be a response decision about how to act in a real or hypothetical moral dilemma (a situation with moral rules or principles attached, where a response choice is required), or it can be a judgement or evaluation about the moral acceptability of the actions, or moral character of others, including judgements of individuals, groups or institutions. Moral reasoning is one process that can guide moral decisions but other processes are also involved. To fully understand moral decision making and behaviour is it is important to understand: a) how real time, online moral decisions are made, b) what component skills and processes need to develop to enable mature moral decisions, and c) how these components develop.

Traditionally, moral development theory has focused on the cognitive or affective skills involved in moral decision-making, bearing in mind that the processes are complex and are likely to involve other related skills, which have not always been included within theory. Alongside this, many have focused on the processes involved in reaching a moral decision, or in other words, moral reasoning, while others have focused on development, while both are sometimes referred to synonymously, leading to some confusion. Within developmental psychology, there is obviously a tradition of trying to measure developmental stages, with a lack of focus on other factors, such as situational factors, which may influence moral decisions and behaviour. Studies from social neuroscience tend to typically measure either brain activation while making moral decisions, or the type of decisions made by individuals with damage to particular brain regions, without focusing on the moral reasoning process, and subsequently, development. Neuroimaging moral decision-making studies can reveal which brain regions are more active during moral decision-making, and the brain regions involved change with development (Hareksni et al, 2012). However, instruments used in these studies tend to be limited in how much they can tell us about moral development, predominantly because they do not reference the rich tradition of moral developmental theory. Moral reasoning

instruments (e.g. Sociomoral Reasoning Measure Short-Form; Gibbs, Bassinger & Fuller, 1992 and So-Moral; Dooley, Beauchamp, & Anderson, 2010) firmly grounded in developmental psychology, and moral developmental theory provide richer detail about developmental level, and an indication of a person's highest capacity for moral reasoning across differing questions or moral dilemmas. The difference in focus within developmental psychology and social neuroscience has limited the integration of theory and research. Bridging the gap between traditional developmental psychology and social neuroscience would prove fruitful for advancing theory and research, potentially allowing for an explanation of how online moral decisions happen, and how they mature over time, partly as a result of the development of moral reasoning, and associated component skills and processes such as empathy, indexed or associated with the maturation of relevant brain regions.

Alongside the gap between developmental psychology and social neuroscience, there has also been a longstanding debate about whether moral decisions are driven by cognitive, affective, or both cognitive and affective processes, with perhaps fewer studies examining the developmental interaction between the two constructs. While moral development is the maturation of both moral decisions and reasoning, which typically develop with age, this maturation does not occur in isolation; it is facilitated by the development of related cognitive and affective skills or processes (e.g. empathy, perspective-taking, working memory, attention), which we term the 'components of moral development'. These component skills, abilities or processes have not yet been integrated into one comprehensive theory of moral development. We wish to broaden the definition of 'moral development' to include not only the maturation of moral decisions and moral reasoning, but also the development of core related components. The *capacity* to make mature moral decisions is an integral part of development, and whether mature decisions are made often depend on situational factors, as well as previous experience. Real time, online moral decisions do not occur in isolation; they are affected by processes involved in other types of decision making, including situational factors, and how information is processed and the capacity to process the information, as well as the morally relevant influences, such as the moral rules attached to a situation, and the strength and accessibility of relevant moral schemas.

This paper will firstly review moral development theory and more recent neuroscience theories, which although not always developmental, offer some suggestions of what is involved in moral decision making. This paper aims to highlight *what* develops, i.e. the components of moral development and discuss what we know about *how* these components develop and mature. We will then discuss how online moral decisions may occur, based on a Social Information Processing (SIP) approach, and how development of the components can facilitate more mature online moral decision making. We will finish by discussing the future of moral development theory, in terms of the promise and limitations of creating an integrative developmental model.

A brief review of moral theory

Historically, moral psychology has been dominated by the rationalist, cognitive-developmental theoretical perspective (Kohlberg, 1976, 1984; Piaget, 1932), while the importance of emotion has increasingly been recognised and integrated into theory (Gibbs, 2013; Hoffman, 2000). Although neuroscience studies measure moral decisions rather than developmental stages of moral reasoning, recently, social neuroscientists have introduced theories or perspectives of moral development (Baird, 2008; Kagan, 2008; Taber-Thomas & Tranel, 2012), highlighting the importance of brain development. In this section we will review both traditional developmental psychology theories and more recent social neuroscience approaches.

Reasoning or intuition?

One divide among moral development theories is the emphasis on whether moral decisions are driven by emotional intuitions or cognitive reasoning processes, and reconciliation between the two perspectives is needed.

Piaget's (1932) theory, often considered to be the first cognitive developmental theory of moral development, outlined four stages of logical reasoning and two stages of moral development. He proposed that logical reasoning develops alongside related cognitive processes such as abstract reasoning, and this paved the way for moral development. At stage four, logical reasoning is defined by the ability to use complex, abstract cognitive skills to solve problems, in turn

facilitating more mature moral decisions. Piaget (1932) hypothesised that moral development occurs as a child moves away from egocentrism, which required the cognitive capacity to differentiate between the ego and social environment, and is facilitated by the maturation of language and imagination. Kohlberg (1984a) expanded Piaget's theory to encompass adolescence and adulthood, and argued that, "since moral reasoning clearly is reasoning, advanced moral reasoning depends upon advanced logical reasoning. There is a parallel between an individual's logical stage and his or her moral stage" (Kohlberg, 1984, p. 171). Kohlberg (1984a) and Piaget (1932) proposed that the development of logical reasoning facilitated moral development, with both of them highlighting the importance of cognitive development for moral development.

Through their focus on logical reasoning development, early cognitive-development theorists proposed that moral decisions are *driven* by reasoning, within the cognitive domain. On the other hand, more recent conceptualisations, such as social intuitionist theory (Haidt, 2001) have proposed that moral decisions are driven by emotionally-based intuitions, and that moral reasoning is constructed *after* a decision, to explain a decision that had been made intuitively. Haidt and Bjorklund (2008) argued that moral beliefs and motivations come from a small set of intuitions that have evolved. Support for the theory comes from studies which show 'moral dumbfounding'; people give quick answers to moral dilemmas but then struggle to explain their answers (Haidt & Hersh, 2001). The real difference between rationalist and intuitionist theories is one of emphasis; while rationalists believe that the real action is reasoning, intuitionists believe that the real action is "gut feeling", moral emotions and quick intuition (Haidt & Bjorklund, 2008). The social intuitionist view of intuitions driving moral decisions is not entirely dissimilar to Damasio's (1994) somatic marker hypothesis, although there are differences with reference to the role of reasoning. Somatic markers are another intuitive, automatic process which may guide some moral decisions. The somatic marker hypothesis (Bechara & Damasio, 2005; Damasio, 1994) recognised the role of emotions in decision making and proposed that when we think of a bad outcome connected with a given response option that comes to mind, we experience an unpleasant gut feeling, which is a 'somatic marker'. This somatic marker then forces our attention onto the negative outcome and may lead to rejection of this option. Somatic markers can be stored in

memory as affect-event links, which further aid future decision making (Damasio, 1994) and they can also guide decision making by anticipating future events, even when not consciously recognised (Bechara and Damasio, 2005). Damasio (1994) argued that this is an automatic step that helps to narrow down the number of response options and that this process occurs before reasoning, increasing the accuracy and efficiency of the decision process. This is in contrast to the social intuitionist view that reasoning is not involved in the decision making process but is only carried out to explain a decision already made.

Haidt (2001) argued that the important distinction between intuition and reasoning is that intuition occurs quickly, effortlessly and automatically, while reasoning is slow and requires more effort, including attentional resources. In Kahneman's book 'Thinking, Fast and Slow' (2011) he uses the metaphors of System 1 and System 2 to describe fast and slow thinking. System 1 is responsible for intuitive, automatic thinking and operates with little or no effort, while System 2 is responsible for more deliberate thought and reasoning and requires effortful mental activities. Kahneman argues that System 1 is responsible for more of the decisions we make than System 2, and his view seems to mirror that of the Social Intuitionists: "If System 1 is involved the conclusion comes first and the arguments follow" (p 45). System 2 is needed to monitor and control thoughts and actions suggested by System 1, however, so deliberate thought and reasoning are needed to confirm, reject or reformulate the automatic suggestions, or intuitions of System 1. In most situations, System 2 accepts the suggestions of System 1 without much, or any deliberation needed, but System 2 is activated when an event violates the model of the world that System 1 maintains (Kahneman, 2011). This would suggest that most everyday decisions are made with very little deliberate thought, but we argue that some moral decisions differ from everyday decisions and may activate System 2 (specifically, moral reasoning) to a greater extent. We hypothesise that moral decisions can be driven by *both* a rational reasoning process and more intuitive, automatic processes, which may by affective, cognitive, or both.

Moral reasoning requires logical reasoning and cognitive skills but differs from other forms of reasoning because it is guided by morally relevant rules, knowledge and understanding, stored in memory as moral schemas; many of which have to be learned. We propose that some moral decisions are driven by automatic

processes, either a somatic marker or automatic activation of a strong moral schema, which then guides rapid moral reasoning which the individual is unaware of engaging in, or bypassing the reasoning process altogether resulting in a moral decision which feels intuitive. Such instances are likely to result from situations with strong moral rules engrained in cultural norms, such as those relating to incest, which are the type of examples used in social intuitionist studies (Haidt & Hersh, 2001). As somatic markers can be stored in memory as affect-event links and guide future decision making, automatic activation of relevant moral schemas could also develop over time with increased exposure to the moral rules of a culture or society. Automatic activation of moral schemas may drive more moral decisions over time; familiar or more often encountered moral dilemmas may become driven by this automatic schema activation, or require less moral reasoning. Gibbs (2013) suggested that moral reasoning stages can be viewed as schemas rather than stages, with schemas developing with age and facilitating moral development. An integrative developmental theory of moral decision making should include both automatic processes and moral reasoning as factors which can drive online moral decisions, and which develop over time to increase the capacity for making more mature moral decisions. The relationship between reasoning and automatic processes may be bi-directional; engaging in moral reasoning or making a certain moral decision may trigger a certain moral schema or a somatic marker and vice versa, influencing further reasoning.

Emotion or cognition?

Another related, but differing theoretical divide among moral development theories is the emphasis on either cognitive or emotional processes. Whereas cognitive primacy theories view cognition as the main driver of moral decisions, affective primary theories view affective processes as the main driver, while others tend to integrate both in some way. Traditional perspectives within this area have been published by Hoffman (2000), Rest (1983) and Gibbs (2013).

Hoffman's (2000) theory of empathy and moral development focused on affective empathy as the main driver of moral decision-making, though he did highlight the role of cognition for achieving a "self-other" distinction. His developmental framework of empathy involved four broad stages in the development

of self and other, and he proposed that empathy is congruent with the moral principles of caring and justice, playing an important role in moral decision-making and reasoning. Hoffman concluded that empathy, construed as affect, rather than cognition became bonded with moral principles gave the principles motive force, while empathy could act as a powerful retrieval cue, triggering moral schemas stored in memory. Hoffman (2000) also linked cognition with emotion, as he hypothesised that the attributions people make about the cause of events can affect the level of empathy experienced; empathic distress may be neutralised if a victim is viewed as being responsible for their own plight. He hypothesised that a person's moral structure, made up of empathic affects, cognitive representations and motives is internalised when they accept and abide by its principles without regard to external reward or punishment, which is similar to Piaget's (1932) proposition that when children move from the heteronomous to the autonomous stage they realise that rules are worthy of respect.

Rest's componential model of moral developmental (Rest, 1984; Rest, Bebeau, & Thoma, 1999) stated that the four components underlying moral action are moral sensitivity, moral judgement, moral motivation and moral character. Moral sensitivity involves interpreting the situation and an awareness of the relevant moral factors and implications, including how actions would affect others, which requires perspective taking. The moral judgement component involves deliberation over possible courses of action and deciding which would be most morally justifiable. The moral motivation component involves prioritising moral values over other competing values and moral character refers to skills and strategies that support the moral choice, such as self-control (Rest, 1984; Walker, 2002). This model integrates both cognitive and affective processes and also highlights both moral action and behaviour need explanation, not just moral judgements. Rest and colleagues (Rest et al., 1999) presented a neo-Kohlbergian approach, moving the field away from stage theory and argued that rather than one stage at a time, development is a gradual increase of higher over earlier forms of thinking. Rest et al (1999) also recognised the usefulness of schema theory to moral development, which was further developed by Gibbs (2013).

Gibbs (2013) offered an alternative to affective or cognitive primacy theories, and argued that the most plausible position within developmental theory is that

moral motivation occurs as a consequence of affective and cognitive *co*primacy; that is, both affect and cognition act as motives for moral action. Gibbs (2013) argued that the standard stages of moral development reflect gains in working memory and hypothesised that attentional abilities are required to develop for the maturation of moral decisions. Increases in attentional abilities allow individuals to attend to more than one feature of a situation, moving away from an egocentric bias, and gains in working memory capacity allow for more than one source of information in mind when making decisions. Gibbs (2013) proposed that the mature stages of moral development are constructed through social perspective taking. He developed Rest et al's (1999) proposition that moral stages should be conceptualised as schemas, proposing that adaptive refinement and reorganisation of schemas enables moral development to take place. Schemas are "general knowledge structures that reside in long-term memory and facilitate information processing" (Walker, 2002, p. 361) with moral schemas being knowledge structures regarding moral events. However, moral decisions do not just mature because they are based on an increased quality and quantity of empirical knowledge schemas are frameworks, and moral maturity, or "growing beyond the superficial" requires a deeper understanding of fairness and moral reciprocity (Gibbs, 2013).

Rest (1983, 1999) and Gibbs's work (2013) has been crucial for advancing the moral development field towards a co-primacy approach and in conceptualising moral stages as schemas. However, further developmental of theory is needed to include both cognitive and affective processes, intuitions and moral reasoning, alongside contributions from social neuroscience research in order to explain both how online moral decisions are made and how they mature over time.

Social neuroscience theories and perspectives.

There has been an increased interest in moral decision making amongst social neuroscientists (Beauchamp, Dooley, & Anderson, 2013; Dooley et al., 2010; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Mendez, Anderson, & Shapira, 2005). Here, we will outline social neuroscience theories and perspective of moral development, which can be useful in highlighting the importance of certain brain regions for moral decision making, and linking brain development to the cognitive and affective skills required for mature moral decision making.

Kagan (2008) presented a theory of the development of morality, drawing on both cognitive developmental stages and neuroscience, with the inclusion of affective components such as guilt and empathy. He argued that children follow a universal sequence of stages and each stage involves the emergence of a new cognitive achievement, which are due to corresponding changes in brain circuitry. Kagan's fifth stage, occurring between ages 5 and 10 is an understanding of abstract constructs such as fairness and ideals, which is facilitated by profound maturational changes in the brain between ages 5 and 7. Similar to Kagan (2008), Baird (2008) linked moral development to brain development within her theory, although she particularly focused on brain development in adolescence and argued that the maturation of the prefrontal cortex (PFC) produced significant improvements in behavioural and emotional control, decision making and abstract reasoning. Baird (2008) also focused on the integration of emotion and cognition in adolescence, and argued that we have an innate capacity to develop a moral sense. She incorporated ideas from the somatic marker hypothesis (Damasio, 1994) to explain how emotional states can guide future decisions, by stating that developmental improvements in cognition lead to the development of self-conscious emotions. Taber-Thomas and Tranel (2012) presented a cognitive neuroscience perspective of social and moral functioning, and argued that there is a functional hierarchy underlying socio-moral functioning, from basic functions such as processing emotion from faces, to higher cognitive processes such as moral cognition. They concluded that social and moral functioning critically depend on a core fronto-limbic network centred on the vmPFC, but acknowledged that this network does not function in isolation and relies on other social functions. As with Baird's theory (2008), their perspective incorporated aspects of the somatic marker hypothesis (Damasio, 1994) and they asserted that the vmPFC is crucial for the anticipation of emotional consequences of behaviour.

One frequently considered theory of moral cognition within this area is the dual-process theory of Greene and colleagues (Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008; Greene, Nystrom, Engell, Darley, & Cohen, 2004; Greene et al., 2001). They proposed that people make moral decisions (specifically, hypothetical moral response choices) either based on negative emotional responses the dilemma elicits, or by engaging in utilitarian moral reasoning. Initial emotional responses can be overridden by moral reasoning but this requires increased cognitive

control. Support for this theory comes from studies showing increased activity in the medial PFC (emotional responses), dorsolateral prefrontal cortex (cognitive reasoning) and the anterior cingulate cortex (signals need for cognitive control) when choosing responses to hypothetical moral dilemmas, mainly the trolley dilemma (Greene, 2009). One issue is that this theoretical perspective focuses only on explaining utilitarian moral decision making (i.e. approving harmful actions that maximise good consequences), and the life vs. death hypothetical dilemmas used in research studies do not tend to reflect everyday moral dilemmas. Also, while this theory can help in understanding how online moral decisions are made, it tells us little about how moral maturity develops.

In Van Bavel et al's (2015) recent review of the neuroscience of moral cognition, they argued that moral cognition depended on a widely distributed set of brain regions, including those involved in self and other-related processing, as well as many different component processes such as basic perception and abstract reasoning. Van Bavel et al (2015) also argued that hypothetical scenarios used in neuroscience research usually ignore the influence of social and contextual factors, and they advocated a shift from dual-process theories to a dynamic systems model of moral cognition. We agree that a model of moral decision making needs to incorporate more than two processes. While dual process theories such as Greene's (2001) and Kahnemeann's (Kahneman, 2011) are useful for understanding the automatic, intuitive processes and the slower, reasoning processes involved in decision making, they are not sufficient for explaining how online moral decisions are made, and how they mature over time. To fully explain moral decision making and behaviour, it is important to understand all the components that may be involved in making moral decisions, how these develop over time to increase the capacity for making mature moral decisions, and what influences whether a mature moral decision will be made in different contexts and social situations.

There are other social neuroscience theories, which while not moral development theories, are of relevance here, as they incorporate moral reasoning and some of the relevant component skills. Anderson and Beauchamp (2012) presented SOCIAL, a theoretical developmental social neuroscience framework of social function. They defined social skills as social competence, social interaction and social adjustment. Within this framework, moral reasoning and theory of mind

(ToM) are categorised as sub skills of social cognition. Components from this framework could be incorporated into a model of moral development to add to our understanding of how social skills affect social interactions and moral behaviour. The SOCIAL framework (Anderson & Beauchamp, 2012) contains moral reasoning as a sub skill of social cognition, while we propose that social cognition, and particularly ToM (both cognitive and affective perspective taking) is a sub skill of moral reasoning and decision making. However, immature moral reasoning could in turn impact on social interactions and the development of social skills, indicating that the relationship is bi-directional. Brain development is one of the components of the SOCIAL framework (Anderson & Beauchamp, 2012), a component which has not yet been explicitly included in any models of moral development.

Summary of moral theories

Taken together, traditional psychology theories of moral development and more recent insights from social neuroscience provide a fuller picture of the skills and processes required for mature moral decision making. An integrative theory would include both affective and cognitive processes and show how both intuitions and reasoning can guide moral decisions. Moral psychology theories have outlined that the cognitive and affective skills required for mature moral decision-making develop with age, but have not explicitly explained how this occurs as a consequence of brain development. More recent neuroscience perspectives have emphasised the importance of brain development for the maturation of moral reasoning and related skills, but often neglect the moral developmental psychology literature. The field of moral development would benefit from clearer integration of the moral developmental psychology literature with insights from social neuroscience research.

Table 1. The components of moral development

Component type	Component	Main theories/perspectives which have suggested this component is involved in moral development
Cognitive	Working memory	Gibbs (2013)
	Perspective taking	Baird (2008); Piaget (1932); Gibbs (2013); Kohlberg (1976; 1984a, b)
	Attention	Gibbs (2013)
	Abstract thought	Baird (2008)
	Logical reasoning	Piaget (1932); Kohlberg (1984a, b)
	Schemas/scripts	Gibbs (2013); Hoffman (2000)
	Attributions	Hoffman (2000); Gibbs (2013); Arsenio & Lemerise (2004)
	Self-control	Rest (1984; 1999)
	Memory organisation/store	Baird (2008)
Affective	Affective empathy	Hoffman (2000); Kohlberg (1984a, b); Gibbs (2013)
	Emotion regulation	Eisenberg, Spinrad & Sadovsky (2006)
	Emotion recognition	Anderson & Beauchamp (2012); Taber-Thomas & Tranel (2012)
	Somatic markers	Damasio (1994)
	Intuition	Haidt (2001)
Social	Social functioning/competence/skills	Anderson and Beauchamp (2012); Gibbs (2013); Yeates et al (2012)
	Peer interaction/socialisation	Piaget (1932); Gibbs (2013); Hoffman (2000); Haidt (2001)
	Socio-economic status	Colby, Kohlberg, Gibbs & Lieberman (1983); Anderson & Beauchamp (2012)
	Culture	Haidt (2001)
	Parenting	Piaget (1932); Hoffman (2000) Palmer (2003)
Other	Brain development	Baird (2008); Kagan (2008); Taber-Thomas and Tranel (2012), Anderson & Beauchamp (2012)
	Temperament/personality	Haidt (2001); Kagan (2008)
	Social information processing	Arsenio & Lemerise (2004); Palmer (2000)

The components of moral development: What develops and how?

"Central to any discussion of developmental issues is the consideration of "what develops"" (Crick & Dodge, 1994, p. 80). Following on from the review of moral development theory, this paper will now highlight 'what develops'; the components of moral development, and discuss how the main components develop. Table 1 displays the main components of moral development suggested by the various theories and perspectives, some of which we have reviewed above. The components are grouped into broad categories of cognitive, affective, social and other. Some of the affective components listed could be viewed as either cognitive or affective (e.g. emotion regulation) but we have adopted the position that they are by and large mainly affective. We will firstly discuss selected research into the development of moral or prosocial behaviour and moral decision making before discussing selected research into the development of the main related components in turn.

Development of moral behaviour and moral decision making

Most research into moral decision-making has focused on moral evaluations or response choices in adults, but there is some research into the development of moral or prosocial behaviour in children and adolescents. Evidence of an understanding of moral rules, as well as showing moral preferences and expectations have been found to be present in children as young as 3 months, shown by their preference to attend to a prosocial character (Kiley Hamlin, Wynn, & Bloom, 2010) and infants who behave altruistically also expect others to act pro-socially. Svetlova et al (2010) found that children as young as 18 months old could help adults in instrumental, empathic and altruistic contexts, although empathic helping required greater communication input from the adults, and altruistic, costly helping was the most difficult for the infants. Findings from 18 and 30 month olds suggested that during the second year of life, prosocial behaviour moves from relying on action understanding and explicit communication to understanding others' emotions from more subtle clues (Svetlova et al., 2010).

Neuroimaging studies using moral decision making tasks have found that the brain region most commonly activated is the ventromedial prefrontal cortex (vmPFC; Fumagalli & Priori, 2012). There is evidence that people with damage to

the vmPFC make abnormally utilitarian moral judgements (Moretto, Làdavas, Mattioli, & di Pellegrino, 2010; Thomas, Croft, & Tranel, 2011) and that early onset vmPFC damage affects moral decisions more than adult onset damage (Taber-Thomas et al, 2014), suggesting that if development of this region is compromised it can affect moral decision making. The vmPFC is involved in emotional processing (Etkin, Egner, & Kalisch, 2011) so its recruitment during moral decision making offers some support for the view that moral decisions are driven by emotions. However, the majority of moral fMRI studies used moral evaluation tasks, which involved judging the actions of others' (e.g. Avram et al., 2014; Parkinson et al., 2011); more neuroimaging research into moral response decisions is needed for a full picture of the neural correlates of moral decision making. Neuroimaging studies which do use moral response decision tasks typically use hypothetical dilemmas where the choice is to kill or save a life (Greene et al., 2001), which may not reflect everyday moral decision making. Most neuroimaging studies of moral decision making are on adults so there is limited research into how the maturation of relevant brain correlates with mature moral decision making. Harenski and colleagues (2012) did include 15 adolescents in their fMRI sample (age 13-18) alongside an adult sample (age 19-53) and found a positive correlation between age and hemodynamic activity in the temporo-parietal junction when participants rated the severity of moral transgressions. This region is known to contribute to mentalising during moral decision making in adults, so these findings suggest that adolescents use mentalising less when rating moral transgressions. Another developmental fMRI study found age-related increases in activity in the vmPFC and increased functional connectivity when judging whether moral transgressions were intentional or not (Decety, Michalska, & Kinzler, 2012). These studies only concerned rating moral transgressions, not making moral response decisions; further developmental neuroscience research is needed into how the maturation of relevant brain regions affects the development of all types of moral decision making.

Moral reasoning is often measured as an indicator of an individual's highest capacity for reasoning across different questions or moral dilemmas. Research has found that moral reasoning scores develop with age to higher levels of reasoning maturity (Colby et al., 1983; Gibbs, Basinger, & Fuller, 1992). Moral developmental delay is the persistence of immature morality into adolescence (Gibbs, 2013) and

delayed moral reasoning has been found for offenders (Stams et al., 2006) and survivors of traumatic brain injuries (Beauchamp et al., 2013; Dooley et al., 2010). Eisenberg's longitudinal research (1995) demonstrated age-related development in prosocial reasoning, with an increase in empathic reasoning coupled with a decrease in hedonistic reasoning between preschool and elementary school age children, suggesting a shift from self to other-orientation with age. This study also found that there was a significant correlation between moral reasoning and prosocial behaviour. This relationship was confirmed by Carlo et al (2010), who found that moral reasoning and emotions were interrelated and predicted prosocial behaviours.

In addition to research into moral behaviour and moral decision-making, research about how the components of moral development mature is exceptionally relevant (Table 1). We will now discuss some research into the development these components and consider how they can be synthesised to take the form of an integrative framework.

Development of perspective taking

The component cited by most theories as being crucial for moral development is perspective taking. Perspective taking here is considered to be the cognitive component of empathy and refers to the ability to infer another's mental states and attributions; also referred to as mentalisation ability or theory of mind. Lapsley stated that, "the root developmental achievement that underlies every domain of social cognitive development is perspective taking" (Lapsey, 2006, p. 58). Perspective taking is important for moral development as it allows for others' thoughts and feelings to be taken into account when making moral decisions, as attributions of intent can affect how moral decisions are processed, and whether empathy is triggered. Although perspective taking can be viewed as a cognitive component, the ability to know, feel, and understand others' mental states is highly relevant and often referred to as affective empathy (feeling another's states), or 'affective resonance' – this is affective perspective.

Perspective taking has been described as the "ultimate integration of emotion and cognition" (Baird, 2008, p. 334). Research has found that visual perspective taking develops between 12-14 months (Sodian, Thoermer, & Metz, 2007) and that

by 4 years old children can pass false belief tasks (Wellman, Cross, & Watson, 2001), showing an understanding that a person can have a belief that contradicts reality. Most ToM research has involved children but it has been found that the ToM, and its interaction with executive functions continues to develop into late adolescence (Dumontheil, Apperly, & Blakemore, 2010). For example, Gredebäck et al (2015) conducted an event-related potential study of prosocial preferences in 6 month old infants and found greater amplitude of P400 when infants watched agents who had previously helped rather than hindered another agent, suggesting that the P400 component indexes activation of the memory of agents pro or antisocial actions, and that this is processes is functional by 6 months. A longitudinal study of 13-18 year olds found that perspective taking increased during adolescence (Van der Graaff et al., 2014), while a study into the development of the neural network associated with perspective taking found that in adults (age 25-32), activity increased in the left inferior parietal cortex and precuneus when processing third person compared to first person judgments, and children (age 8-10) additionally showed increased activity in the dorsolateral PFC and the right inferior parietal cortex (Dosch, Loenneker, Bucher, Martin, & Klaver, 2010). There was also a decrease in reaction time differences between third and first person judgements with age, suggesting that adults are more efficient at processing third person judgements (Dosch et al., 2010). While, Lane et al's (2010) longitudinal study found that theory of mind and emotion understanding both prospectively predicted young children's moral reasoning and decision making, and further, while perspective taking is the component most frequently proposed to be involved in moral development, there is not a wealth of research linking the development of perspective taking to moral reasoning or decision making.

Perspective taking is hypothesised to develop through role-taking and pretend play (Piaget, 1932; (Selman, 1976). A child's social environment provides role-taking opportunities, and participation in role-taking spurs on moral development (Kohlberg, 1976). The importance of peer interaction for perspective taking development in adolescence has been emphasised over parent interaction (Baird, 2008). Research has found that children's competence in peer interaction is significantly related to ToM understanding (Peterson, Slaughter, Moore, & Wellman, 2016). As perspective taking develops through interaction with the social

environment, social factors can influence its development, which in turn affects moral development. A model of moral development, therefore, needs to include perspective taking, the factors affected by perspective taking (e.g. affective empathy), and the factors which influence the development of perspective taking (e.g. peer interaction).

Development of affective processes

The main affective process seen as important to moral development is affective empathy. Affective empathy allows individuals to experience other's feelings, including anticipated guilt when making a moral decision. Empathy can act as a motivator for moral behaviour and also a powerful retrieval cue (Hoffman, 2000). The role of empathy in moral reasoning and decision making may be linked to other skills. For example, for empathy to motivate moral behaviour, this may involve or require the ability to recognise others' emotions, regulate one's own emotions and retrieve relevant empathy-cognition bonds from memory. Emotion regulation is the control of emotional experience and expression (Campos, Campos, & Barrett, 1989) and consists of extrinsic and intrinsic processes responsible for monitoring, evaluating and modifying emotional reactions (Thompson, 1994) and is also linked to empathy. Eisenberg, Spinrad and Sadovsky (2006) argued that emotion regulation can influence whether children experience sympathy or personal distress, and this in turn can influence moral development, while Lockwood, Seara-Cardoso and Viding (2014) found that emotion regulation moderates the relationship between empathy and prosocial behaviour.

Development of cognitive processes

Attention and working memory are cognitive processes proposed to be required for moral development. Development of attention abilities allows for individuals to focus on more details within a situation while an increased working memory capacity allows for individuals to hold multiple features of a situation in mind while making a decision.

Working memory capacity develops during childhood, with a linear increase in performance on various working memory tasks, from age 4-15 (Gathercole, Pickering, Ambridge, & Wearing, 2004). De Wilde et al (2016) investigated the

developmental relationships between children's working memory capacity and their social development. It was found that lower working memory scores were related to increases in teacher-child conflict one year later, and that teacher-child conflict was negatively associated with the development of working memory, suggesting that working memory can affect social development, and vice-versa. A longitudinal study into the neural networks of working memory in a sample of 6-25 year olds revealed that working memory capacity correlated with activity in frontal and parietal regions, cortical thickness in the parietal cortex, and white matter structure of fronto-parietal and fronto-striatal tracts, while fractional anisotropy in white matter tracts and caudate activity predicted future working memory capacity (Darki & Klingberg, 2015).

Visual attention develops rapidly during the first 5-10 months (Ross-Sheehy, Schneegans, & Spencer, 2015). Staying alert to cues shows significant developmental improvement after age 7 in terms of speed of processing (Pozuelos, Paz-Alonso, Castillo, Fuentes, & Rueda, 2014), and executive attention develops strongly between ages 4-6 (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005) showing further improvements in late childhood (Pozuelos et al., 2014). A study of 400 3-12 year olds found a staging in the development of attention and executive functions from age 6, starting with the maturing of inhibitory functions, followed by maturation of auditory and visual attention at age 10 and the development of fluency in adolescence (Klenberg, Korkman, & Lahti-Nuuttila, 2001). An MRI study of children (7-12) and adults (18-31) found that children showed greater functional connectivity of regions in the dorsal attention network compared to adults, whereas adults showed greater functional connectivity between regions within the ventral attention network than children (Farrant & Uddin, 2015). This pattern of development of attention networks may be a neural signature of the developmental shift from bottom-up attention mechanisms to top-down attentional capacities (Farrant & Uddin, 2015).

The development of attention and working memory can also facilitate logical and abstract reasoning abilities, which in turn facilitates mature problem solving and moral decisions (Piaget, 1932). Abstract reasoning is the ability to base reasoning on relationships between representations rather than just simple features of a stimulus

(Dumontheil, 2014), so it is important for moral development as it enables moral concepts and necessities to be understood and applied across different settings, even those not previously experienced. The Wisconsin Card Sorting Task is used as a measure of abstract reasoning, attention regulation and working memory in research studies and performance on the task has been found to increase with age (Bujoreanu & Willis, 2008; Somsen, 2007). A shift from using concrete to abstract strategies to solve algebra problems has been found by age 15-16 (Susac, Bubic, Vrbanc, & Planinic, 2014) and abstract reasoning has been found to be impaired in children and adolescents with autism spectrum disorders (Solomon, Buaminger, & Rogers, 2011). A neurodevelopmental study of relational reasoning (abstract reasoning) found that similar to adults, children recruited the rostrolateral PFC when processing relations but failed to use this region when integrating across two relations (Crone et al., 2009). Despite the proposal of the importance of abstract reasoning to moral reasoning development, there is a lack of research linking these components.

Brain development

Brain development is important for moral decision making directly, through development of brain regions thought to be involved in making online moral decisions, and also indirectly through the development of brain regions involved in the component skills and processes, and also increased speed of processing with the development of connections between relevant brain regions. "Although morality is a social construct, it would not exist without the brain" (Tancredi, 2005, p. 34). Above we have discussed some neuroscience research into the components of moral development and will now discuss general brain development.

The human brain is still developing into the mid-twenties (Blakemore, 2008) and there is a dramatic rearrangement in structure and function during adolescence (Andersen, 2003), which may partly account for moral decision making and reasoning maturing in late adolescence or adulthood. Adolescence, the period between childhood and adulthood, is second only to infancy in terms of the rate of developmental change in the brain (Arain et al., 2013). Many factors such as environment, nutrition and substance abuse can affect the maturation of the brain (Arain et al., 2013). Although the vmPFC has been found to be the most active area during moral decisions, it has been argued that there is no moral locus, as morality

consists of complex cognitive processes, supported by many areas of the brain (Fumagalli & Priori, 2012; Young & Dungan, 2012). As we propose that many components are required for moral development then it follows that the maturation of many brain regions and connections between regions is important. The PFC is the last brain region to mature and it continues to mature during into adulthood (Arain et al., 2013). The development of the prefrontal cortex (PFC) is linked to increased abilities in abstract reasoning, attention, inhibition and processing speed (Arain et al., 2013; Yurgelun-Todd, 2007). The PFC is also thought to be involved in the processing of secondary emotions and the acquisition of somatic markers (Damasio, 1994). The medial PFC has been suggested to be involved in mentalising ability (Frith & Frith, 2006) so the development of this area may be particularly important for perspective taking. Guilt has been found to be associated with activation in the medial PFC, left posterior superior temporal sulcus, and visual cortex (Takahashi et al., 2004) so the development of empathy-based guilt (Hoffman, 2000) may be influenced by maturation of these regions. The development of working memory has been linked to the development of the superior frontal and intraparietal cortex (Klingberg, Forssberg, & Westerberg, 2002). A social brain network has also been suggested, which includes the fusiform face area, the posterior superior temporal sulcus, the hippocampus, the amygdala, the temporo-parietal junction, the cingulate cortex, medial frontal cortex, and the anterior gyrus (Heyes, Sebastian, & Kadosh, 2012; Yeates et al., 2012) and developmental research has found that the social brain continues to develop structurally during adolescence, stabilising in the mid-twenties (Mills, Lalonde, Clasen, Giedd, & Blakemore, 2014). Development of these regions may facilitate the development of social skills and functioning, in turn facilitating moral development.

Summary of components

Research we have discussed outlined that the components develop and mature with age, and that this may be partly due to increased socialisation and brain maturation, with some abilities or processes being evident in early infancy. Taken together, neuroscience research into development of the components suggests that various brain regions and networks are involved in moral development, and that the structure and functional connectivity of these networks changes with age. Some components such as perspective taking and empathy are proximal factors of moral

development, while other components are more distal factors. Social skills can be seen as distal factors as they affect the development of components such as moral schemas and perspective taking, which in turn facilitate moral development. There are many bi-directional relationships between components, for example, peer interaction influences the development of perspective taking abilities, which in turn can affect an individual's peer interactions. Some research has found developmental and predictive relationships between components, suggesting that the various components could be integrated into one model of moral development. Neuroscience research has highlighted that moral decision making is a dynamic process emerging from the integration and coordination of widely distributed brain regions (Van Bavel et al., 2015) and so neuroscience has much to offer to the field of moral psychology, moving it towards a more dynamic explanation. All the components together are important for moral development and behaviour due to their influence on each other; each component is necessary but not sufficient for moral development.

Online moral decision making: Toward an integrative dynamic framework

We have discussed the development of moral decision making and the related components and will now discuss how online moral decisions might occur, in order to provide a full picture of moral decisions and behaviour. Moral decision making differs from other types of decision making because the situation has moral rules attached, which may invoke moral reasoning and the activation of morally relevant schemas from memory. However, moral decision making shares similarities with other types of decision making as it involves processing information and making judgements, evaluations and response decisions which may lead to behavioural action, and is subject to influences such as situational factors, personality factors and biases.

One issue with moral development theory and research is that moral reasoning does not always correlate with behaviour (Blasi, 1983) and it has been found that people do not always use their highest possible level of reasoning (Krebs & Denton, 1997). A recent meta-analysis (Villegas de Posada & Vargas-Trujillo, 2015) found a significant association between moral judgements (measured using various instruments) and behaviour, with a medium effect size of .20. Findings from

this meta-analysis support Kohlberg's (1984a) view that moral principles are necessary but not sufficient for moral action, and that research needs to examine other factors sufficient to explain moral *action*. We need to link what we know about the development of moral maturity and related components with what we know about decision making in order to gain a better understanding of how online moral decisions are made, how they mature over time and, in turn, a better understanding of moral behaviour. An integrative model of moral development should take into account factors which may influence an individual's decision making, and other factors which may affect their behavioural response, to provide a full picture of moral action. Moral action can refer to any behaviour that occurs in a moral dilemma situation. Most antisocial or offending behaviours involve breaking moral rules or principles, so to explain moral action would explain antisocial or prosocial behaviours.

A recent review of dual-process theories of moral cognition (Van Bavel, FeldmanHall, & Mende-Siedlecki, 2015) concluded that neuroscience research shows the need to move beyond simple dual process theories or moral cognition, and argued that psychological models can benefit from incorporating neuroscience research. While traditional moral psychology theories either focused on intuitions or reasoning, there have been integrations which highlight the complexity of moral decision making, such as integrations of moral theory with social information processing theory (SIP) (Arsenio & Lemerise, 2004). Here, we suggest that a SIP framework can be a useful starting point for developing an integrative, dynamic model of moral development, incorporating situational factors that influence online moral decision making, showing how both affective and cognitive processes can guide moral decisions, and incorporating findings from neuroscience research. We will now briefly outline SIP theory, add the components of moral development to a SIP framework and discuss how this can help to explain online moral decision making and guide future research.

Social information processing theory

Social information processing theory can provide a useful framework for explaining how online decisions are made, and can be adapted to include the components of moral development. The original SIP model was proposed as an

explanation of aggression in children (Crick & Dodge, 1994). Children who display aggressive behaviour can be construed as having atypical processing skills (Crick & Dodge, 1996; Dodge & Coie, 1987), suggesting that the SIP model provides a sound basis for explaining behaviour. Within the SIP model (Crick & Dodge, 1994), children's behavioural responses are a function of the processing of information in a situation. The model consists of six steps: (1) encoding of cues, (2) interpretation of cues, (3) clarification of goals, (4) response access or construction, (5) response decision, and (6) behavioural enactment. Children come to a social situation with a set of biologically determined capabilities and stored memories of past experiences, which can affect how information is processed (Crick & Dodge, 1994). The 6 steps represent a logical order but do not necessarily occur in this order and can co-occur.

Although many factors are involved in determining the development of antisocial behaviour in young people, the actual behavioural act is preceded by a decision making process which serves as the proximal control mechanism (Burks, Laird, Dodge, Pettit, & Bates, 1999). Moral response decisions can be conceptualised as the response decision step in a SIP model, as the proximal decision before a behavioural response, although a behavioural response will only follow if it is perceived that one is necessary, and the intended action is able to be carried out. Emotional processes, such as empathic arousal were incorporated into the SIP model by (Lemerise & Arsenio, 2000), suggesting that a SIP approach can be used to bridge the cognition vs. affect division within moral psychology. Rest's (1984) moral sensitivity component involves interpretation of the situation, which is similar to step 2 of the SIP model, and his proposed moral judgement component, which involves deliberation could be formulated step 5 of a SIP model.

Arsenio and Lemerise (2004) integrated SIP with moral domain theory and argued that moral domain theory can be used to expand on the latent mental structures, or the 'database' suggested by Crick and Dodge (1994). Moral domain theory (also referred to as social domain theory) makes the important distinction between the personal, moral, and social domains and proposed that moral judgements are constructed through reciprocal social interactions (see Smetana, 2006; Turiel, 1983). The majority of research based on domain theory has focused on establishing whether children of different ages can distinguish between moral and social conventional acts (Killen & Smetana, 1999; Smetana, 1985; Song, Smetana &

Kim, 1987; Tisak & Turiel, 1988). While such research has been helpful in highlighting the distinction between domains, the predictions made about how moral decisions develop and mature with age are tenuous. We propose that integration of SIP with moral theory can be taken further, adding components suggested by other moral theories. Crick and Dodge (1994) suggested that SIP ability developed with age due to a growth in experience with social interactions, developmental shifts in attentional ability, mental capacity or speed of processing, and the organisation and interpretation of social information. This is similar to how moral decisions are hypothesised to mature, according to the various moral development theories, suggesting that as well as explaining how online moral decisions are made, the integration of moral theory with SIP has the potential to explain how moral decisions develop and mature.

Here we introduce a conceptual, illustrative framework of moral development, showing how the components of moral development suggested by various theories can be integrated into one dynamic explanation of how moral decisions are made. The format owes much to the original (Crick & Dodge, 1994) and more recent models (Arsenio & Lemerise, 2004; Lemerise & Arsenio, 2000) but we have added components to each step and reconceptualised the centre of the model, incorporating ideas from moral theories and social neuroscience. We will explain how this framework goes beyond previous integrations of moral theory with SIP, and suggest how such a framework has the potential to be developmental. We will also discuss how this illustrative framework can guide future research, and can be a step towards an integrative developmental model of moral decision making.
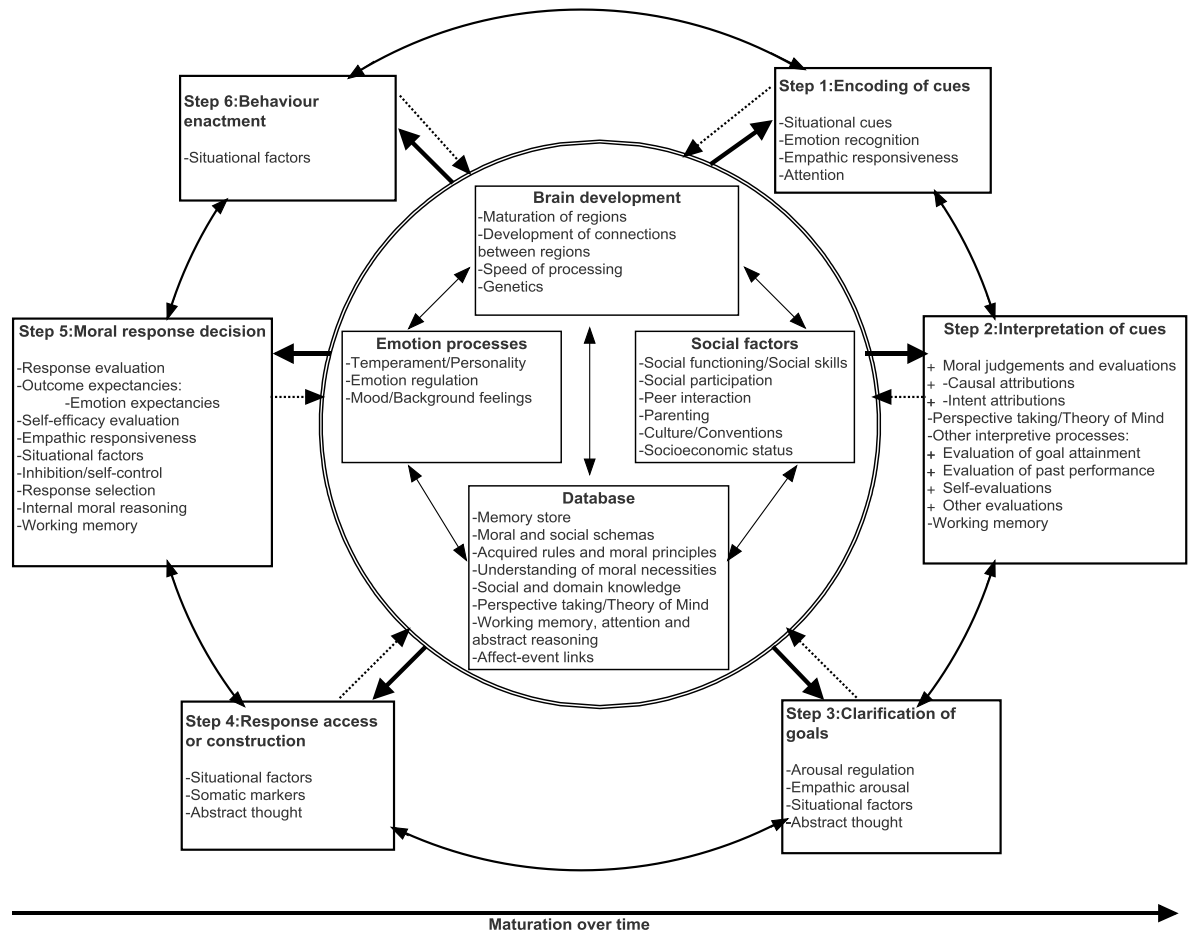
Step 6:Behaviour enactment

-Situational factors

Step 1:Encoding of cues

-Situational cues
-Emotion recognition
-Empathic responsiveness
-Attention

Brain development
-Maturation of regions
-Development of connections between regions
-Speed of processing
-Genetics

Step 5:Moral response decision

-Response evaluation
-Outcome expectancies:
      -Emotion expectancies
-Self-efficacy evaluation
-Empathic responsiveness
-Situational factors
-Inhibition/self-control
-Response selection
-Internal moral reasoning
-Working memory

Emotion processes
-Temperament/Personality
-Emotion regulation
-Mood/Background feelings

Social factors
-Social functioning/Social skills
-Social participation
-Peer interaction
-Parenting
-Culture/Conventions
-Socioeconomic status

Step 2:Interpretation of cues

+ Moral judgements and evaluations
+ -Causal attributions
+ -Intent attributions
-Perspective taking/Theory of Mind
-Other interpretive processes:
+ Evaluation of goal attainment
+ Evaluation of past performance
+ Self-evaluations
+ Other evaluations
-Working memory

Database
-Memory store
-Moral and social schemas
-Acquired rules and moral principles
-Understanding of moral necessities
-Social and domain knowledge
-Perspective taking/Theory of Mind
-Working memory, attention and abstract reasoning
-Affect-event links

Step 4:Response access or construction

-Situational factors
-Somatic markers
-Abstract thought

Step 3:Clarification of goals

-Arousal regulation
-Empathic arousal
-Situational factors
-Abstract thought

Maturation over time

Figure 1. A conceptual illustrative framework of moral development

As with previous SIP models, the online processing steps of the suggested framework are labelled 1-6 to represent a logical order but this is not necessarily how processing occurs in all situations; the steps are not strictly sequential, can occur in parallel and involve continuous updating. This is in line with Rest's componential model, which, although has a logical sequence, there is no set temporal or linear order (Walker, 2002). The 6 steps indicate the processing that is occurring when making a decision about how to behave when dealing with a moral dilemma. All of the processing steps are influenced by factors in the centre of the model, such as one's previous experience in similar situations, and current mood. All of the components in the centre can influence online processing either directly, (such as

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temperament influencing attributions made at step 2), or indirectly through their effect on development of the database. All the relationships in this model are multi-directional: the factors in the centre of the model can influence each step of processing, and engaging in information processing can influence brain development and other factors within the centre of the model, in turn influencing future SIP. The thick arrows from the centre to each step indicate the factors in the centre influencing online decisions, and the dashed arrows indicate processing influencing development of factors in the centre. The arrows are separate, as this relationship is not entirely cyclical; although engaging in SIP can influence development of factors in the centre these developments occur over time and so cannot be used in the same online situation.

Although the 6 steps are not necessarily how processing occurs in every situation, we will now use the order of the 6 steps to illustrate how a moral response decision may be made in an everyday moral dilemma (a situation with moral rules or principles attached where a response decision is required), using the example of deciding whether or not to cheat during a game of Monopoly with friends (an example scenario used in So-Moral, Dooley et al., 2010). We will describe how an individual may decide to cheat in this situation, based on the suggested framework, but will also discuss how the alternative action (not cheating) may occur. At step 1 the individual will encode the cues such as looking at how much money each player has, encoding the other players' emotions and encoding situational cues such as the opportunity to cheat (e.g. other players are distracted or have left the room). Encoding these cues will require attention abilities and emotion recognition, and which cues are encoded will affect subsequent processing. Encoded cues are then interpreted at step 2; this is an important step and is where a situation is recognised as having moral rules attached or not, through moral judgements and evaluations. For cheating at the game to occur, an individual may either not recognise that this situation has moral rules attached, e.g. they may think that because it is a game with friends that the moral rule of not cheating does not apply, or they do recognise the moral rules attached but still decide to cheat for various reasons, e.g. they are losing and want to win. In interpreting cues, the individual may engage in perspective taking; thinking how their friends might feel if they cheated, or thinking how they would feel if their friends cheated, which could influence the goals they set in the

situation. In interpreting cues, the individual may also engage in various evaluations such as evaluating theirs and their friends' past performances of playing Monopoly, which will require working memory in order to keep various sources of information in mind. At step 3, goals for the situation are set, and these can be influenced by whether or not empathic arousal occurs, and also influenced by situational factors (e.g. does the opportunity to cheat still exist). This step is where an individual decides what they want from the situation, such as to cheat at the game by possibly gaining more money to play with, and increase their chances of winning. Possible responses are accessed or constructed at step 4. In this example, an individual may think of various ways in which they can cheat, such as taking some extra money from the bank or hiding some of the other players' money. Responses thought about at this step can be influenced by somatic markers and situational factors, and may require abstract thought. A step 5, the moral response decision is made, i.e. to cheat and how to cheat. Deliberation occurs at this step, which may include engaging in moral reasoning and evaluating the expected outcome. A self-efficacy evaluation may also occur at this step, where the individual evaluates their ability to carry out their intended action, e.g. evaluating if they would be able to take extra money without being caught by the other players. Deliberation at this step could lead to a change in the selected goal, or a change to the chosen response option. The response decided upon at step 5, to cheat at the game, will be enacted at step 6 unless situational factors change (e.g. the opportunity to cheat no longer exists or the game ends), or the individual over estimated their ability to carry out their chosen course of action. As stated, the steps do not necessarily occur in this order, and processing can be rapid.

In terms of choosing a moral or prosocial course of action, in the Monopoly example, an individual may not cheat either because they do not consider cheating as a possible action, or they may consider it but decide against it for various reasons. If an opportunity to cheat was either not encoded (not noticed), or was not interpreted as such, then there is no moral dilemma and no response decision to be made. An individual may recognise the opportunity to cheat but not consider it a possible action, which may be due to knowledge of moral rules related to the specific situation (knowledge that cheating is bad), or due to a deeper understanding and moral necessities (an appreciation of fairness). As individuals develop moral

maturity, more decisions will be made based on a deeper understanding of moral necessities than on situation specific moral rules. At each step, certain components can influence an individual's decision making, leading them to decide not to cheat. For example, engaging in perspective taking at step 2 may lead an individual to decide that the other players would not be happy if they cheated, or thinking about the ways to cheat at step might trigger a somatic marker which feels unpleasant and rules out cheating as a viable option.

In terms of the *development* of moral decision making in such a framework, the development of each of the components of the framework leads to an increased efficiency of online decision making, for example, increases in the ability to recognise emotions (step 1) will enable such cues to be encoded and used in processing a situation, and increases in working memory (step 2) will allow for more features of a situation to be taken into account when making a decision. However, to fully achieve the capacity for mature moral decision making, the components in the database also need to develop. One important difference to this framework compared to previous SIP models is the extension of the database to add components thought to be crucial for moral development, such as perspective taking, an understanding of moral necessities, working memory, attention and abstract reasoning. Moral development is not just achieved through an increase in moral knowledge, but also involves the development of perspective taking and an appreciation of moral necessities for "growth beyond the superficial" (Gibbs, 2013). This framework is dynamic and is in line with Rest et al's (1999) argument that development is gradual rather than one step at a time. The horizontal arrow at the bottom of the framework is to illustrate that the whole process develops over time, but this developmental aspect could be greatly expanded upon by research into developmental relationships between components, and also adding what is known about peaks of brain development.

Based on this framework, to be able to make a mature online moral decision to a moral dilemma, an individual needs to have both a developed database and sufficiently developed component skills and processes to be able to process the situation. In addition to this, situational factors will affect whether a mature moral decision is actually made, and if this is followed by a moral behavioural response. More mature moral decisions are more likely to result in prosocial behaviour but

other factors also influence behaviour, and such factors and their effects (e.g. peer influence) can change over time. Behaviour enactment, at step 6 of this framework is a result of online processing that occurs in a situation, the integrity of the component skills and processes at each step and in the centre of the model, and also situational factors.

This framework suggests how online moral decisions can be driven by both automatic processes and by reasoning. Somatic markers have been added (step 4) as a component which can affect decision making, narrowing down possible responses in a situation, and affect-event links have been added to the database, which may lead to some moral decisions becoming more automatic and efficient with increased experience. Moral reasoning has been added at step 5, as a component involved in making a moral response decision. Based on the suggested framework, an individual's moral reasoning maturity level will indicate their capacity for reasoning, but does not imply that the highest level of moral reasoning will be employed in every situation involving a moral dilemma; it also depends on how information is processed in a given situation, for example whether or not a situation is recognised as having moral rules attached, and how others' intentions are attributed. As with all other components at each step of the framework, moral reasoning can be affected by the database and can become more mature as moral principles are internalised and a deeper understanding of moral necessities occurs.

Arsenio and Lemerise (2004) incorporated some aspects of moral theory by integrating SIP with domain theory but our framework takes integration further by adding components at each step, conceptualising step 5 as 'moral response decision' which is a decision about what to do in a moral dilemma, i.e. a situation with moral rules attached and reformulating the centre of the model.

The behaviour enactment at step 6 in this framework is, therefore, any behaviour in a situation involving moral principles such as harm or justice. Although the steps of the model are not strictly sequential, a moral response decision is the proximal step made before behaviour enactment Moral decisions which are not response decisions, such as judging or evaluating others' actions have been added at step 2, as such decisions made when interpreting a moral situation can influence the response decision that is chosen at step 5. These moral decisions at step 2 can also

influence whether a situation itself is viewed as moral or not, which will influence whether moral schemas are activated. Whether an individual views a situation in moral or personal terms has an influence on their reasoning and decision making (Judith G Smetana, 1981).

The framework suggested here also reformulates the centre of the model, incorporating social factors and brain development alongside the database (Crick & Dodge, 1994) and emotional processes (Lemerise &Arsenio, 2000). Social factors can influence the development of other components, such as peer interaction, which can in turn influence the development of perspective taking. As the brain develops, this can influence both online decisions and the development of other components. Brain activation of areas associated with moral decisions may be particularly important for online decisions and the maturation of brain regions and the connections between regions can also have an impact upon SIP through, for example, increased speed of processing. Decreases in reaction times for adults compared to adolescents when making moral decisions indicates that adults become more efficient at processing such information (Dosch et al., 2010). Perspective taking (or ToM) has also been added to the database as it has been proposed as a pre-requisite for moral development, and is related to affective empathy and empathic arousal at certain steps.

. The suggested framework also adds components to each step, above what has been suggested by previous SIP models. Although Crick and Dodge (1994) proposed that development of attention is important for SIP, and attention has been proposed to be important for moral development (Gibbs, 2013), it has not been explicitly included in previous SIP models. Kahneman (2011) points out that deliberate thought and reasoning requires attention, and is disrupted when attention is drawn away, and although some processes such as seeing are automatic, they rely on the allocation of attention to the relevant stimulus. Step 1, encoding of cues is where an individual selectively attends to a situation and encodes cues. Only the encoded cues can then be used in subsequent processing. Encoding of cues relies primarily on attention, which can be biased, so is important at this step. As attention capacity develops with age, this allows for more features of a situation to be encoded. Related to this, working memory has also been proposed to be important for moral development (Gibbs, 2013) and has been added to steps 2 and 5 as we propose it will

be most important to hold information in mind while interpreting cues and making a moral decision. Perspective taking has also been added at step 2, as making appropriate attributions relies on the ability to infer others' beliefs and intentions. As perspective taking ability develops this will influence processing at step 2, resulting is less egocentric processing. At step 3, individuals bring some goal orientations or tendencies to a situation but also revise and construct goals in response to immediate stimuli (Crick and Dodge, 1994). We have added abstract thinking at step 3 as it will be involved in allowing an individual to think of a goal which they may not have previously experienced. Empathic arousal has also been added at step 3; empathy can be a motivator of moral behaviour (Eisenberg et al., 1995; Eisenberg, Eggum, & Edwards, 2010; Eisenberg et al., 2006; Hoffman, 2000) and this can guide the goal that is 'selected'. Step 4, response access or construction is where an individual accesses from memory possible responses to the situation, or constructs new behaviours if the situation is novel, which can occur in a rather automatic fashion. Abstract thought will be important at this step as individuals may need to construct a novel response, or imagine their ideal response. Step 4 is where we propose that somatic markers (Damasio, 1994) are relevant; some response outcomes (moral response decisions and behavioural responses) which elicit a strong emotional response ('gut feeling') are automatically rejected at this step without further deliberation at step 5.

We have renamed step 5 as 'moral response decision', and added moral reasoning, inhibition/self-control and working memory at this step. We propose that inhibition and self-control is important at this step for inhibiting inappropriate responses generated at step 4. Moral reasoning is just one of the components which guides moral decisions, although it draws upon and is dependent upon other components such as emotion expectancies, attention, encoding, working memory, and perspective taking. Even though initial decisions may be driven by some somatic markers or automatic activation of a moral schema at step 4, reasoning is required to confirm, reject or reformulate this into a moral decision. Moral reasoning in a given situation depends on the processing at other steps of the model, and to what extent the situation activates moral schemas.

'Situational factors' have also been added at steps 1, 3, 4, 5 and 6 as they can affect how information is processed at these steps. Situational factors may be of most

importance at step 6; following the moral response decision at step 5, the enacted behaviour at step 6 can be affected by situational factors, or if an individual overestimated their self-efficacy to carry out the action. More research is needed on the exact situational factors that affect processing and behaviour, but this framework acknowledges that some will have an influence and so need to be taken into account when explaining behaviour. Measuring some of the components of this framework in an individual (e.g. their moral reasoning level and SIP skills) may allow us to predict how they are likely to act in moral situations, but without further exploration of all relevant situational factors, we would be unable to predict behaviour.

This suggested conceptual framework is not a working model but aims to serve as an illustration that the various components of moral development suggested by different theories could be incorporated into one integrative model of moral decision making, showing how moral decisions can be guided by both emotional and cognitive factors, intuitions and reasoning. Such an approach can help to place moral decision making alongside other types of decision making, which could lead to better prediction of moral or antisocial behaviour. This SIP framework can be a useful starting point for explaining the different components and processes involved, integrating diverging fields and suggesting avenues for future research and theory development in this area.

Discussion

In this paper, we have reviewed moral development theory, highlighted what develops, i.e. the components of moral development and discussed research into how these develop. We have also suggested how online moral decision making may occur by introducing an illustrative framework based on SIP. While not a working model, this framework can be used as a starting point to guide further research in this area. We will now discuss the future of moral development theory and research, focusing on the promise and limitations of an integrated developmental theory or moral decision making and suggested areas for further research.

Promise and limitations of an integrated developmental framework of moral decision making

Looking to the future of moral theory development, our suggested framework integrates views from various theories into one explanation of moral decision making. While not a working model, this framework can offer predictions to be tested by future research studies, leading to further clarification of the framework, hopefully increasing insight into developmental relationships between components, leading to better predictions of behaviour, and hopefully more creative ways of helping those who have difficulties within are of the areas described within our framework.

Divides in moral development theory have had an effect upon both research and theoretical developments, such that moral development theory does not always sufficiently explain moral behaviour. The framework suggested here attempts to address this by demonstrating how suggested components from various moral theories can be integrated, and combining both automatic processes (somatic markers and schemas) and moral reasoning, showing how both can guide moral decisions. The framework also incorporates other cognitive and affective processes and places moral decision making alongside other types of decision making by highlighting that situational factors can also influence decisions and behaviour. Moral psychology theories have mostly focused on explaining reasoning and decisions (judgements, evaluations and response choice) rather than explaining moral behaviour. We propose that ideas from these theories can help to explain moral behaviour when incorporated into a SIP framework. Our suggested framework goes beyond previous integrations with SIP theory as it incorporates ideas from various moral theories rather than just moral domain theory. As well as explaining how online moral decisions occur, the framework can also be developmental. Development of the components at each step increases the capacity for more efficient processing and decision making, and development of the database enables moral maturity. The framework also attempts to incorporate ideas from social neuroscience, placing brain development at the centre of the model to highlight its importance and moving towards a dynamic explanation of moral development (Van Bavel et al., 2015). Each of the components of the model develops with age and experience, either due directly or indirectly to the maturation of the brain, which occurs with growth and socialisation. Damage to the brain may alter the developmental trajectories of these components, resulting in less efficient social

information processing and delayed moral development, having a subsequent effect upon behaviour.

To understand moral decision making and behaviour is it is important to understand how real time, online moral decisions are made, the components involved in moral decision making and development, and also how these components develop and mature to facilitate mature moral decisions. This paper has highlighted 'what develops', i.e. the components of moral development suggested by various theories, discussed research into how these components develop and added the components to a framework to explain how online decision making may occur and mature. What develops is actually the *capacity* for more mature moral decisions, but whether or not mature online decisions are made can depend on situational factors. Using the term 'moral decision making' places moral decisions alongside other types of decision making, which can help in thinking about the general influences and processes that guide such decisions (e.g. situational factors), along with the morally specific processes, creating richer explanations of decisions and behaviour. Our suggested framework describes how online moral decisions may occur, based on a SIP approach. "Judgments and decisions of any sort — including those that involve matters of morality — are not a matter of magic but result from processing of information" (Fiedler & Glöckner, 2015, p. 139). Each of the components is necessary but not sufficient for moral development; the capacity to make mature moral decisions requires development of many component skills and processes, including the database, and whether mature online moral decisions are actually made depends on the processing that occurs, which can be influenced by situational factors. This framework is a step towards a dynamic model of moral decision making, which was suggested by Van Bavel et al (2015), showing how moral decisions are not just driven by automatic intuitive processes and/or slower reasoning processes, but that many other components are factors are involved. This framework includes brain development but also references the rich tradition of developmental psychology, helping to bridge the gap between traditional moral theory and social neuroscience. Although brain development has been placed in the centre of the model, this can be greatly expanded on, further integrating what we know about moral development and decision making from social neuroscience research. We did not add specific brain regions to the framework because although

some regions such as the vmPFC have been found to be involved when making moral judgements regarding hypothetical moral dilemmas, it has also been suggested that a wide range of brain regions and networks are required for moral decision making rather than a specifically moral part of the brain (Fumagalli & Priori, 2012; Van Bavel et al., 2015; Young & Dungan, 2012).

As antisocial behaviour involves breaking moral rules of a culture or society, bearing in mind that many of these rules are socially constructed, it could be explained using a moral SIP framework In our suggested framework, antisocial behaviour could be explained as behaviour based on immature moral decision making, which could either be the result of a) developmental delay or deficiencies in one or more of the component processes such as perspective taking or working memory, or b) due to an underdeveloped database (a lack of adaptive moral schemas or an understanding of moral necessities), or c) it could be the result of poor information processing, such as failing to attend to all the salient feature of a situation, a misinterpretation of cues, or failing to recognise a situation as having moral rules attached. This fits with the Situational Action Theory of crime (Wikström, 2005; Wikström, Oberwittler, Treiber, & Hardie, 2012) which proposes that crimes are moral actions, that crime involves an interaction of personal and environmental factors, and that whether an individual views crime as a possible action in a situation is determined by their moral evaluation of action alternatives. Screening some of the component skills of our suggested framework in atypically developing individuals, or those at risk of engaging in antisocial behaviours could allow for targeted interventions which may prove more useful than general interventions. For example, people with brain injuries and also offender populations have been found to have deficits in facial emotion recognition (Croker & McDonald, 2005; Robinson et al., 2012). If an individual has deficits in emotion recognition, our framework would suggest that they will have problems encoding this information, which may potentially bias subsequent processing and moral decisions and behaviour. Teaching generic social problem solving skills may be of limited utility in such a case, as in a real life situation the individual will still struggle to use information from others' facial expressions in their moral decision making, so emotion recognition training may be more beneficial. It is possible to increase moral behaviour and reduce antisocial behaviour by training individuals in some of the

components of moral development. A study which trained perspective taking abilities in preschool children found that training increased visual, cognitive and affective perspective taking, and that these increases were related to increased prosocial behaviour and decreases in aggressiveness (Cigala, Mori, & Fangareggi, 2015). Further increases in prosocial behaviour and decreases in aggression may potentially be achieved by training individuals in some additional components of moral development, such as moral reasoning, moral rules and attention and working memory.

While there is promise of what a fully integrative working model of moral decision making and development could offer, developing such a model that predicts online moral decision making and moral development is an ambitious task. In incorporating all of the components thought to be involved in moral development, online decision making and all the factors required for their development (e.g. specific brain regions and networks and all social factors), there is a risk of creating a theory of everything, which is either too broad and non-specific or is overly complicated. There are also challenges in reconciling differing theories and philosophical viewpoints, and also incorporating social neuroscience research which has largely developed separately from developmental psychology research. Bearing in mind these limitations, we will now discuss some suggestions for future research, which we see as the next step to creating an integrative model.

Suggestions for future research

The framework we have presented here is so far just a suggestion of how online moral decision making may occur and how development of the components can increase the capacity for mature moral decision making. Research is needed to either confirm or reject the predictions of this framework, for example, do developments in emotion recognition abilities affect what is encoded in a moral dilemma, and does this in turn have any effect on moral reasoning and decision making? The suggested framework can be used to generate hypotheses about online moral decision making and moral development, to guide research and theory development.

Conceptualising online moral response decisions within a SIP framework allows for such decisions to be measured with a SIP instrument, using vignettes

which depict violations of moral rules or principles. Measuring moral decisions this way can allow for an investigation of how more real-life moral response decisions are made, based on a response constructed by the individual rather than forced-choice judgements to hypothetical dilemmas. For example, the social information processing test (van Nieuwenhuijzen, Vriens, Scheepmaker, Smit, & Porton, 2011) includes a vignette of a boy in a wheelchair being bullied, which relates to the moral principles of justice and harm, and decisions about this dilemma are more 'real-life' than choosing to kill one person or to kill five people (Greene et al, 2001). Future studies could use a SIP measure alongside measure of moral reasoning and other component skills to provide a better understanding of relationships between components for online moral decision making. Also, further research into the situational factors that may affect moral decision making will help to better predict moral behaviour. Situational factors have been incorporated into some steps but we acknowledge that we have not elaborated on specific situational or contextual factors. This is an area that needs further research and clarification in order to improve the predictive power of such a framework in different situations. Situational factors that affect moral decision making may change over time, for instance, peer influences may be particularly important during adolescence. So far, moral reasoning measures can provide us with an indication of an individual's capacity for reasoning but we do not yet have a full picture of what affects whether this highest capacity is used or not in different situations.

It was beyond the scope of the current paper to systematically review all research into the development of all of the components of moral development but we have summarised selected research, which suggests that they all of the components mature with age. Studies typically just measure one component of moral development or decision making, but some studies have found developmental an predictive relationships between components (Carlo et al., 2010; de Wilde et al., 2016; Eisenberg et al., 1995; Peterson et al., 2016) and that training some of the components can lead to improvements in prosocial behaviour (Cigala et al., 2015). Further developmental research which measures moral reasoning and decision making alongside some of the other component skills and processes (e.g. perspective taking and emotion recognition), SIP skills and behaviour can help to provide a clearer picture of the relationships between all of these factors, including predictive

relationships. Our framework describes 'what develops' but the 'and how?' could be expanded on by further research into the developmental relationships between components. A better understanding of relationships between components, and which components are the best predictors of behaviour can help further theory development and also help in targeting interventions to increase the capacity for mature moral decision making.

Most moral neuroscience research has been informed by the dual-process theory (Greene et al., 2001), focusing on investigating whether cognitive or affective brain regions are recruited when making hypothetical dilemmas. Neuroimaging studies typically measure moral evaluations, such as judging the appropriateness of others' actions (Parkinson et al., 2011) or identifying statements as morally right or wrong (Avram et al., 2014). Fewer neuroimaging studies measure brain activity for moral response decisions and those which do tend to use versions of the utilitarian life or death scenarios first used by Greene et al (2001) (Chiong et al., 2013; Han, Glover, & Jeong, 2014) Future moral neuroscience research could use dilemmas which are more real life than the life or death scenarios, and also focus more on investigating brain activity for moral response decisions. There has been some developmental neuroscience research linking brain development and functional connectivity to judging moral transgressions (Decety et al., 2012; Harenski et al., 2012) but there is a lack of such studies linking brain development to moral reasoning or response decisions. Research which measures brain development from infancy to adulthood alongside measuring moral reasoning, moral decision making and related components such as perspective taking would provide a fuller picture of the brain networks required for moral decision making. Such research would allow the 'brain development' of our framework to be greatly expanded upon, pinpointing which brain regions are most important for the maturation of moral decision making, and highlighting developmental windows of importance which can be useful in training to enhance moral decision making.

Conclusion

Moral development is a complex process involving many factors. We have expanded the definition of moral development to incorporate the maturation of the component skills or processes, as well as the maturation of moral decision making

and reasoning. We argue that each of the components is necessary, but not sufficient, for mature moral decision making. Development of component skills and processes, including the database, can lead to increase in the capacity for making more mature moral decisions, but whether a mature online moral response decision is made, and results in a moral behaviour, depends on situational factors and the processing that occurs in that situation. This is the first attempt to incorporate all of the suggested relevant components into one descriptive framework of moral decision making and behaviour. Such a framework can explain how online moral decisions are made and can help in describing the components that need to develop in order for mature moral decisions to be able to occur. Further research in this area can provide either support for this framework, or arguments for reformulation. For a fully working model which explains both online moral decision making and behaviour alongside moral development specific situational factors need to be further explored and developmental processes expanded upon.

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