MAKING MORAL DECISIONS: EXAMINING THE INTERPLAY OF CONTROLLED COGNITION AND AUTOMATIC INTUITIONS DURING THE RESOLUTION OF MORAL DILEMMAS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Recent evidence investigating moral psychology has suggested that moral decisions result from the interplay of two distinct and separable processes: one fast, automatic and affective, the other slow, effortful and abstract. Central to this dual-process theory are assumptions about when and how each mechanism emerges, interacts and is reconciled. It is largely assumed, for example, that decision-making is driven by fast, automatic intuitions that can be overcome by slower, more deliberative thought. While there is now a substantial body of research supporting the distinction between two systems during moral reasoning, little is known about the interaction between the systems. This thesis investigated when and how controlled cognition and automatic intuitions contributed to the production of moral judgements using the reach-to-touch paradigm. In two separate experiments participants were presented with moral dilemmas that differed according to the doctrine of double effect. Participants were shown two response options to the question "What would you do?" with one characteristically utilitarian and the other deontological. Participants indicated their response by reaching to the right or left of a central start position. A Polhemus Liberty motion capture system rapidly sampled the position of the participant's hand throughout the movement. Experiment 1 required participants to make decisions about moral dilemmas alone. In Experiment 2, a cognitive load manipulation was introduced. Results provide temporal support for the dual process theory. At an early stage in processing deontological responses to high conflict dilemmas were comparatively more rapid than utilitarian decisions. In an extension of previous research results revealed utilitarian preferences to be, rather than slow and more taxing, variable on a trial-by-trial basis. Together, these findings suggest that cognitive resources mediate the interaction between intuition and cognition.

STATEMENT OF AUTHENTICATION

I declare that this thesis is submitted in fulfilment of the requirements for the degree of Master of Research and has not been submitted for a higher degree to any other university or institution. The research presented in this thesis is my original work. I have appropriately acknowledged help or assistance that I received during the preparation of this thesis, as well as any sources of information that I have used. All research presented in this thesis was approved by Macquarie University Ethics Review Committee (Human Research), reference number 5201300060. Documentation of this approval is given in Appendix C.

Signed: Date: 6 October 2015

Samantha Parker

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Making Moral Decisions: Examining the Interplay of Controlled Cognition and Automatic Intuitions During the Resolution of Moral Dilemmas

Humans inherently possess a system of values and principles that guide their behaviour, their interactions with others and the laws that define their society. These are the standards upon which judgements as to what is "right" or "wrong," "good" or "bad" are made and are commonly known as moral values. Moral decision-making is a pervasive aspect of human behaviour, with our actions and the actions of others constantly assessed in moral terms. Often these judgements are formed instantly and automatically, such as the condemnation of random acts of violence. Other decisions can feel conflicting and difficult, where even after careful deliberation, a satisfying conclusion cannot be reached. This type of moral evaluation undeniably involves the coordination of a number of complex processes that can be both complementary and competing. It is the investigation of these mechanisms and how they are involved to produce moral decisions that has become of critical interest to researchers.

Traditionally, research has debated the extent to which moral decisions are driven by automatically elicited "gut responses" as opposed to rational, deliberative thought. While this tension has permeated the moral psychology literature for decades, more recent research has established that both mechanisms play an integral role in the production of end-state judgement. In contrast to the past focus on characterising judgement as either automatic or rational, more recent evidence suggests that it may be the interplay of these mechanisms that is critical to producing moral decisions (Greene, Morelli, Lowenberg, Nystrom & Cohen, 2008; Greene, Nystrom, Engell, Darley & Cohen, 2004; Greene, Sommerville, Nystrom, Darley & Cohen, 2001). That is, when forced to decide whether to sacrifice one, in order to save a number, our thinking is driven by fast automatically

elicited intuitions, that may be overcome by slower more deliberative thought. While there is now an extensive amount of research investigating the contribution of both processes to moral judgement, research is currently limited in its ability to examine the nature of the interaction between these mechanisms. The research presented in this thesis seeks to examine the interplay of automatic intuitions and controlled cognition during the resolution of moral dilemmas by examining the dynamics of decision-making as they emerge across time.

1.1. Rationalisation and Reason

Moral psychology was originally studied from a developmental perspective. Researchers were concerned primarily with identifying the "rational" basis upon which individuals made ethical decisions and how this developed as a function of age (Kohlberg, 1969; Piaget, 1965). An examination of this literature, suggests however, that reasoning alone cannot account for the entire ethical decision-making process.

Developmentalists believed that as children matured, so did their moral reasoning, proceeding through a series of stages (Kohlberg, 1969). Critically the cognitive mechanisms responsible for producing moral judgement were thought to be conscious and language-based (Kohlberg, Levine & Hewer, 1983). Evidence for this proposition arose from a series of experiments that required participants to give post-hoc justifications for their moral judgements (Nucci & Turiel, 1978; Turiel, 1983; Turiel, Killen & Helwig, 1987). Nucci and Turiel (1978), for example, tasked children to make decisions in response to ethical scenarios. Following these judgements children were then asked a series of questions designed to probe their application of moral rules. The results suggested that as children mature their logical reasoning and justification for moral decisions

becomes more articulated. This research does not make clear however whether moral reasoning produces judgement, or whether reasoning follows an initial decision.

Other studies have suggested that reasoning alone is not sufficient to predict moral behaviour. Haidt and Hersh (2001) in a study of sexual morality attitudes, found participant's affective reactions to be more predictive of their moral decisions than calculations based on harm. The authors reporting that participants were often unable to find supporting reasons for their judgements, yet refused to change them – an effect termed "moral dumbfounded" (Haidt, 2001). These results suggest, that aside from deliberate reasoning, moral judgement may also involve an intuitive mechanism, unavailable to conscious awareness, but critical in shaping moral decisions.

1.2. Affect and Intuition

Given the evidence suggesting that conscious reasoning alone cannot explain moral action, more recent research has begun to emphasise the role of automatic intuitions in driving moral behaviour (Greene & Haidt, 2002). Intuitive mechanisms are characterised as fast, automatic and effortless, where the outcome of the process is available to conscious awareness, but not the steps through which it was reached (Bastick, 1982; Simon, 1992). In contrast, reasoning is thought to be slow, effortful and deliberative, the steps of which are available to consciousness (Haidt, 2001). Haidt (2001), in contrast to the traditional rationalisation approach, proposed a model of moral judgement that emphasised intuition. The Social Intuitionist Model of moral judgement suggests that decisions are driven primarily by automatic affect-laden intuitions (Haidt, 2001). That is, in response to ethical scenarios, people have instant feelings of approval or disapproval. Rather than deliberate reasoning producing moral judgement, reasoning is thought to be post-hoc, providing justification for an already reached conclusion.

Evidence for the importance of intuition has stemmed from judgements made in other social domains. For example, impression formation is found to occur rapidly and extend to moral attributions. After being exposed to a person's behaviour for as little as five seconds, people are found to form judgements that are similar to those they reach upon longer reflection (Ambady & Rosenthal, 1992). These impressions include descriptions of moral traits, such as the tendency to judge an attractive person as being kind and of good character (Dion, Berscheid & Walster, 1972). People similarly stereotype instantly, often attributing rapid moral generalisations to certain ethnic groups (Devine, 1989). This evidence suggesting that some moral judgements are the result of an automatic affective process, one that is robust and not subject to slow deliberation.

Studies have now found reasoning to be significantly less predictive of moral judgement than affect. Patients who have suffered damage to the ventromedial prefrontal cortex (VMPFC), an area of the brain known to be associated with emotional responses (Ongur & Price, 2000; Rolls, 2000), exhibit an irregular pattern of moral judgement. Although knowledge of explicit social rules remains intact, when patients are faced with real life moral decisions they show poor judgement, irrational behaviour (Damasio, 1994) and significantly less emotional reactivity than controls (Damasio, Tranel & Damasio, 1990). This research suggests that beyond deliberative reasoning, moral decision-making is critically influenced by intuition and affect.

1.3. Intuition and Cognition: A Dual Process Theory

It is now accepted that rather than being the product of one process alone, moral judgement seems to involve both automatic intuition and deliberative cognition. The most prevalent theory of moral decision-making, the dual process theory, attempts to synthesise the previous approaches by suggesting that moral judgement is the product of two

separable neural systems – one fast, automatic and affective, the other, slow, effortful and abstract (Greene et al., 2004; Greene et al., 2001). This theory states, that although these processes are often complementary, often producing compatible responses to moral scenarios, it is when these mechanisms are placed into conflict that their true cognitive structure is highlighted (Cushman & Greene, 2012). While the precise characterisation of these mechanisms is far from agreed (Huebner, Dwyer & Hauser, 2009; Kvaran & Sanfey, 2010; Moll, de Oliveira-Souza & Zahn, 2008), there is now a substantial body of research investigating their contribution to the resolution of moral dilemmas. The evidence suggests that moral judgement results from the interplay between both intuition and cognition. What remains unclear, however, is how these processes interact over the course of moral decision-making to produce a reconciled judgement. In order to understand the nature of the relationship between slow deliberative cognition and automatic affect-laden intuitions it is critical to examine the emergence of moral decisions across time.

1.3.1. Dual process theory.

Dual process theories have become a prevalent way to understand and interpret the reasoning behaviour of humans in a wide variety of tasks (Evans, 2002; Evans & Stanovich, 2013; Kahneman, Slovic & Tversky, 1982). Specifically, the existence of two systems is thought to explain why humans possess a large number of information processing biases and errors in logic. These mistakes are thought to be the product of two distinct reasoning systems (Epstein, 1994; Evans, 2003; Evans & Over, 1996; Sloman, 1996; Stanovich & West, 2000). The first system is thought to be fast, automatic and based on heuristics – shortcuts in information processing. While, in contrast, the second system is described as slow, deliberative and uses reasoning based on standards of logic. Operation of the first system occurs instantly and automatically, and hence may lead to a number of

biases in our information processing system and ultimately our judgement. In contrast, the second system is more cognitively demanding and is hence performed slower and with more reliance upon executive resources (De Neys, 2006b). While this approach has garnered much empirical support, this research has traditionally been limited to the study of logical reasoning. More recently however, researchers have begun to apply the central propositions of a dual process theory to the mechanisms of moral decision-making. That is, when deciding whether it is appropriate to sacrifice one in order to save many, decision-making may be driven by both a fast, automatic and affective system that can be overridden by a slower, more deliberative and conscious second system.

1.3.2. Dual process theory for moral decision-making.

The original conception of the dual process theory for moral decision-making arose out of the tendency for people to make distinct judgements in relation to a set of moral dilemmas known as the "trolley" and "footbridge" problems (Foot, 1967; Thomson, 1976). These dilemmas were designed to place into conflict affect-laden intuitions and controlled reasoning (Christensen & Gomila, 2012). To create this conflict, these hypothetical scenarios pit deontological concerns, that is, "universal" principles of morality, such as never harming others, against utilitarian considerations, such as the weighing of costs and benefits (Christensen, Flexas, Calabrese, Gut & Gomila, 2014). Specifically, most judge it as appropriate to save five people by diverting a "trolley" onto a track where one person stands. While, in contrast, most judge it as inappropriate to throw one person off a "footbridge" in order to save five (Hauser, Cushman, Young, Jin & Mikhail, 2007; Thomson, 1985). Greene (2009) suggests that the best explanation for these results is that the content of each dilemma triggers a different affective response (Greene, 2007; Greene et al., 2008; Greene et al., 2004; Greene et al., 2001). The harm in the "footbridge"

scenario, for example, elicits a strong emotional reaction that favours deontological decisions and disapproval of the action. The "trolley" dilemma, in contrast, does not elicit a strong emotional reaction and controlled cognition is therefore able to produce responses that favour utilitarian outcomes.

In an fMRI study Greene and colleagues (2001) made participants respond to a series of dilemmas designed with a similar distinction as the trolley and footbridge problems. Specifically, dilemmas were split into "personal" and "impersonal" scenarios. Personal dilemmas were defined as those that could reasonably be expected to lead to serious bodily harm, to a particular person, where this harm was not a result of deflection (Greene et al., 2001). Thus, the "footbridge" scenario is considered a personal dilemma because one is required to push an individual off a bridge in order to save five. In contrast, impersonal dilemmas were those that did not fulfil these criteria. More specifically, the trolley scenario is considered an impersonal dilemma because harm is deflected from five onto one. The authors reported that when compared to the resolution of non-moral and impersonal dilemmas, personal dilemmas were associated with significantly more activation in brain regions related to emotion. Additionally, participants took longer to respond in ways that were incongruent to the countervailing emotional response, such as judging it as appropriate to throw a stranger off a footbridge. This led the authors to conclude that the difference between the trolley and footbridge problems was the activation of emotion and that automatic emotional responses inclined people to disapprove of harm. Greater emotional activation on personal dilemmas was thought to more strongly engage automatic intuitions, hence leading to more deontological responses. In contrast, impersonal dilemmas being less affective in content, only weakly elicited an automatic response. Given this weak activation, conscious deliberation was able to override the automatic intuition and hence favour a utilitarian judgement.

Longer reaction times (RTs) on trials answered incongruently to the default emotional reaction were thought to be a reflection of the cognitive control necessary to overcome the prepotent automatic response (Greene et al., 2004; Greene et al., 2001). That is, participants took longer to provide a utilitarian answer to personal dilemmas as they were forced to overcome their automatic intuition favouring disapproval of the action, with a slow, effortful cost-benefit analysis. To investigate this interpretation of longer RTs as markers of cognitive conflict, Greene and colleagues (2004) conducted a follow up fMRI study. Participants were given the same set of dilemmas, but neural activation was compared between dilemmas that produced long RTs and those that produced short RTs (Greene et al., 2004). When compared to trials completed quickly, difficult personal dilemmas (longer RTs) were associated with greater activation in the anterior cingulate cortex (ACC), a brain region associated with cognitive conflict on tasks such as the Stroop task (Botvinick, Braver, Barch, Carter & Cohen, 2001). Similarly the dorsolateral prefrontal cortex (DLPFC), an area associated with abstract reasoning and cognitive control (Baraclough, Conroy & Lee, 2004; Ernst & Paulus, 2005; Fleck, Daselaar, Dobbins & Cabeza, 2006; Miller & Cohen, 2001; Van't Wout, Kahn, Sanfey & Aleman, 2005), also exhibited increased activation during long RT trials, reflecting the engagement of more deliberative reasoning during difficult dilemmas. The authors reported that the amount of activation in the DLPFC correlated with the proportion of utilitarian judgements made. That is, greater DLPFC activity was associated with a higher number of utilitarian judgements. Leading them to conclude that utilitarian, as opposed to deontological judgement, was associated with greater cognitive control.

While the dual process theory has garnered much attention in the moral psychology literature, the central assumptions arising from Greene and colleagues original study are far from agreed. Whilst many disagree about the characterisation of the systems in general

(Huebner et al., 2009; Kvaran & Sanfey, 2010; Moll et al., 2008), others question the experimental control used in the original studies. Specifically, the conception of the "impersonal" and "personal" distinction has been criticised for being poorly defined and vague, particularly the "impersonal" criteria (Mikhail, 2007). The dilemmas themselves have been scrutinised for poor standardisation of language, emotionality and content between categories (McGuire, Langdon, Coltheart & Mackenzie, 2009). Perhaps most significantly however was a reanalysis by McGuire and colleagues (2009) that questioned the original interpretation of the RT results (Greene et al., 2001). The authors found that upon reanalysis, longer RTs for utilitarian responses to personal dilemmas were carried by a small number of dilemmas eliciting a large level of agreement and rapid responses. Once these dilemmas were removed, so too was the RT effect. Such criticisms highlight the inherent difficulties in attempting to study moral cognition. Yet since these original experiments there has been a growing body of work addressing these concerns, replicating and extending the findings (Conway & Gawronski, 2013; Moore, Lee, Clark & Conway, 2011; Nakamura, 2013). It is now clear that there are at least two distinct systems that contribute to moral decisions – one that is characteristically fast, automatic and intuitive, the other which is slow, conscious and deliberative.

1.4. Clarifying the Contribution of Intuition and Cognition

Studies involving both clinical populations and a range of different behavioural manipulations have helped to clarify the unique contribution of both an intuitive mechanism and a more deliberative, conscious process. These studies have specifically provided evidence implicating a distinct and separable role for both slow, effortful deliberation and fast, automatic intuition. Critically this research supports Greene and colleagues original proposition that these two systems favour unique response tendencies

and are perhaps mediated by distinct neural circuitry (Greene et al., 2004; Greene et al., 2001).

1.4.1. Clinical evidence.

Judgement in clinical populations has been central in establishing that affective intuitions, as distinct from controlled cognition, are critical in the production of deontological moral decisions. Mendez, Anderson and Shapira (2005) examined moral judgement in a sample of patients suffering from fronto-temporal dementia, a condition characterised by emotional blunting but intact knowledge of moral rules. These patients were found to respond predictably to trolley dilemmas, but disproportionately utilitarian in footbridge type dilemmas. Leading the authors to suggest that emotion plays a unique and critical role in driving deontological decisions. A finding that is also consistent with the assumption that, in contrast to impersonal scenarios, personal dilemmas strongly engage affective intuitions.

Damage to the VMPFC, an area of the brain containing neurons thought to encode emotional responses, (Ongur & Price, 2000) disturbs moral decision-making in characteristic ways. Patients with lesions to the VMPFC produce abnormally high numbers of utilitarian decisions (Koenigs et al., 2007; Moretto, Ladavas, Mattioli & di Pellegrino, 2010), often reaching these conclusions significantly faster than controls (Ciaramelli, Muccioli, Ladavas & di Pellegrino, 2007). VMPFC patients are also significantly less emotionally aroused during the resolution of these dilemmas, where skin conductance is reported to be at normal levels (Moretto et al., 2010). These findings suggest that when emotional processing is limited, people are more likely to rely upon cost-benefit analyses to guide judgement. The selective interference of deontological decisions, further suggests that emotionally driven intuitions are dissociable from deliberative cognition.

1.4.2. Behavioural manipulations.

While results from neuropsychological patients suggest that affect-laden intuitions drive deontological responses to moral dilemmas, behavioural manipulations have sought to clarify the contribution of slow, deliberative cognition. Utilitarian judgements are thought to be the result of a time consuming, effortful and conscious process, requiring significant amounts of cognitive control to overcome the default emotional response (Greene et al., 2004; Greene et al., 2001). As such, it follows that when cognitive resources are limited, these processes should be more difficult to engage (De Neys, 2006b). Indeed numerous experiments have found this to be true. When participants are required to simultaneously make moral decisions whilst completing taxing cognitive tasks, utilitarian judgement is selectively disturbed (Conway & Gawronski, 2013; Greene et al., 2008; Trémolière & Bonnefon, 2014; Trémolière, De Neys & Bonnefon, 2012). Greene and colleagues (2008) reported that when participants were tasked to complete moral dilemmas, whilst having to identify a number in a scrolling string during the reading and deliberation period, the production of utilitarian responses took significantly longer than under control conditions. In contrast, deontological decision-making remained unaffected by the load condition. Requiring participants to memorise complex character strings (Conway & Gawronski, 2013) or the location of dots in a matrix (Trémolière & Bonnefon, 2014) during the resolution of moral dilemmas has similarly been found to selectively decrease utilitarian responding. Whilst inducing participants to think of their own mortality, a task known to tax cognitive resources, is found to decrease utilitarian responding, but only when intuition is placed into conflict with reasoning (Trémolière et al., 2012).

In a similar way, stress has likewise been shown to selectively disturb utilitarian decisions (Starcke, Ludwig & Brand, 2012). Given that stress is known to impact both cognitive functions, such as memory and attention, and emotional reactions (Jackson, Payne, Nadel & Jacobs, 2006), assessing its interference in moral judgement highlights the contribution of each process. Objective stress measures, such as cortisol levels are found to correlate with judgement type (Starcke, Polzer, Wolf & Brand, 2011). That is, higher levels of cortisol positively correlate with likelihood to answer egoistically, and less likelihood to answer altruistically. A finding replicated with moral judgements, where stress-induced participants make more deontological decisions than controls (Conway & Gawronski, 2013; Starcke et al., 2012; Youssef et al., 2012). A finding that suggests stress inhibits the cognitive control necessary to override our initial automatic response to moral dilemmas (Starcke et al., 2012). Taken together these results support the proposition that there are at least two distinct and separable systems producing moral decisions. That is, the selective interference of utilitarian decisions by cognitive load tasks, suggests that slow, conscious and effortful mechanisms are uniquely involved in the production of these response tendencies. Deontological decisions, in contrast, are the result of a distinct automatic system that does not rely upon cognitive resources.

These processes have likewise been examined in experiments comparing and manipulating reasoning style. Moore, Clark and Kane (2008) examined whether an individual's working memory capacity varied with their tendency to respond a certain way to moral dilemmas. As working memory is thought to be fundamental to the ability to control emotion and engage in conscious reasoning (Hinson, Jameson & Whitney, 2003), it follows that greater capacity would enable more utilitarian decision-making. However, working memory capacity was found to be predictive of response type, in certain moral scenarios only. Larger working memory capacity was found to correlate with quicker and

more utilitarian judgement in scenarios involving avoidable or inevitable harm only. In a similar study Bartels (2008) found that people who were more likely to reason intuitively, were correspondingly more likely to make deontological decisions.

Experimental manipulations of reasoning and affect have likewise provided support for the idea that moral judgements are a result of at least two distinct systems. Valdesolo and DeSteno (2006) experimentally induced positive emotion and had participants complete moral dilemmas. Positive emotion was found to increase utilitarian judgement on footbridge dilemmas only. A finding that led the authors to suggest that positivity decreased the amount of negative affect associated with footbridge dilemmas, and hence the level of intuitive engagement. Paxton, Ungar and Greene (2011), similarly reported that when participants were given a cognitive reflection test to encourage deliberate reasoning, before responding to dilemmas, they were more likely to approve of utilitarian action.

The selective interference of moral judgement through behavioural manipulations suggests that there are at least two dissociable systems that produce moral decisions. In addition the evidence suggests that each system possesses distinct characteristics and follows a unique time course. One system does not rely upon executive resources – operating fast, automatically and favouring deontological decisions. The second system, in contrast, is mediated through cognitive resources – requiring effort, time and ultimately favouring utilitarian responses. A finding that is further supported by studies employing stimulation methods.

1.4.3. Stimulation studies.

Stimulation studies have been used to directly assess the contribution of affect and controlled cognition to the production of moral judgement. In line with previous behavioural, imaging and clinical research, this approach suggests that, not only do two

dissociable processes uniquely contribute to the production of moral decisions, but that they may be mediated by distinct neural circuitry.

Neuroimaging and lesion studies have implicated the DLPFC as a critical brain region involved in cognitive control and decision-making (Ciaramelli et al., 2007; Forbes & Grafman, 2010; Greene et al., 2004; Koenigs et al., 2007; Mendez et al., 2005; Young & Koenigs, 2007). In contrast, an area of the right temporal parietal junction (TPJ) has been found to play a role in social cognition and empathy (Saxe & Kanwisher, 2003). Given the evidence suggesting that moral decision-making may result from the interplay of two dissociable systems, namely one that is cognitive and deliberate, and the other which is emotional and automatic, researchers have begun to temporarily disrupt these regions in order to assess their contribution to the production of moral judgement (Jeurissen, Sack, Roebroeck, Russ & Pascual-Leone, 2014; Tassy et al., 2011).

Jeurissen and colleagues (2014) applied transcranial magnetic stimulation (TMS) to temporarily disrupt the DLPFC and TPJ to assess their respective contributions to the resolution of "personal" and "impersonal" dilemmas. They reported that TMS-induced disruption to the DLPFC impacted judgement in personal dilemmas only, with participants being more likely to judge utilitarian action as inappropriate. This finding is consistent with the idea that following disruption to the DLPFC there is less cognitive control over the initial emotional response. Stimulation of the TPJ at the same time point, led to interference in impersonal dilemmas only, increasing deontological decision-making. This result was thought to reflect a boost in the emotionality of the dilemma.

In an earlier study (Tassy et al., 2011), that compared the effects of TMS for subjective ("What would you do?") and objective ("Was the action appropriate?") judgements, it was found that repetitive TMS to the DLPFC decreased utilitarian judgements on the subjective task for high conflict dilemmas, and increased utilitarian

decisions on the objective task. This finding led the authors to suggest that the DLPFC plays a secondary role, being critically involved in the integration of emotionally salient information necessary to guide behaviour based on abstract rules.

Taken together these studies suggest that there are at least two distinct mechanisms involved in moral decision-making and that these processes are capable of being separated, with each favouring certain response tendencies. That is, one is characteristically automatic, intuitive and driven by emotion, favouring deontological responses. While the other is slow, deliberative and consciously mediated, tending to favour utilitarian considerations. What is not clear however is how these processes interact to produce a final moral judgement. Fundamental to producing a single resolution to a moral dilemma must be the integration and reconciliation of these two processes.

1.5. When and How do Intuition and Cognition Interact?

The dual process theory inherently contains assumptions about how both controlled cognition and automatic intuitions emerge and the nature of the interaction between them. That is, in a similar way to a default interventionist model (Evans & Stanovich, 2013), it is suggested that the automatic initial response to moral dilemmas is an affect-laden intuition favouring disapproval of moral violations. The stronger the affective engagement the more cognitive control is necessary to overcome intuition and engage in deliberate reasoning. This reasoning is conscious, effortful and slow, emerging later in time and taking longer to complete (Greene, 2007; Greene et al., 2008; Greene et al., 2004; Suter & Hertwig, 2011). Although widely assumed, there is little direct evidence examining these predictions.

Manipulations of deliberation time offer one way in which the nature of the interaction can be examined, albeit indirectly. When participants are forced to make moral decisions within eight seconds of reading a dilemma, they are found to make significantly

more deontological responses than utilitarian decisions (Suter & Hertwig, 2011). In contrast, when participants are given up to three minutes to deliberate, they tend to make more utilitarian judgements (Cummins & Cummins, 2012). This suggests that the process favouring deontological responses occurs instantly and is unaffected by time pressure, whilst the mechanism underlying utilitarian responses emerges later and is more time consuming, using conscious deliberation to overturn the default intuitive position. Although supportive of the dual process assumptions, such an approach means that the nature of the interplay must be inferred from end-state measures.

In an attempt to better understand the emergence of these two processes, and examine moral decision-making directly, recent work in moral cognition has begun to use ERP methods. Sarlo and colleagues (2012) used a set of moral dilemmas that followed the doctrine of double effect (DDE). This doctrine is known to guide moral reasoning and involves the resolution of scenarios that differ in terms of intentionality (Bartels, 2008). That is, it is morally unacceptable to kill one individual as an intended means of promoting greater good (instrumental), but it is acceptable if the consequence is foreseen but unintended (incidental) (Aquinas, 2006; Foot, 1967). The authors used ERP to investigate when in the decision-making process affect and controlled reasoning contributed to judgement. ERPs were recorded in two distinct phases. The first occurred after the presentation of the dilemma and option text, and upon the appearance of a slide in which the response options were presented side-by-side. The second was before the implementation of a response. Participants were explicitly instructed to delay deliberation until the onset of the decision slide. The authors reported that instrumental dilemmas, thought to be more emotionally evocative, elicited a greater early positivity in the frontal locations of the brain. Critically, this cortical response was found to correlate with participant's reported unpleasantness and was therefore interpreted to be indicative of an

early affective response. In contrast, incidental dilemmas, thought to only weakly elicit affective-intuitions, demonstrated a late positivity in areas associated with controlled cognition. This led the authors to suggest that instrumental and incidental dilemmas relied upon functionally distinct processes that differentially engaged affect and cognition. A similar pattern of neural activity has been reported in response to everyday moral decisions (Sommer et al., 2010). That is, during judgements as to whether to follow personal desires or moral values, the same cortical areas are activated as when the decisions involve life and death consequences.

Together these studies seem to support the assumptions of the dual process theory. That is, instrumental dilemmas seem to elicit an early emotional response, perhaps motivating deontological response tendencies. Whilst, incidental dilemmas are associated with a later cortical activation in areas related to working memory and cognition. These studies are limited, however, both in their ability to examine the on-line judgement process and capacity to provide an assessment of the interaction mechanism. ERP methods necessitate isolating recording into distinct phases. Given that decision-making is a continuous process, this approach inevitably fails to capture the dynamics of ongoing reasoning. Similarly, the authors themselves acknowledge that forcing participants to delay deliberation until the onset of a third screen, is likely unable to capture the automatic intuitive emotional response, elicited rapidly and instantly. Examining neural responses to various dilemma types although informative, cannot examine the interplay between an early emotional response and later more controlled activity. It is therefore critical to examine decision-making in a way that enables an investigation of the on-line reasoning process.

1.5.1. Examining the dynamics of moral judgement.

Although seemingly central to understanding moral judgement, there is little direct evidence to support the notion that intuitions emerge early and if given enough time and cognitive control, can be overturned by conscious deliberation. Moral judgement is a highly complex cognitive task that involves the integration and reconciliation of both automatic intuitions and more conscious reasoning. Yet the nature of the current methodological approach is such that we are unable to examine the emergence and interaction of these two processes directly. Reaction times indicate a participant's response choice and the total duration of all mental and motor processes involved in making that selection. These analyses are therefore limited to *inferring* the interplay between intuition and cognition from experimental manipulations (Greene et al., 2008; Jeurissen et al., 2014; Suter & Hertwig, 2011). They leave open the possibility that the systems interact and reconcile in a number of different ways. It is possible, for example, that longer reaction times when producing utilitarian responses to emotionally engaging moral dilemmas result from a laboured, demanding and time-consuming suppression of intuition by cognition throughout the reasoning process. An alternative possibility, however, is that intuition need only be suppressed once, but that this interaction emerges later in the reasoning process. These possibilities – only two of the many ways in which automatic intuitions and controlled cognition may interact – point to the need to consider the time course of moral decision-making. Although ERPs provide us with a method to examine when intuitive and cognitive areas of the brain are activated, they are unable to provide any insight into the characteristics of this interplay. The method also necessitates that all analyses must be conducted in stages and thus the dynamic nature of decision-making is lost. Examining *when* and *how* controlled cognition and automatic intuition contribute to the *ongoing* decision-making process is critical in uncovering the interplay between these mechanisms.

1.6. The Present Study

The aim of this thesis was to examine the interplay between controlled cognition and automatic intuitions during the resolution of moral dilemmas by examining the time course of moral decision-making. To this end, in two separate experiments participants were required to respond to standardised moral dilemmas that differed according to intentionality (Lotto, Manfrinati & Sarlo, 2014). In order to maximise lives saved, dilemmas involved either committing harm intentionally (instrumental), or as a foreseen but unintended consequence (incidental). Participants were presented with two response alternatives to the question "What would you do?" with one option characteristically utilitarian and the other deontological. In Experiment 1 participants completed this task only. Experiment 2 required participants to respond to moral dilemmas whilst simultaneously completing a cognitive load task. In order to assess the interaction between intuition and cognition, we employed a behavioural paradigm capable of revealing experimental effects as they unfold across time.

1.6.1. Continuous measure of cognitive processing.

In the standard version of the reach-to-touch paradigm (Freeman, Dale & Farmer, 2011; Song & Nakayama, 2009; Spivey, Grosjean, Knoblich & McClelland, 2005) participants are required to categorise a target by reaching to the left or right, while the position of their hand is sampled across time. Effects of interest are observed by comparing the mean reaching trajectories across conditions. Observable properties of the trajectory are thought to reflect underlying cognitive mechanisms (Spivey, 2007). For example, a less direct trajectory is taken to reflect a less efficient cognitive processing strategy (Spivey et al., 2005).

The majority of research employing this paradigm, has been used to investigate the cognitive mechanisms involved in lower order perceptual tasks or the identification and categorisation process (Dale, Kehoe & Spivey, 2007), in which a response is objectively correct or incorrect. More recently the paradigm has been used to investigate the cognitive processes that underlie higher order decision-making, particularly those decisions that involve a preference based response (Dschemuchadse, Scherbaum & Goschke, 2013; Duran, Dale & McNamara, 2010; Kieslich & Hilbig, 2014; Koop & Johnson, 2013). The method, for example, has been used to investigate the emergence and nature of intertemporal decision-making in gambles, in which people naturally prefer smaller immediate rewards, than delayed larger rewards (Dschemuchadse et al., 2013; Koop & Johnson, 2013). In these situations reaching measures offer the opportunity to assess the continuous dynamics of cognitive mechanisms, and how multiple processes compete and converge to drive end state decisions (Freeman et al., 2011). Response dynamics in higher order tasks provide information about moment-to-moment changes in preference; information that may be used to reveal the characteristics of underlying cognitive processes (Koop & Johnson, 2013; McKinstry, Dale & Spivey, 2008).

Current applications of continuous methods to higher order decisions, however, have so far been limited in their ability to examine *when* these changes arise. That is, current methods detect how many times on average participants change their mind during a response, but do not map *when* these changes occur, as is possible for lower order perceptual decisions (Finkbeiner, Coltheart & Coltheart, 2014; Quek & Finkbeiner, 2013). Finkbeiner and colleagues (2014) for example, in a lexical decision task, analysed how the initial segment of a reaching trajectory varied as a function of how long the participant viewed the target before commencing their response. The dependent measure therefore, revealed how much the subject knew about the target at the time of movement initiation,

and enabled the authors to map the onset and growth of the experimental effect in real on-line processing time (Quek & Finkbeiner, 2013). This approach allowed them, for example, to establish that reliable task performance emerged earlier for high frequency targets compared to low frequency targets.

In contrast, Koop (2013) in his investigation of moral decision-making used a mouse-tracking paradigm to test the processing assumptions that arose from the dual process theory. In this version of the paradigm the author used mouse tracking to examine the dynamics of moral decisions during the resolution of personal and impersonal moral dilemmas. Rather than examining when and how response preference emerged, Koop chose to assess how many times on average participants changed their mind. His results failed to reveal any discernable differences between dilemmas, despite replicating the RT effect expected by the dual process theory. That is, for personal dilemmas participants took longer to complete their mouse movement when making utilitarian responses relative to deontological decisions. Given the assumption that emotionally engaging stimuli elicit an immediate, automatic response that must be overcome by time demanding, conscious deliberation, it is critically important to examine the emergence of these processes *across time* in order to assess the nature of their interplay.

With this in mind, in our version of the paradigm we will analyse how the kinematic properties of the initial segment of the reaching movement vary across time. In order for reaching movements to reliably reflect internal cognitive mechanisms, they must be made while stimulus processing is still ongoing (Finkbeiner et al., 2014). This is particularly important if the dynamics of automatically elicited intuition are to be examined. To ensure this, participants will be trained to begin their movement with the occurrence of an auditory cue. This cue will co-occur with the first appearance of two response options. The dependent measure will be initial *x-velocity*, which represents the

velocity of the hand as it moves towards one response location. By using initial *x*-velocity as the dependent measure, we will be able to track the development of moral judgements across an early time period. The ability to examine the on-line reasoning process is of particular importance in these experiments as research so far has been unable to examine the interplay between intuition and cognition directly. We are therefore limited to inferring the characteristics of the interaction process from RT and proportional measures or ERP methods, which, as mentioned above, are able to segment stages of processing but have not yet been able to reveal the dynamic interaction between cognitive and emotional processes. The goal of using a continuous behavioural measure in the present study is to examine the qualitative characteristics of the two processes as reasoning is *ongoing*. The intended outcome of this work is to provide, for the first time that we are aware of, an assessment of the interaction between intuition and cognition during the resolution of moral dilemmas.

1.6.2. Moral dilemmas.

The stimuli used in these experiments were adapted from previous literature (Lotto et al., 2014). A number of ethical principles have been found to differentially affect moral judgement, including inevitability (Moore et al., 2008), proximity (Greene et al., 2009), actions, outcomes (Cushman, 2013; Cushman, Young & Hauser, 2006) and beliefs (Young, Camprodon, Hauser, Pascual-Leone & Saxe, 2010), amongst many others. While other authors have reported that the level of "intuitiveness" inherent in dilemma scenarios may be responsible for differences between utilitarian and deontological judgement (Kahane et al., 2012; see also Paxton, Bruni & Greene, 2014). Our stimuli were selected and adapted to examine the interaction between intuition and cognition specifically; other important dimensions of moral judgement were beyond the scope of this thesis. With this in mind, dilemmas were selected that differed according to one clearly defined principle,

intentionality. Participants were required to respond to dilemmas that differed according to the DDE. On every trial participants had to decide whether to harm one person to save a number. In half the dilemmas harm was caused intentionally for the greater good ("instrumental"), while the other half involved harm being caused as a foreseen but unintended side effect ("incidental"). For example, an instrumental dilemma could describe a scenario in which several people in an elevator shaft may be saved from an out of control elevator by pushing one individual into the lift mechanism. An incidental dilemma, in contrast, may describe a situation in which in order to prevent a poison from spreading to a room with a number of people, a switch could redirect the poison to another location where one person stands (see Table 1). People tend to find instrumental action unacceptable, but incidental permissible (Borg, Hynes, Van Horn, Grafton & Sinnott-Armstrong, 2006; Cushman et al., 2006; Hauser et al., 2007; Moore et al., 2008). These dilemmas map broadly onto trolley (incidental) and footbridge-like (instrumental) dilemmas, without suffering from the vague personal/impersonal distinction (Borg et al., 2006; Lotto et al., 2014; McGuire et al., 2009).

Stimuli were standardised across the instrumental and incidental dilemma categories. There was no significant difference in the length of the dilemmas between categories. All involved life and death consequences, while the number of people saved and killed was balanced across dilemma conditions, as larger ratio sizes (i.e. save 1 versus 1000) are less cognitively taxing (Trémolière & Bonnefon, 2014). As such, the amount of people that could be saved by an action was no greater than eight. No dilemma involved saving one's own family or friends, as this has been found to differentially engage emotion (Chen, Qiu, Li & Zhang, 2009). Involvement of self and other was also manipulated such that the benefit of the action included saving oneself on half the dilemmas. On the remaining dilemmas the action benefitted only others.

Stimuli were presented across two screens. The first frame presented the scenario of the dilemma. The second frame presented two response alternatives side-by side, one characteristically utilitarian the other deontological. Participants were required to choose between two possible courses of action, in an attempt to best capture the competition between mechanisms (Manfrinati, Lotto, Sarlo, Palomba & Rumiati, 2013). The consequences were presented below each action, with the final line of the response option presenting explicitly the numerical cost of each action *"Five people will die"*. The language used to describe the consequences was matched, as far as possible across each choice type to avoid any unwanted framing effects (Petrinovich & O'Neill, 1996). The dilemmas were presented such that participants were not exposed to the response alternatives until the onset of the second screen and the co-occurrence of the auditory cue. This cue was designed to encourage participants to begin reaching within 750ms of the onset of response options. These changes were made to ensure that response trajectories captured the ongoing evaluation process.

Table 1.
Example of Dilemmas and Response Alternatives

Dilemma	Scenario	Utilitarian	Deontological
Incidental (Other)	You are a nurse who is in charge of a machine, which controls drug dosage levels in patients' blood. Because of a technical failure, the machine is supplying a lethal dose of the drug to four patients. Another patient, in a single room, is hooked up to the same machine and has not undergone any variation in dosage. It is possible to redirect supply.	REDIRECT SUPPLY Single patient will receive the dose. This patient will die.	DO NOT REDIRECT SUPPLY Four patients will receive the dose. Four patients will die.
Instrumental (Self)	You are on a trip to Nepal with some other tourists. Your aeroplane has crashed in the Himalayas and only five of you have survived. You have no food and the temperature is below zero. The only possibility of surviving is to go as quickly as possible on foot to a small village on the other side of the mountain. In these conditions if you are too slow you will freeze. One of the survivors is injured and is slowing you down.	SHOOT THE INJURED PERSON Reach the village. Injured person will die.	DO NOT SHOOT THE INJURED PERSON Do not reach the village. You and five others will die.

2. Experiment 1

2.1. Aim and Hypotheses

The aim of Experiment 1 was to assess the interplay between controlled cognition and automatic intuition during the resolution of moral dilemmas by examining the time course of moral decision-making. With this in mind, participants were required to respond to a set of standardised moral dilemmas by reaching out. We sought to examine several hypotheses in this regard.

First we predicted that discrete measures would replicate previous literature. People would be more likely to provide utilitarian responses to incidental than instrumental dilemmas (Borg et al., 2006; Cushman et al., 2006; Hauser et al., 2007; Lotto et al., 2014; Moore et al., 2008; Sarlo et al., 2012). It was also hypothesised that for instrumental dilemmas, utilitarian responses would be slower than deontological decisions (Greene et al., 2004).

Secondly, on the assumption that instrumental dilemmas, as opposed to incidental dilemmas, elicit an automatic and default intuitive response that conflicts with controlled cognition (Mendez et al., 2005; Sarlo et al., 2012; Trémolière et al., 2012; Valdesolo & DeSteno, 2006), we expected reaching trajectories to vary by dilemma type early.

Thirdly, since the research suggests that incidental dilemmas involve little or no activation of the default response (Greene, 2007; Greene et al., 2004; Greene et al., 2001), it was hypothesised that there would be no significant difference in the emergence of deontological or utilitarian response preferences across time. On the assumption that instrumental dilemmas are emotionally evocative and place into conflict intuition and cognition (Greene et al., 2004; Greene et al., 2001; Sarlo et al., 2012), it was also hypothesised that the dynamics of responses would differentiate early in the judgement process. Specifically, given that the literature suggests automatic intuitions elicit an initial

moral aversion to emotionally engaging moral content, and only a later more time-demanding cognitive deliberation can override this response (Greene et al., 2008; Sarlo et al., 2012; Suter & Hertwig, 2011); it was hypothesised that deontological decisions would initially emerge rapidly, while utilitarian preferences at the same time point would be slower.

2.2. Method

2.2.1. Ethics.

Experimental protocols were approved by the Human Research Ethics Committee of Macquarie University and all procedures were in compliance with the National Health and Medical Research Council National Statement (2007) guidelines. Informed written consent was obtained from all participants.

2.2.2. Participants.

Twenty-six undergraduate psychology students (5 male) from Macquarie University participated in the experiment in return for course credit.[1] Participant age ranged from 18 – 41 years (M = 20.81, SD = 4.36). All participants were native English speakers, identified as strongly right handed (Oldfield, 1971) and had normal or corrected to normal vision.

2.2.3. Stimuli.

Moral dilemma stimuli were adapted from previous research (Lotto et al., 2014). The stimuli consisted of 60 experimental moral dilemmas and 20 practice dilemmas. Experimental dilemmas varied according to the DDE (Aquinas, 2006) where 30 of the 60 experimental dilemmas were classified as "incidental dilemmas," and the other 30 were "instrumental dilemmas." Within each of these dilemma categories risk involvement varied. For example, 15 incidental dilemmas involved risk to self, and 15 involved risk to others. This created four categories of dilemma type, Incidental-Other, Incidental-Self, Instrumental-Other, Instrumental-Self. Incidental and instrumental dilemmas were matched for numerical consequences (i.e. how many people would be saved/killed).

[1] Five participants were replaced as they only produced responses of one type and the statistical analysis required no empty cells (i.e. responses in each design cell).

Each dilemma was presented in white Arial font, size 25, against a black background. The presentation of the dilemma material proceeded through a series of two screens. The first screen presented an adapted version of the dilemma scenario. All reference to responses was removed from the first screen. The second screen presented the participant with the two response alternatives for the first time. Response options were formulated to reflect a utilitarian and deontological option. The response alternatives were presented as the action in capital letters, with the consequences written in lower case below, including the explicit inclusion of the numerical consequences of the action (see Appendix A for full list of experimental stimuli). One response option was displaced to the left of the monitor, with the alternative displaced to the right. Response location (reaching left or right for the utilitarian response alternative) was kept constant during each session. This was done so participants could implicitly learn the location of responses and make reaching movements during ongoing evaluation. Response location was, however, counterbalanced across participants.

There was no significant difference between the mean number of words for incidental (M = 74.83) and instrumental dilemmas (M = 74.03, $t(58) = 0.34$, $p = .40$). Utilitarian response options had an average of 11.70 words, while the deontological response option had an average of 15.37 words (see Table 2). The deontological response option was necessarily longer, as it was always presented as the alternative to the utilitarian response with the words *"DO NOT"* preceding the action.

Table 2.
Dilemma and Response Word Length from Experiment 1

Type	Dilemma	Utilitarian	Deontological
Incidental-Other	70.13	12.40	14.93
Incidental-Self	79.53	10.33	14.53
Instrumental-Other	73.40	11.67	15.73
Instrumental-Self	74.67	12.40	16.27

2.2.4. Experimental design.

Every participant completed 20 practice items using a separate set of stimuli, followed by 60 experimental trials. The experimental stimuli followed a 2 x 2 nested factorial design (dilemma type [incidental v instrumental] x involvement [other v self]). The order of experimental trials was randomised for every participant.

2.2.5. Apparatus and procedure.

Participants sat in a darkened room in front of a CRT monitor placed 85cm from the front edge of the desk. Two lateral response panels, each 50cm from the front edge were positioned to the left and right of the monitor (see Figure 1). Participants initiated a trial by moving their right index finger to a "start" position, located at the front edge of the desk aligned with the body midline. The participant's task was to indicate what action they would take between two response alternatives, given the moral scenario presented to them. They indicated their response by reaching out and touching the left or right panel, corresponding to the utilitarian or deontological response option presented on the left or right of the monitor. A Polhemus Liberty (240Hz) electromagnetic motion tracking system with a sensor taped to the tip of the participant's right index finger was used to record reaching movements during the experiment.

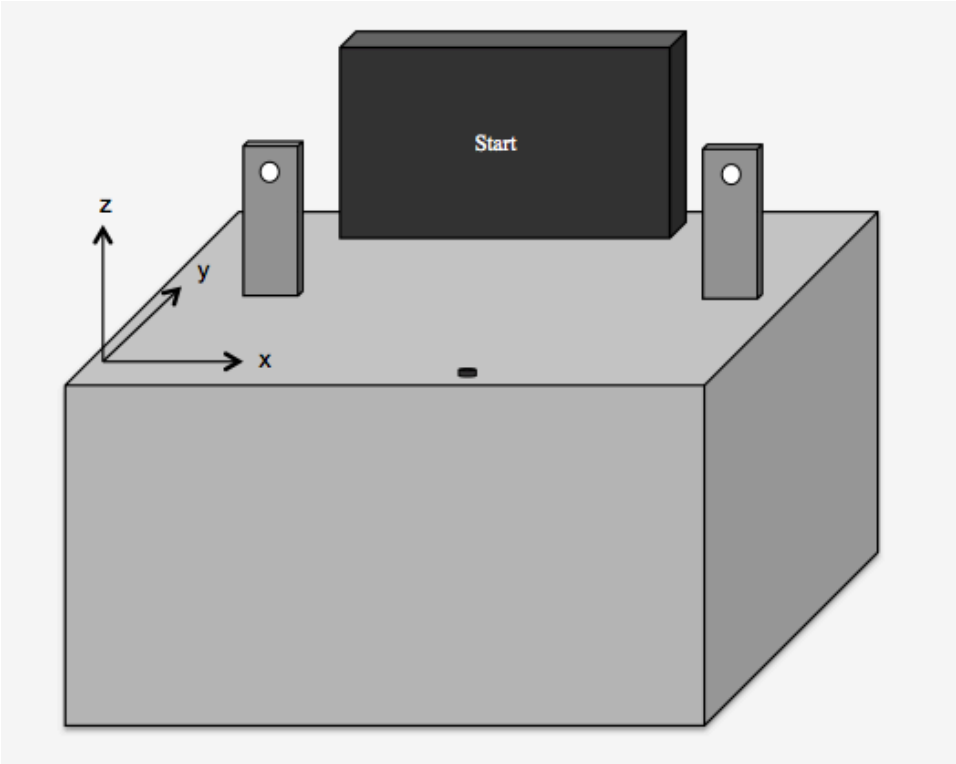

Figure 1. Apparatus. Participants sat at a desk with a CRT monitor and two lateral response markers (white circles). Participants placed their right index finger at the start position (black circle) to initiate the trial. Participants responded by reaching to the right or left and touching one of the response panels.

The trial commenced when participants moved their right index finger to the "start" marker. The first frame displayed the moral scenario (see Figure 2). This frame was also accompanied by an audio recording of the scenario text. The text remained on screen for the duration of the audio recording, which ranged from 16000ms to 29000ms (M = 21400ms). This was done to standardise the amount of time each participant was exposed to the moral scenario and ensure comprehension of the text, without having to accommodate for variations in reading speed. Following the first frame the second frame displayed the two response options. Each displaced to the left or right of the screen. Participants had to make their decision by reaching out to the corresponding response location. Following this, participants were given neutral feedback ("OK").

Participants were instructed at the outset to time the beginning of their movement in response to an auditory go-signal, the third tone in a series of three ascending beeps. The onset of the go-signal coincided with the presentation of response options, and the third tone occurred 750ms after the onset of the screen. Although instructed to time their movement as close as possible to this go-signal, there was no penalty for movement that was initiated before or after the third beep and participants had a maximum of 20000ms to make their decision before the trial timed-out.

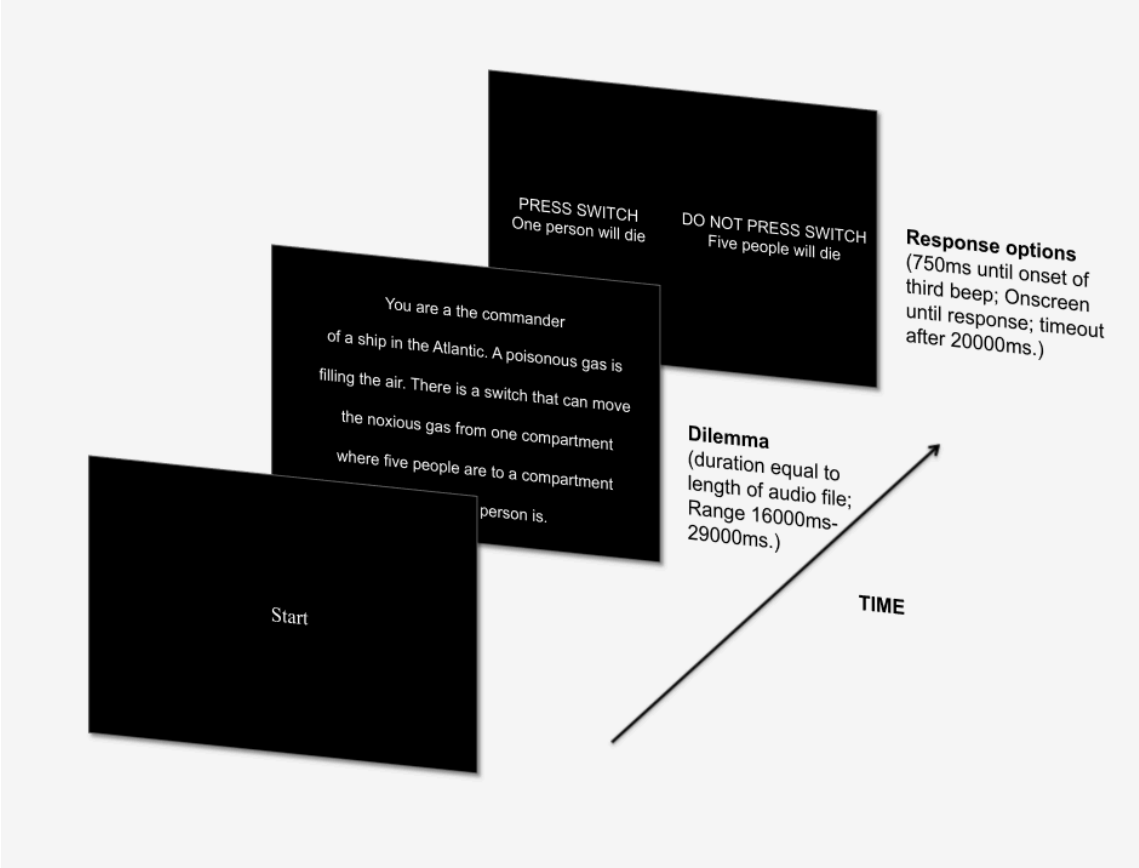

Figure 2. Schematic of Experiment 1 trial structure. The first frame displayed the moral dilemma for the duration of an audio recording of the same text. After this, the second frame displayed the two response alternatives, displaced to the left or right. The second frame co-occurred with an auditory cue. Participants were trained to time their movements with the onset of the third tone in a series of three ascending beeps, occurring 750ms after onset. Options remained on screen until response or timeout (20000ms).

2.2.6. Data analysis

To prepare the reaching trajectories for analysis, the *xyz* coordinates for each sample between the onset of the second screen and a point corresponding to 3000ms after target onset were selected. A signed value termed *x-velocity* was then calculated at each of these samples. X-velocity reflects the finger's velocity along the left-right axis, i.e. the axis along which the participant must select a response. As such, *x*-velocity values represent the finger's velocity *towards a response preference* on a moment-to-moment basis. A positive *x*-velocity value indicates the finger is heading, for example, towards the deontological response option, and a negative *x*-velocity indicates that the finger is heading away from this option (i.e. towards the utilitarian response alternative). To visualise the dynamics of these decisions, the *x*-velocity profiles for effects of interest were graphed across time from target onset.

The dependent measure was limited to the initial portion of the reaching movement, as it is thought this segment may best reveal the participant's initial response (Finkbeiner et al., 2014; Quek & Finkbeiner, 2013). Given that rapid and automatic intuitions are thought to mediate deontological decisions, the initial 3000ms of reasoning is likely to provide the best example of early competition. Faster initial velocity toward one response option compared to another can be interpreted as a measure of more efficient processing in that condition. That is, faster initial velocities toward the deontological alternative reflect an initial preference toward this option. Such a pattern would be similar to a RT effect, where participants are quicker to make deontological decisions to personal dilemmas (Greene et al., 2008); participants move in the direction of deontological alternatives with a greater initial velocity.

2.3. Results

Analysis of reaching trajectories necessitated that the data contain no empty cells. This led to the replacement of five participants who answered exclusively with one response option for any one experimental condition. The data of 26 participants were included in the main analysis.

2.3.1. Discrete measures.

Response choice data. The analysis began by examining response choice. An ANOVA revealed a significant effect of dilemma type only ($F(1, 25) = 62.64$, $p < .001$). Participants were more likely to provide a deontological response to instrumental dilemmas ($M = 56\%$) than incidental dilemmas ($M = 32\%$). Analyses revealed no significant effect of involvement ($F(1, 25) = 0.07$, $p = .80$) and no significant interaction between dilemma type and involvement ($F(1, 25) = 1.65$, $p = .21$). Selection of utilitarian and deontological responses did not vary whether the dilemma involved saving oneself or others. As Figure 3 demonstrates this was true of both incidental and instrumental dilemmas.

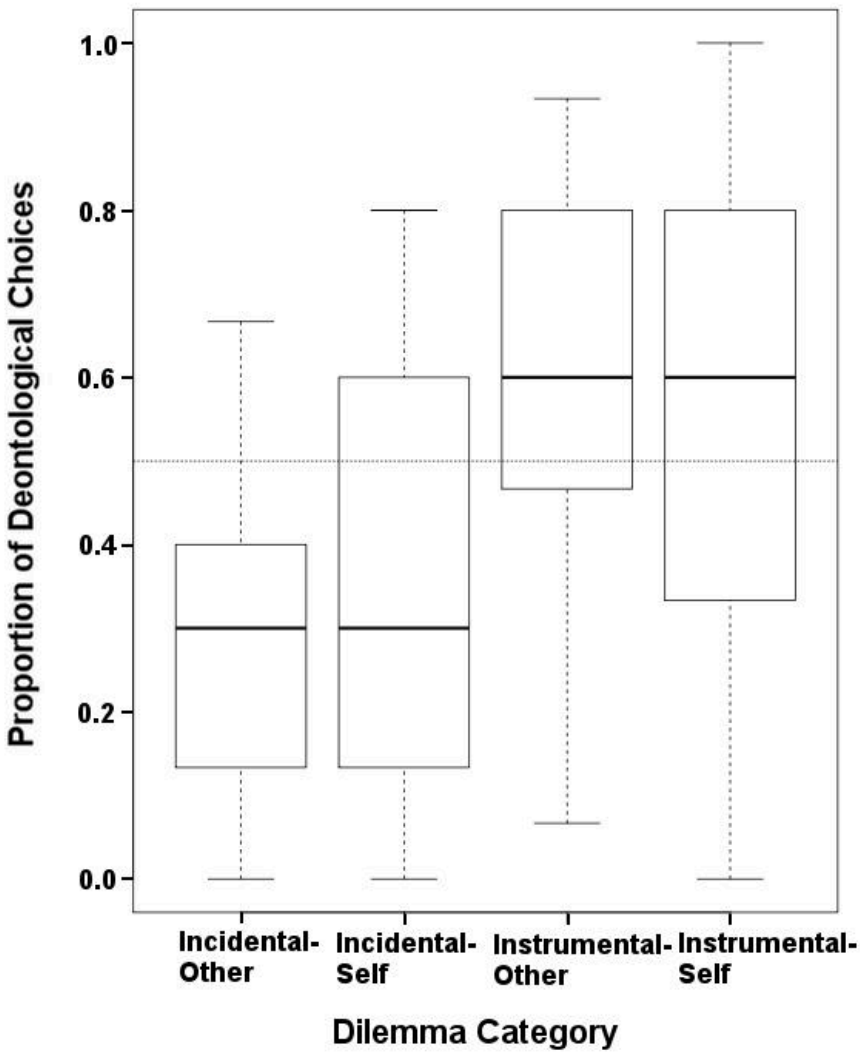

Figure 3. Proportion of deontological choices by dilemma category from Experiment 1. Error bars represent 95% confidence intervals. Participants were more likely to make deontological choices to instrumental dilemmas than incidental dilemmas. This did not vary by involvement.

Reaction time data. There was no significant difference in the time taken to respond to incidental (M = 2645.21ms) or instrumental dilemmas (M = 2608.38ms; $F(1,25) = 2.43$, $p = .13$). Neither was there any significant difference between the time taken to produce utilitarian (M = 2856.04ms) or deontological responses (M = 2624.08ms; $F(1,25) = 1.73$, $p = .20$). As can be seen in Figure 4, the interaction between dilemma type and response was not significant ($F(1, 25) = 0.27$, $p = .61$).

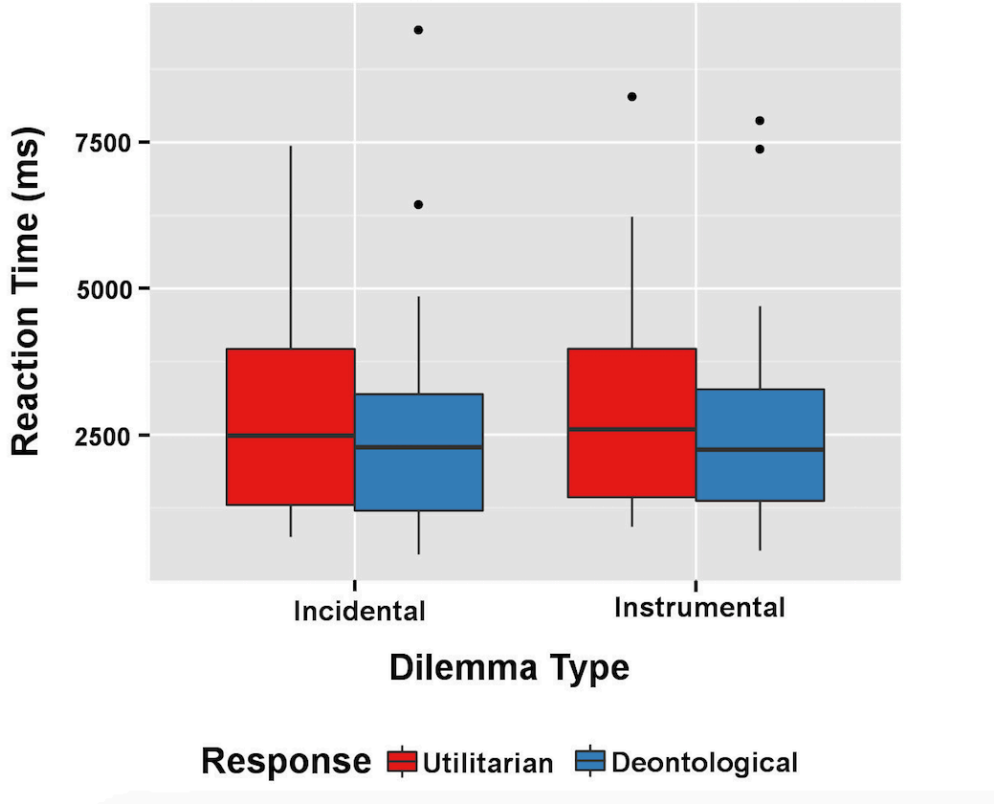

Figure 4. Reaction time by dilemma type and response from Experiment 1. Error bars represent 95% confidence intervals. Points represent outlier values. There was no significant difference in the time taken to make utilitarian or deontological choices. This did not vary across incidental or instrumental dilemmas.

2.3.2. Reaching trajectory analysis.

LiftOff latency. In order for reaching trajectories to reliably reflect the underlying judgement process they must be made whilst reasoning is ongoing. To confirm that the results captured the on-line judgement process we examined the time between target onset and the commencement of the reaching movement, termed LiftOff latency. If a substantial portion of the reasoning process fell outside the reaching trajectory, experimental effects should be evident in LiftOff latency. An ANOVA confirmed that there was no significant difference in LiftOff latency for incidental (M = 2060.09ms) compared to instrumental dilemmas (M = 2079.35ms; $F(1, 25) = 3.98$, $p = .06$). Similarly there was no significant difference between LiftOff latency for utilitarian (M = 2189.58ms) or deontological choices (M = 2148.71ms; $F(1, 25) = 0.21$, $p = .65$) and no significant interaction between dilemma and response choice ($F(1, 25) = 0.08$, $p = .78$). As can be seen in Figure 5 there were no experimental effects exhibited in the pre-movement window. It is therefore reasonable to assume that the participants' reaching movements were made while decision-making processes were still unfolding.

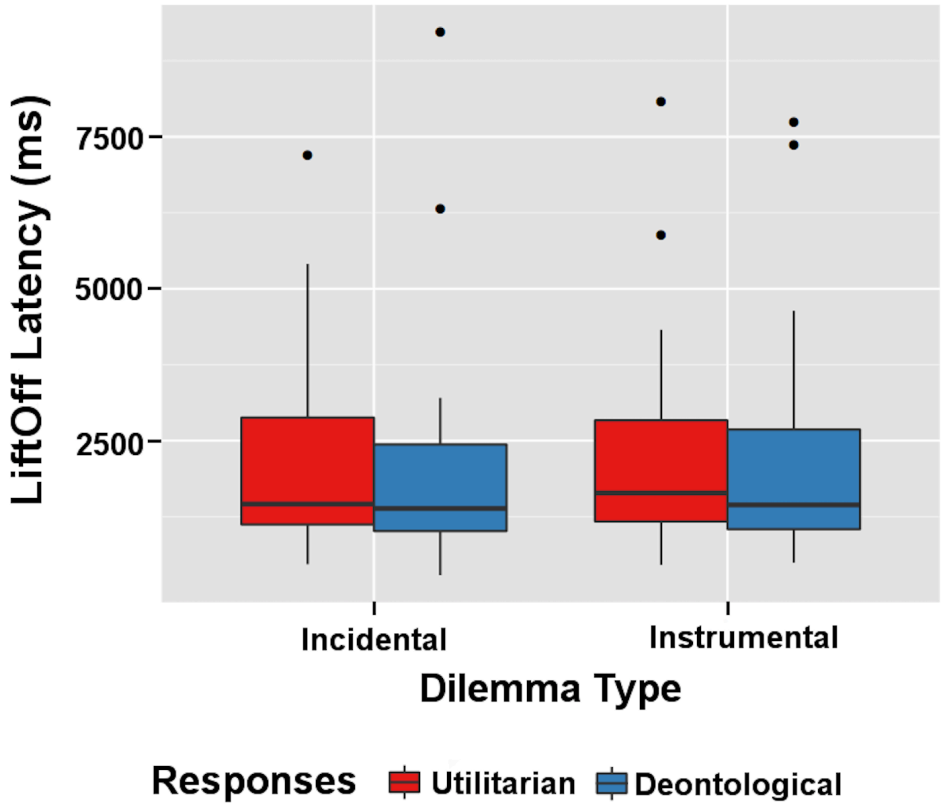

Figure 5. LiftOff latency by dilemma type and response from Experiment 1. Error bars represent 95% confidence intervals. Points represent outlier values. There was no significant difference in LiftOff latency for the production of either response to incidental or instrumental dilemmas.

Response trajectories. To examine *x*-velocity, linear mixed effects modelling (LMM) was implemented using the software package lmer4 (Bates, Maechler & Bolker, 2012). Reliability of each effect of interest was evaluated using an incremental model of comparison approach in which goodness-of-fit statistics (AIC, BIC and Log Likelihood values; Akaike, 1974; Schwarz, 1978) were used to determine which of the models best fit the data. This was done through comparison between a model that included the effect of interest and a model that excluded the effect of interest. Only terms that significantly improved the fit of the model were included. As is practice in reporting LMM results (Kliegl, Masson & Richter, 2010; Kliegl, Wei, Dambacher, Yan & Zhou, 2011) a coefficient magnitude of at least twice its standard error (i.e. $|t| > 2$) was the criterion of significance.

The model comparison procedure verified that the inclusion of dilemma type, $\chi^2(1) = 12.45$, $p < .001$, involvement, $\chi^2(1) = 198.37$, $p < .001$, response, $\chi^2(1) = 1027.32$, $p < .001$, and the interaction between dilemma type and response, $\chi^2(1) = 38.53$, $p < .001$, all significantly improved the fit of the model. Thus all four terms were included in the final model of initial *x*-velocity. The analyses included only interactions pertinent to the hypothesis, as such no interactions including involvement were analysed.

As Figure 6 demonstrates, there was a main effect of dilemma type ($b = -0.47$, $SE = 0.05$, $t = -8.61$), whereby *x*-velocity profiles differed significantly across time for incidental and instrumental dilemmas. In the early stages of reasoning the finger moved faster for incidental than instrumental dilemmas.

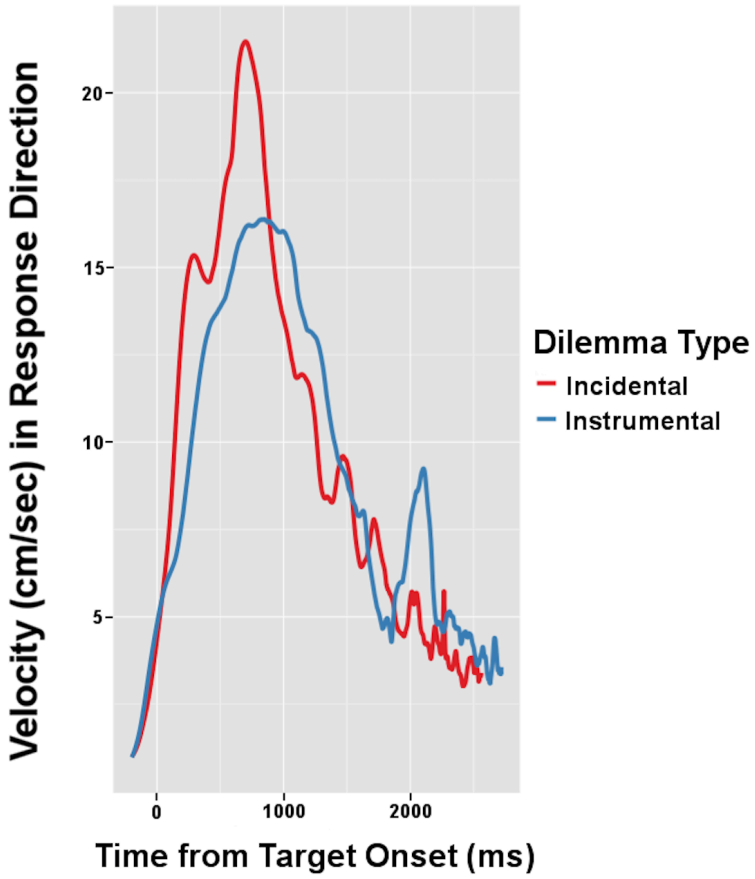

Figure 6. Dilemma type across time from Experiment 1. Velocity profiles for incidental and instrumental dilemmas varied across the initial 3 seconds of responding. People were faster when responding to incidental compared to instrumental dilemmas.

There was also a main effect of involvement ($b = 0.58$, $SE = 0.04$, $t = 15.01$). As Figure 7 demonstrates, *x*-velocity profiles for dilemmas that involved saving others and saving self varied across the initial portion of the reaching movement. Specifically, in the initial stages the finger moved faster for self-involvement compared to other-involvement.

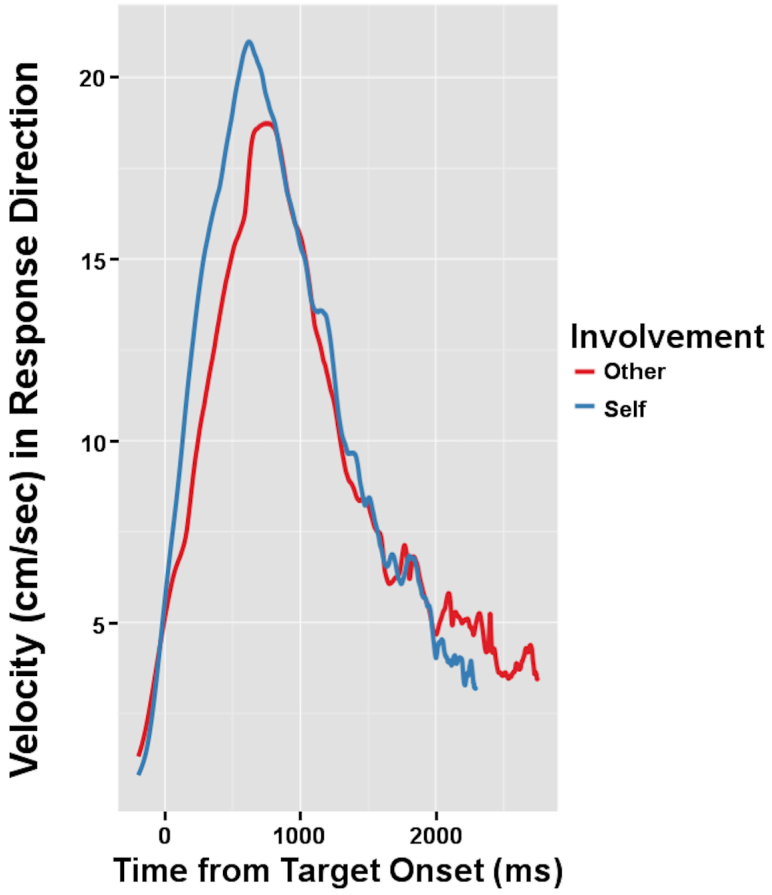

Figure 7. Involvement across time from Experiment 1. Results revealed that velocity profiles for other and self-involved dilemmas varied across time. People were faster to respond to dilemmas that involved self, compared to others.

There was also a main effect of response (b = 1.01, SE = 0.05, t = 18.79). Initial x-velocity profiles varied differently across time for utilitarian and deontological responses (see Figure 8). People moved earlier and faster for deontological decisions.

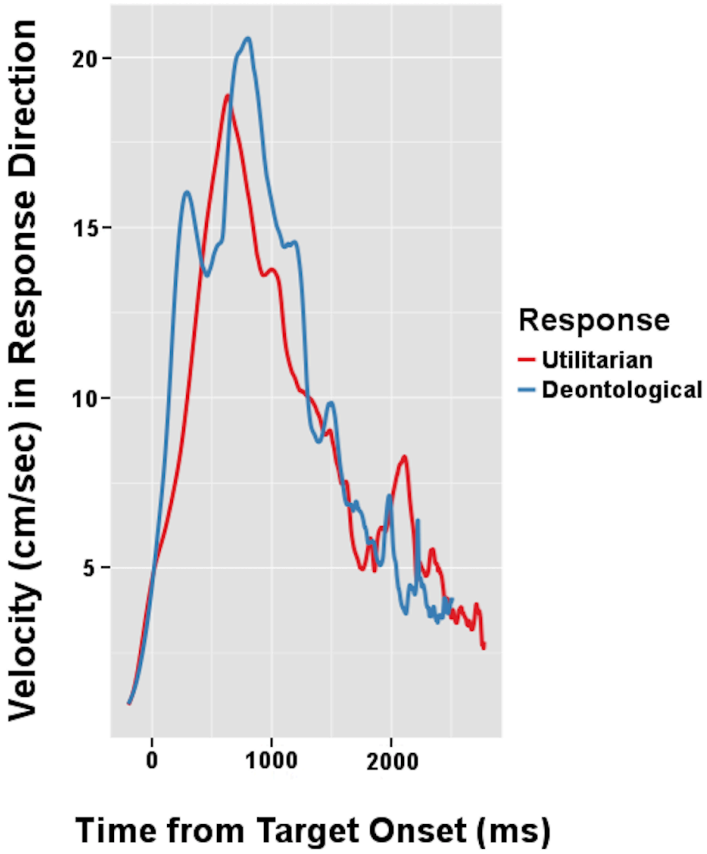

Figure 8. Response across time from Experiment 1. Velocity profiles revealed a main effect of response across the initial 3 seconds of responding. People moved faster and earlier for deontological preferences compared to utilitarian decisions.

Analysis revealed a significant interaction between dilemma type and response (b = 0.48, SE = 0.08, t = 6.21). Figure 9 demonstrates that utilitarian and deontological x-velocities varied by dilemma type across time. That is, incidental dilemmas elicited x-velocity profiles that appeared similar for both utilitarian and deontological responses across the initial segment of the reasoning process. Responses to instrumental dilemmas, in

contrast, appeared to vary across time. *X*-velocity profiles show that initially the finger is moving faster in the deontological response direction. In contrast, at the same time point the finger is moving slower towards the utilitarian response preference.

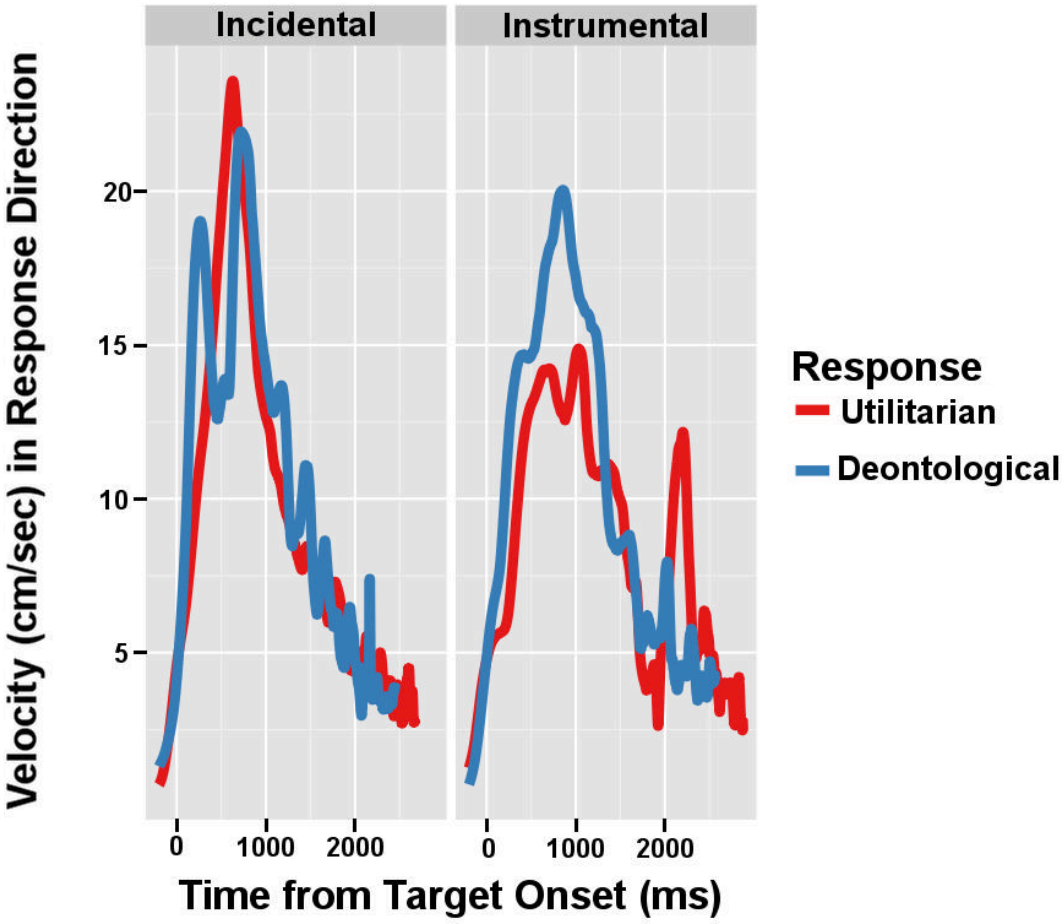

Figure 9. Interaction between dilemma type and response across time from Experiment 1. Velocity profiles for utilitarian and deontological decisions to incidental dilemmas appear similar across time. In contrast, velocity profiles for responses to instrumental dilemmas appear to vary across time. Specifically, deontological decisions were faster and more rapid than utilitarian decisions at the same initial time point.

Max velocity. A large early *x*-velocity for deontological decisions to instrumental dilemmas suggests that people have an initial rapid preference towards this alternative. Lower *x*-velocity at the same time point for utilitarian decisions, suggests that the production of these responses is relatively slower. This pattern of velocity profiles at first glance suggests that initially deontological decisions are more certain, rapid and automatic, while utilitarian decisions are slow, time consuming and laboured. It is possible however that the continuous data, rather than reflecting laboured utilitarian processing, reflects an initial variability in the production of these decisions. That is, the same *x*-velocity profile may result from trials in which the production of utilitarian decisions vary. On some trials participants provide a rapid utilitarian response from an initial stage, whilst on other occasions these decisions emerge later. The aggregate of these varied responses would result in an average *x*-velocity profile that would be indistinguishable from one that reflects a systematically slower mode of reasoning. Both, however, would carry different implications about the nature of the interaction between intuition and cognition. As such we followed the analysis of continuous data by examining how the maximum *x*-velocity for utilitarian and deontological responses varied by dilemma type. It follows that if the *x*-velocity profile for utilitarian decisions reflects a systematically slower process, then the distribution of maximum *x*-velocities in that condition should be significantly lower than the distribution of maximum *x*-velocities for deontological decisions. To investigate this possibility, we calculated the mean maximum *x*-velocity for each participant and response choice.

An ANOVA confirmed that there was no significant difference in the participant means of maximum velocity between incidental and instrumental dilemmas ($F(1, 25) = 0.79$, $p = .38$). There was also no significant difference in the maximum velocity between deontological and utilitarian responses ($F(1,25) = 0.13$, $p = .72$). As Figure 10

demonstrates there was no significant difference in the average maximum *x*-velocity for response selection across dilemma type ($F(1,25) = 0.50$, $p = .49$).

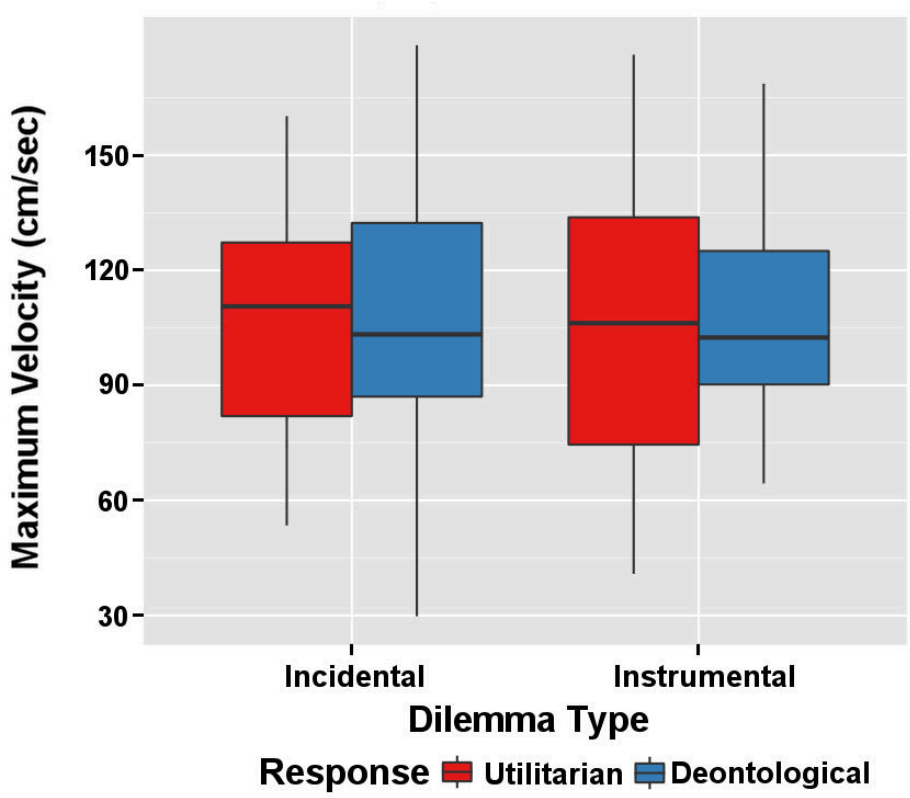

Figure 10. Mean maximum *x*-velocity by dilemma type and response from Experiment 1. Error bars represent 95% confidence intervals. There was no significant difference in the average maximum *x*-velocity for utilitarian or deontological responses between dilemma types. This finding suggests that the velocity profiles for utilitarian responses were not systematically slower at every time point, but, rather, more varied. The increased variability in the maximum velocity time points resulted in an aggregate profile that appeared relatively slow.

2.4. Discussion

The aim of Experiment 1 was to assess the nature of the interplay between controlled cognition and automatic intuitions during the resolution of moral dilemmas by examining the time course of moral decision-making. Previous studies have suggested that moral decisions result from the interplay of two processes. One process is automatic, rapid and favours deontological response options, whilst a second system is slow, time consuming and deliberative, favouring utilitarian outcomes. However, there is little evidence that speaks directly to the nature of how these two processes interact. Instead the majority of these studies infer the behaviour of each mechanism from discrete measures (Greene et al., 2008; Suter & Hertwig, 2011). As a result, current research leaves open the possibility that intuition and cognition may interact in a number of possible ways. Examining the dynamics of how these decisions emerge across time provides, for the first time, an on-line examination of the interaction process between intuition and cognition. In an extension of previous studies we are able to demonstrate that the process underlying controlled cognition, rather than being on average slower and more laboured, is variable. Below I detail how our results suggest that cognitive resources mediate the interaction between intuition and cognition and how our findings speak to the 3 main hypotheses discussed in the Introduction.

Firstly, as expected, analysis of choice data revealed that people were more likely to provide utilitarian answers to incidental than instrumental dilemmas. This pattern of results is consistent with previous literature. People are more likely to approve of harm as an unintended side effect (incidental), than intentionally inflicted (instrumental) (Borg et al., 2006; Cushman et al., 2006; Hauser et al., 2007; Lotto et al., 2014; Moore et al., 2008; Sarlo et al., 2012). Unlike previous research however, RTs revealed no significant effects. There was no significant difference in the amount of time people took to complete

incidental or instrumental dilemmas. This did not vary whether participants were producing a utilitarian or deontological decision. Although inconsistent with previous research (Greene et al., 2004), the results are not surprising given the nature of the reaching paradigm. It is typical for the velocity of corrected movements to be higher than the velocity of uncorrected movements. That is, on movements in which the participant begins to reach to the left, for example, and then changes direction to finish his/her movement on the right, the second "corrected" movement to the right is typically very fast. Thus, while the total distance travelled may be greater for corrected movements, RTs (total travel time) do not tend to systematically differ between corrected and uncorrected movements. It is likely, therefore, that RTs in reaching paradigms, may fail to capture experimental effects in the same way that RTs do in button-press paradigms. Velocity profiles of the initial segment of the reaching trajectory are better able to detect when and how subtle changes in preference emerge.

Secondly, the analysis of reaching trajectories revealed, as predicted, that responses varied by dilemma type early on in the judgement process. In the initial three seconds of reasoning, people were faster when answering incidental than instrumental dilemmas. Greater velocities for incidental dilemmas suggests that, in contrast to instrumental dilemmas, people were more certain when confronted with these scenarios. An early effect of dilemma type supports the suggestion that instrumental and incidental dilemmas differentially engage intuition and cognition (Greene et al., 2004; Greene et al., 2001; Sarlo et al., 2012). Incidental dilemmas elicit no initial moral aversion that conflicts with cognitive mechanisms (Greene, 2007; Greene et al., 2004; Greene et al., 2001); hence these scenarios are responded to rapidly.

Thirdly, in an extension of previous studies analysis of utilitarian and deontological responses across time revealed that these preferences emerged differently for incidental

and instrumental dilemmas. As predicted, results revealed that there was no significant early difference in the production of utilitarian or deontological responses to incidental dilemmas. At the same stage for instrumental dilemmas, people were faster to elicit a deontological preference than a utilitarian one. A finding that suggests an early, rapid and automatic mechanism mediates deontological responses, whilst a slower process favours utilitarian decisions.

This finding left open the possibility that utilitarian responses could be achieved by two different underlying mechanisms. That is, the continuous results could reflect either 1) a slow and time-consuming mechanism supporting utilitarian decisions, or 2) variability in the process that supports these preferences. Both characteristics would result in equivalent velocity profiles, but carry different implications about the interaction between intuition and cognition. As such, we followed this analysis with an investigation of participants' mean maximum velocities. It follows that if the *x*-velocity profile for utilitarian decisions reflects a slower and more laboured process, average maximum *x*-velocity in that condition should be significantly lower than that of deontological responses, as utilitarian decisions do not reach the same maximum speed on average as deontological decisions. If however the lower mean velocity profile in one condition is due to a greater amount of trial-by-trial variability in *when* these preferences emerge, then the mean maximum velocity profiles for both types of responses should be equivalent.

Importantly, our analysis of maximum velocities found no significant differences across utilitarian or deontological decisions to instrumental dilemmas. Utilitarian decisions consistently reached the same maximum velocity as deontological ones, but when in the reasoning process this emerged varied. Sometimes utilitarian responses were rapid from an early point, other times these preferences did not emerge until later. Deontological

responses, in contrast, were consistently elicited rapidly during the early stage of reasoning.

Taken together our analyses provide, not only, temporal support for the dual process theory, but also a qualitative assessment of the interaction between intuition and cognition. Critically our results found that rather than controlled cognition being generally slower and more laboured than intuition, utilitarian responses are produced by a variable mechanism. This finding is consistent with the notion that utilitarian decisions result from a strategic, conscious and deliberate override of intuition that depends upon the availability of cognitive resources. Interpretations of these findings are explored below.

2.4.1. Interpretation of findings.

Dilemmas differentially engage intuition and cognition early.

Experiment 1 found that dilemmas differentially engaged intuition and cognition from an *early* stage in the reasoning process. People responded more rapidly to incidental than instrumental dilemmas initially. This finding supports the assumption that instrumental scenarios selectively create a conflict between intuition and cognition (Mendez et al., 2005; Sarlo et al., 2012; Trémolière et al., 2012; Valdesolo & DeSteno, 2006). Incidental dilemmas are not as affectively engaging as instrumental dilemmas (Lotto et al., 2014); it is likely, therefore, that these initial responses are rapid because there is no default emotional response elicited. In contrast, instrumental dilemmas are slower at the same time point because their affective content triggers an automatic aversion that creates competition.

This finding is consistent with previous literature that has found judgement on instrumental or footbridge-like dilemmas to be dissociable to the effects of incidental or trolley-like scenarios (Jeurissen et al., 2014; Mendez et al., 2005; Sarlo et al., 2012). TMS

studies have found dissociation between personal and impersonal moral dilemmas (Jeurissen et al., 2014). Disruption of the DLPFC leads to a decrease in utilitarian judgement for personal dilemmas only, while stimulation of the TPJ increases deontological decisions for impersonal dilemmas. Studies involving clinical populations have similarly found that damage to the emotion processing areas of the brain selectively impacts judgement on personal dilemmas only. Mendez and colleagues (2005), for example, reported that patients with fronto-temporal dementia responded predictably on trolley problems, but disproportionately utilitarian on footbridge type dilemmas. Taken together, these results suggest that instrumental or footbridge problems, selectively elicit affect-laden intuitions that interact with cognition to drive end-state decisions. No such competition is created by the content of incidental or trolley scenarios. In an extension of this research we have established that this dissociation occurs within the *early* stages of reasoning.

To further investigate this we followed our analysis by examining the early dynamics of utilitarian versus deontological preferences across dilemmas. Our results revealed no significant differences in the production of utilitarian or deontological responses for incidental dilemmas. Both responses were rapid at this early stage. In contrast, results revealed that utilitarian and deontological preferences exhibited distinct dynamics during the early stage of reasoning about instrumental dilemmas. Deontological decisions were faster than utilitarian responses. A rapidly elicited preference for deontological responses supports the idea that an automatic, default process mediates the emergence of this response (Bartels, 2008; Ciarmelli et al., 2007; Greene et al., 2008; Starcke et al., 2012; Suter & Hertwig, 2011). Comparatively slower utilitarian responses at the same time point, suggests that these decisions are mediated by a time-consuming,

laboured and cognitively taxing deliberative system (Conway & Gawronski, 2013; Greene et al., 2008; Paxton et al., 2011; Trémolière et al., 2012).

These findings are inconsistent with the null result reported by Koop (2013). It is likely that differences emerge because of the sensitivity of our temporal measure. Koop's analysis revealed no average changes in preference across the entire response trajectory. Our analysis revealed an initial early difference in velocity that may be lost in an examination, which averages across the entire response trajectory. Our results provide for the first time direct temporal support for the dual process theory (Greene et al., 2008; Greene et al., 2004; Greene et al., 2001; Sarlo et al., 2012; Suter & Hertwig, 2011). That is, early reasoning to high conflict dilemmas is driven by an automatic and rapid response that favours deontological decisions, while cognitive processes are comparatively slower.

Utilitarian responding is variable.

While the continuous data suggests that high conflict dilemmas are initially driven by a default aversion to consequentialist action, our analysis left open the possibility that intuition and cognition could interact in a number of different ways. To investigate this interplay, we examined continuous effects by comparing maximum velocity data. Results revealed the mechanism mediating utilitarian preferences to be, not generally slower than deontological decisions, but more variable trial-by-trial. This finding carries important and novel implications about the characterisation of the interaction between intuition and cognition.

It is assumed that the automatic reaction to emotionally engaging moral content is an affect laden-intuition favouring disapproval. The stronger the affective engagement the more cognitive control is necessary to overcome intuition and engage in deliberate reasoning (Conway & Gawronski, 2013; Greene et al., 2008; Greene et al., 2004; Greene et

al., 2001; Starcke et al., 2012). This reasoning is presumed to be conscious, effortful and slow (Greene et al., 2004; Greene et al., 2001; Suter & Hertwig, 2011). Although assumed, no direct evidence to date, has examined this interaction process. At first glance, our findings suggest that utilitarian decisions result from a laboured competition between intuition and cognition throughout the decision-making process. Hence, resulting in comparatively slower production of these decisions across an early stage. The continuous analysis does not, however, rule out alternate possibilities.

An examination of mean maximum velocity reveals utilitarian responses to be produced, on average, just as rapidly as deontological decisions, but more variable. That is, on some trials rapid utilitarian decisions can be elicited from an early stage, whilst on others, these decisions are not produced until later in the decision-making process. Deontological decisions, in contrast, consistently emerge during the early stage of reasoning. This interaction suggests that, rather than a continual competition between intuition and cognition throughout decision-making, default intuition need only be suppressed once. Greater variability for utilitarian decisions indicates that this process is deliberate, strategic and likely cognitive resource dependent. It is possible that when people have sufficient executive resources, the deliberate mechanism is able to rapidly suppress intuitive responses and an early preference for utilitarian decisions can emerge. In contrast, if resources are taxed, the deliberate mechanism may take longer to suppress intuition and therefore utilitarian decisions emerge later in time. A finding that critically suggests executive resources mediate the relationship between intuition and cognition.

Experiment 1 therefore extends the literature in two ways. Firstly, we establish that responses vary by dilemma type *early* in the decision-making process. That is, instrumental dilemmas selectively elicit conflict between intuition and cognition at an early stage in processing. Deontological decisions are elicited rapidly and by default, whilst

utilitarian responses are slower. Secondly, and most importantly, we have established that the process mediating utilitarian decisions is highly variable.

3. Experiment 2

3.1. Introduction and Background

Experiment 1 used a reaching paradigm to examine the dynamics of intuition and cognition during the resolution of moral dilemmas that differed according to intentionality. In support of the dual process theory, the results of Experiment 1 suggest that during an early stage of reasoning there is a conflict between intuition and cognition for instrumental dilemmas only. People move faster at an early stage towards deontological response alternatives, than utilitarian options. Critically, in an extension of previous studies, we establish that utilitarian responses to instrumental dilemmas are highly variable. These decisions were not on average slower than deontological responses, but more varied. That is, on some trials utilitarian preferences could be rapidly elicited in the early stages of reasoning, whilst on others, these preferences emerged later in time. In contrast, a rapid preference for deontological decisions consistently emerged at the same stage of reasoning across all trials. This greater variability suggests that the process favouring consequentialist outcomes is strategic, deliberate and dependent on cognitive resources. Rather than controlled cognition involving a continued, laboured and taxing suppression of intuition, it is more likely that cognition need only suppress intuition once, but that this process is highly dependent on the availability of cognitive resources. Experiment 2 seeks to extend this finding by examining the role of cognitive resources, and specifically working memory, in the interaction between intuition and cognition.

3.1.1. Cognitive resources mediate the interaction between intuition and cognition.

A number of studies have consistently found cognitive resources to be selectively involved in the production of utilitarian decisions (Conway & Gawronski, 2013; Greene et

al., 2008; Trémolière & Bonnefon, 2014; Trémolière et al., 2012). Taxing executive resources reduces the amount of utilitarian decisions made (Conway & Gawronski, 2013) and increases the amount of time taken to produce these responses (Greene et al., 2008). This selective interference has led authors to suggest that utilitarian judgements are the result of a time consuming and deliberative process. When executive resources are limited, participants are unable to engage in the conscious deliberation necessary to overcome the default emotional response (Greene et al., 2004; Greene et al., 2001).

These studies, however, have been unable to clarify the nature of the interaction between intuition and cognition; as such it is assumed that, rather than being variable, controlled cognition is in general more slow, deliberate and demanding than intuition. When these mechanisms are selectively taxed by secondary tasks, deontological decisions are favoured and utilitarian responses take longer to complete (Greene et al., 2008). The results of Experiment 1 have revealed, however, that rather than controlled cognition being a generally slower and more taxing process, it is strategic, deliberate and hence variable. On some trials utilitarian responses can be elicited from a very initial stage and compete with intuition almost automatically. On other occasions a utilitarian preference does not emerge until later, having taken longer to suppress the default intuitive response. It is likely that the variability in utilitarian responses results from the availability of cognitive resources on a trial-by-trial basis. Given that studies have consistently demonstrated the importance of cognitive resources to the production of utilitarian decisions (Conway & Gawronski, 2013; Greene et al., 2008; Starcke et al., 2012; Trémolière & Bonnefon, 2014; Youssef et al., 2012) it is reasonable to assume that the interaction between intuition and cognition is mediated by the availability of these resources. That is, when executive resources are limited intuition takes longer to suppress and utilitarian preferences emerge later in the reasoning process. In order to understand the relationship between intuition and

cognition, it is therefore important to isolate precisely what "cognitive resources" are utilised in the production of moral judgement.

3.1.2. Cognitive load manipulations and cognitive resources.

In order to establish a dissociation between an intuitive process and controlled cognition a number of studies have manipulated cognitive resources through the introduction of load tasks. It is consistently reported that these tasks selectively impact the production of responses that rely upon "executive resources" (Conway & Gawronski, 2013; De Neys, 2006a, 2006b; Greene et al., 2008; Trémolière et al., 2012). There is however, a large amount of variability in the nature of these manipulations. Greene and colleagues (2008) asked participants to simultaneously detect the number 5 in a scrolling stream of digits during the reading and deliberation of a number of moral dilemmas. This arguably involves a division in perceptual load and spatial attention, but it is less clear if this manipulation leads to a greater demand on executive resources. In contrast, Conway and Gawronski (2013) asked their participants to remember a complex symbol string (e.g. *n63#m1Q*) and report it after reading and responding to dilemmas. This task engages attention and working memory, whilst given the inclusion of non-alphabetic symbols likely requires visual memory for accurate reproduction. Other studies investigating the dynamics of analytic and intuitive processes during logical reasoning have utilised cognitive load manipulations that selectively engage visuo-spatial memory (Miyake, Friedman, Rettinger, Shah & Hegarty, 2001). That is, participants were required to remember the location of dots in a grid matrix and then reproduce these upon completion of reasoning (De Neys, 2006a, 2006b). The same matrix has been used to investigate the effect of kill/save ratios in moral dilemmas (Trémolière & Bonnefon, 2014).

Other studies have employed novel manipulations in order to engage cognitive resources. Trémolière and colleagues (2012), for example, reminded participants of their own mortality before asking them moral dilemmas. Reminding people of their own death is said to engage cognitive resources as people actively suppress morbid thoughts (Greenberg et al., 1990). It is difficult however, to isolate precisely what cognitive mechanism this task disturbs. Studies that have introduced stress manipulations simultaneously limit attention and memory capabilities whilst also increasing emotional reactivity (Jackson et al., 2006; Starcke et al., 2012; Starcke et al., 2011; Youssef et al., 2012). Stress therefore impacts a wide variety of cognitive mechanisms making it difficult to assess the executive capacities that uniquely contribute to moral decision-making.

Stimulation and neuroimaging studies similarly do not specify the precise mechanisms of cognitive control that are involved in moral judgement. TMS studies selectively disrupt brain regions that are known to be associated with cognitive control and abstract reasoning (Jeurissen et al., 2014; Tassy et al., 2011). It is not clear however what specific functions are disturbed. Neuroimaging research that has found utilitarian responding to be uniquely associated with activity in these "cognitive areas" (Greene et al., 2004) has been unable to specify the precise nature of these mechanisms. Recent evidence investigating the role of the DLPFC, for example, highlights how these areas contribute to the production of moral judgement in multiple ways (Kuehne, Heimrath, Heinze & Zaehle, 2015). Given that Experiment 1 suggests executive capacities mediate the relationship between intuition and cognition during the resolution of emotionally engaging dilemmas, it is increasingly important to determine what elements of "cognition" impact moral judgement and when.

3.1.3. Working memory and cognition.

Working memory is considered to be a core component of cognitive capacity. It is generally known to be predictive of the ability to reason abstractly (Kane, Bleckley, Conway & Engle, 2001) and override prepotent responses (Kane & Engle, 2003; Kane, Hambrick & Conway, 2005; Oberauer, Schulze, Wilhelm & Süß, 2005). Studies investigating thinking and reasoning have consistently implicated its role in the production of controlled, deliberate and conscious reasoning (Stanovich & West, 1998, 2000). In a similar way to moral judgement, research investigating logical thinking, generally posits that reasoning results from the interplay of automatic heuristics and deliberative cognition (De Neys, 2006a, 2006b; Evans & Curtis-Holmes, 2005; Evans & Stanovich, 2013). Working memory capacity is found to positively correlate with ability to avoid committing heuristic errors and reason according to normative standards (Klaczynski, 2001; Newstead, Handley, Harley, Wright & Farrelly, 2004; Torrens, Thompson & Cramer, 1999; Valentine, 1975).

It follows that as working memory is integrally involved in these cognitive tasks, it should selectively impact the deliberative mechanism, which favours utilitarian decisions. Yet studies investigating the contribution of working memory to moral judgement are rare and the results varied (Hauser et al., 2007; Moore et al., 2008). One study revealed that individual differences in working memory capacity were predictive of certain elements of moral judgement (Moore et al., 2008). Working memory was found not to interact with the personal/impersonal distinction, but was predictive of hastening personal killing when harm was inevitable. These findings hint at a complex relationship between working memory and moral judgement, but do not speak definitively to the role working memory may play in the suppression of intuition and the production of end-state judgement.

3.1.4. Rationale of Experiment 2.

The dual process theory of moral decision-making suggests that an automatic intuitive reaction must be overcome by controlled cognition in order to produce utilitarian decisions. The results of the first experiment support this characterisation of the process and suggest that our ability to suppress intuition is dependent upon the amount of cognitive resources available trial to trial. Current research investigating "cognitive resources" during the resolution of moral dilemmas vary in the type of executive capacities they tax. It is therefore unclear which executive resources are specifically involved in the interaction between intuition and cognition.

Experiment 2 extends the examination of the interplay explored in Experiment 1 by combining a continuous behavioural measure with a cognitive load manipulation that specifically taxes working memory. In Experiment 2 cognitive load is manipulated by the introduction of a serial recall task. The low load condition will require participants to remember the colour of one square presented at the beginning of a trial. The high load condition will require memorisation of the order of four colours. In contrast to the low load manipulation, the high load requires substantial engagement of working memory. In order for participants to correctly recall the serial order of four colours they must hold this information in working memory for the duration of reading and responding to the moral dilemma. Rather than introducing a spatial or perceptual element, it is likely that participants will have to verbally rehearse the order for accurate reproduction. Given this, the aim of Experiment 2 was to examine the interplay of intuition and cognition by assessing when and how working memory contributes to moral decision-making.

Several hypotheses were tested in this regard. First, given that low and high load differentially engage working memory, it was hypothesised that response trajectories would vary, not only between dilemma conditions, but also between load conditions.

Specifically, it was hypothesised that responding across incidental and instrumental dilemmas would replicate Experiment 1 in the low load condition.

Secondly, it was hypothesised that high load would impact responding to instrumental dilemmas only, as incidental dilemmas are not thought to elicit a conflict between intuition and cognition (Mendez et al., 2005; Sarlo et al., 2012; Trémolière et al., 2012; Valdesolo & DeSteno, 2006).

Thirdly, in regard to instrumental dilemmas, on the assumption that an automatic, intuitive process produces deontological preferences (Greene et al., 2008; Moore et al., 2008; Paxton et al., 2011; Trémolière & Bonnefon, 2014; Trémolière et al., 2012) it was hypothesised that these responses would not vary by load. A central tenet of the dual process theory is that executive resources mediate utilitarian judgement. Following from this, it was hypothesised that these preferences would vary across low and high load. Specifically, if working memory mediates the interaction between intuition and cognition, limiting this capacity will make utilitarian judgements more difficult to produce early. Therefore we hypothesised that utilitarian responses in the high load condition would emerge significantly later than the low load condition.

3.2. Method

3.2.1. Participants.

Twenty-eight participants (8 male) were recruited from Macquarie University and participated in return for course credit or money ($15/hr).[2] All participants were naïve to the experiment and had not participated in Experiment 1. Participant age ranged from 18 – 49 years (M = 20.75, SD = 5.99). Again all participants were native English speakers, identified as strongly right handed and had normal or corrected to normal vision.

3.2.2. Stimuli.

The stimuli used for Experiment 2 were the same as those used in Experiment 1. However to allow for counterbalancing four additional stimuli were created following the same DDE principle used in the original dilemmas (Lotto et al., 2014). One new dilemma was created in each category. The experimental stimuli therefore consisted of 64 dilemmas (see Appendix B for additional stimuli) and 20 practice dilemmas. Again there was no significant difference between the mean words for incidental (M = 74.50) and instrumental dilemmas (M = 73.56, $t(62) = 0.41$, $p = .68$). The utilitarian response had an average of 11.70 words, while deontological response options had an average of 15.42 words (see Table 3).

Table 3.
Dilemma and Response Word Length from Experiment 2

Type	Dilemma	Utilitarian	Deontological
Incidental-Other	69.81	12.38	14.94
Incidental-Self	79.19	10.31	14.75
Instrumental-Other	73.19	11.75	15.75
Instrumental-Self	73.94	12.38	16.25

[2] Ten participants were replaced for failing to reach the minimum level of accuracy in the low load condition of 75%. Additionally, 13 participants were replaced as they only produced responses of one type and the statistical analysis required no empty cells (i.e. responses in each design cell).

3.2.3. Experimental design.

Participants completed 20 practice dilemmas followed by 64 experimental dilemmas, presented in random order. On each trial the dilemma could appear with either a low or high cognitive load manipulation. The experiment used a 2 x 2 x 2 nested factorial design (dilemma type [incidental v instrumental] x involvement [other v self] x load [low v high]). For every participant half the dilemmas within one category type were in the low load condition, while the other half were in the high load condition. For example eight dilemmas from the incidental-other category were in the low load condition, while the remaining eight were assigned to the high load condition. The assignment of dilemma to load condition was counterbalanced across participants, such that every dilemma appeared in every load condition across every second participant. Response location (reaching left or right for utilitarian responses) was also counterbalanced. Thus, the fully counterbalanced design was realised across every fourth participant.

3.2.4. Apparatus and procedure.

The study followed the same experimental set up as Experiment 1. However cognitive load was manipulated by the introduction of a serial recall task that required participants to memorise and replicate the order of a number of coloured squares (red, yellow, green or blue). Participants were instructed to not only identify which action they would take between the response alternatives, but also to actively memorise the serial order of colours.

The trial commenced when participants moved their right index finger to the “start” marker. The first frame displayed the coloured squares to be remembered. In the low load condition this was a single colour displayed for 500ms. In the high load manipulation, four colours were displayed sequentially for 500ms each (total 2000ms) (see Figure 11). The

second frame displayed the text of the moral scenario, which remained on screen for the duration of the audio recording (16000ms – 29000ms, *M* = 213000ms). Upon completion of the audio recording the next frame displayed the two response options accompanied by the onset of the cue as in Experiment 1. Participants again had to make their decision by reaching out and touching the corresponding response location. Following this, participants were presented with an array of the four possible colours and instructed to use the mouse to indicate the order of the colours as they were presented to them at the start of the trial. The array remained on screen until response. Depending on their response participants received appropriate visual feedback ("OK" or "WRONG"). In order to familiarise participants, Experiment 2 began with 10 practice items of the cognitive load task, followed by the practice and then experimental stimuli.

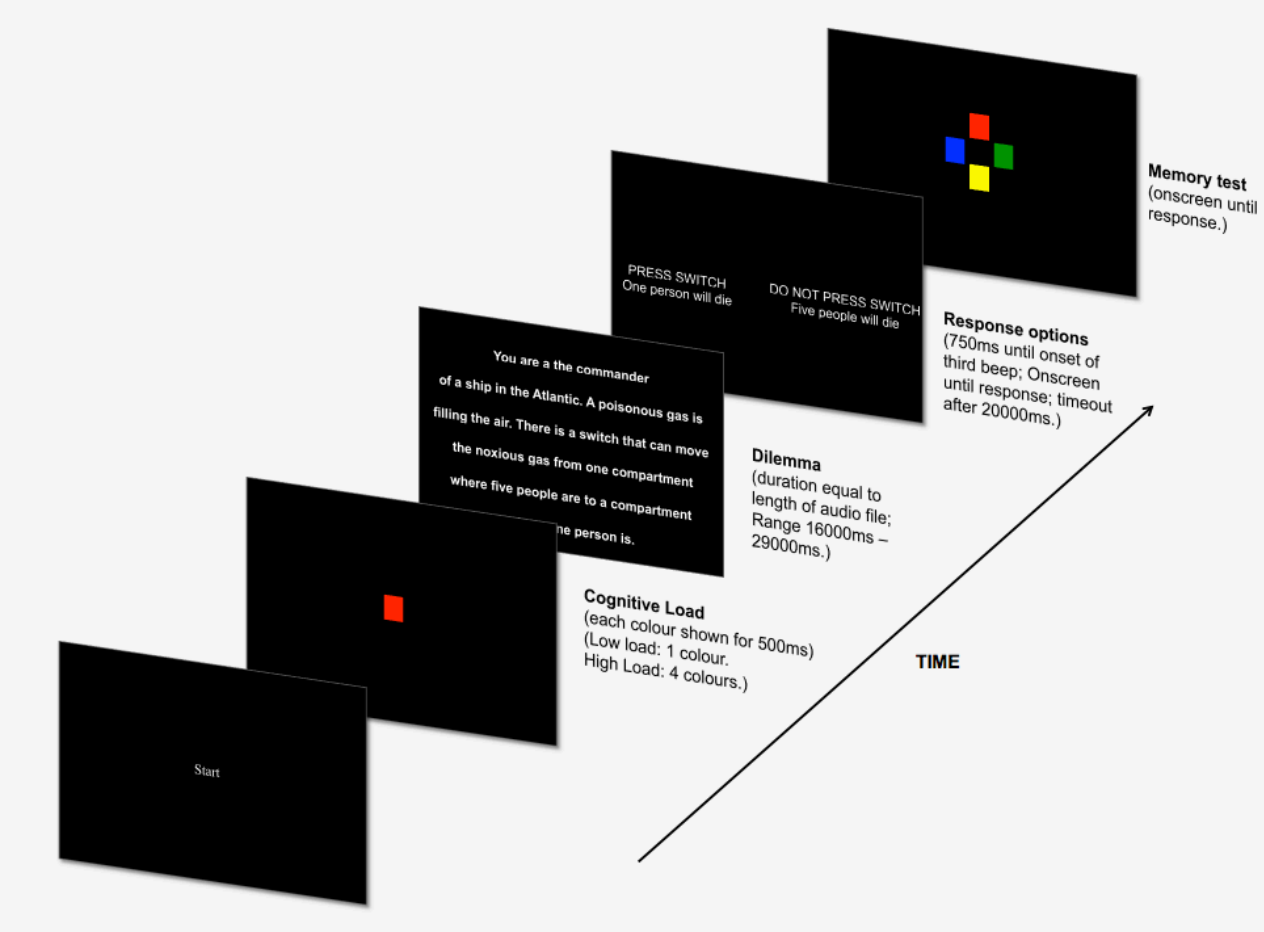

Figure 11. Schematic of Experiment 2 trial structure. The first frame displayed the coloured squares required to be remembered throughout the trial (low load, 500ms; high load, 2000ms). The second frame then displayed the moral dilemma text, on screen for the duration of the audio recording. The third frame presented the two response options. The onset of this screen coincided with the occurrence of a series of three beeps, the third beep occurring 750ms after onset. Options remained on screen until response or timeout (20000ms). The last screen presented participants with an array of colours and required them to use the mouse to indicate the order of the colours that were presented at the beginning of the trial.

3.2.5. Data analysis.

Reaching trajectories were analysed in an identical way to Experiment 1.

3.3. Results

3.3.1. Cognitive load task.

Participants were replaced if they failed to meet the minimum accuracy criteria on the low load condition of 75%. This led to the replacement of 10 participants. It is assumed that these participants were unable to sufficiently engage with the memory task and were thus replaced.

Results from the serial recall task indicate that it was performed properly. Average recall in the low load condition was 89% (*SD* = 8.00) with accuracy ranging from 75% to 100%. In contrast, average performance in the high load condition was 62% (*SD* = 21.05) with accuracy ranging from 9% to 97%.

3.3.2. Discrete measures.

Our chosen analysis necessitated that there be no empty cells in the design. This led to the replacement of 13 participants who answered exclusively with one response option in any one condition. A total of 28 participants were included in the main analysis.

Response choice data. An overall ANOVA revealed that there was a main effect of dilemma type on proportion of choices. Participants were significantly more likely to provide a deontological response for instrumental (*M* = 51%) compared to incidental dilemmas (*M* = 31%; $F(1,27) = 44.92$, $p < .001$). There were no main effect of load ($F(1,27) = 1.23$, $p = .28$) or involvement ($F(1,27) = 0.27$, $p = .61$). The two way interaction between load and dilemma type was not significant ($F(1,27) = 3.20$, $p = .08$). As Figure 12 demonstrates, proportion of deontological decisions varied only across incidental and instrumental dilemmas.

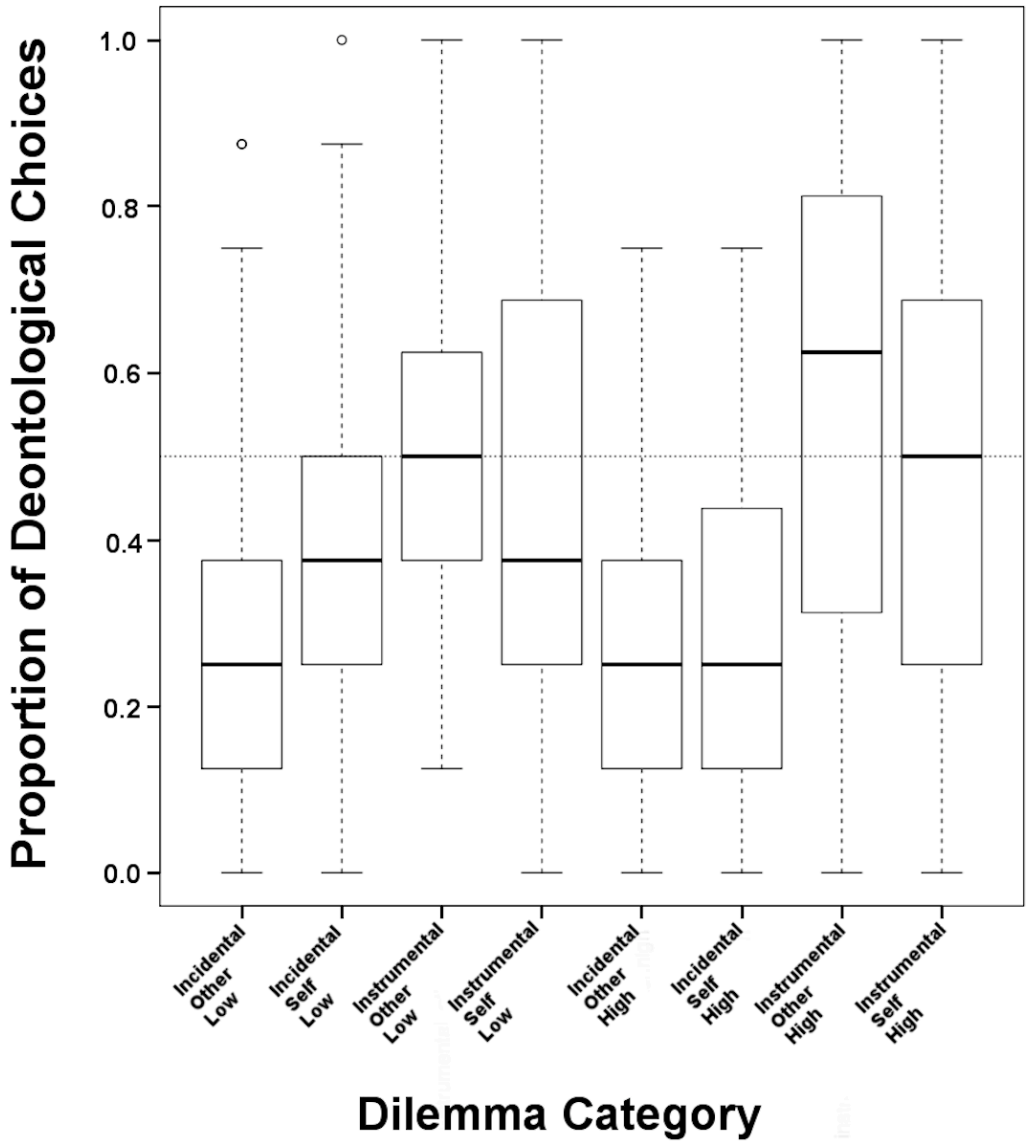

Figure 12. Proportion of deontological choices by dilemma type, involvement and load from Experiment 2. Error bars represent 95% confidence intervals. Points represent outlier values. An ANOVA revealed there was a significant main effect for dilemma type only. People were more likely to produce deontological decisions for instrumental than incidental dilemmas.

Reaction time data. An ANOVA revealed no significant difference in the time taken to produce utilitarian (M = 3559.66ms) or deontological responses (M = 3781.82ms, $F(1, 27) = 1.21$, $p = .28$). There was also no significant difference in the amount of time taken to respond to incidental (M = 3552.42ms) or instrumental dilemmas (M = 3460.20ms, $F(1, 27) = 0.01$, $p = .91$). There was no significant difference in the time taken to respond in the low (M = 3537.45ms) or high load conditions (M = 3475.17ms, $F(1, 27) = 0.09$, $p = .77$). There was however a significant interaction between response and dilemma type ($F(1, 27) = 4.70$, $p = .04$). As can be seen in Figure 13, the RT of utilitarian and deontological responses varied across dilemma type. Specifically, utilitarian responses to incidental dilemmas (M = 3472.98ms) were elicited faster than deontological choices (M = 4052.67ms). While utilitarian responses to instrumental dilemmas (M =3747.89ms) were slower than deontological decisions (M = 3660.23ms). Neither the interaction between dilemma type and load ($F(1, 27) = 0.05$, $p = .83$) or response and load ($F(1, 27) = 0.07$, $p = .80$) revealed any significant differences in RT. While the three way interaction between response, load and dilemma type was also not significant ($F(1, 27) = 0.30$, $p = .60$).

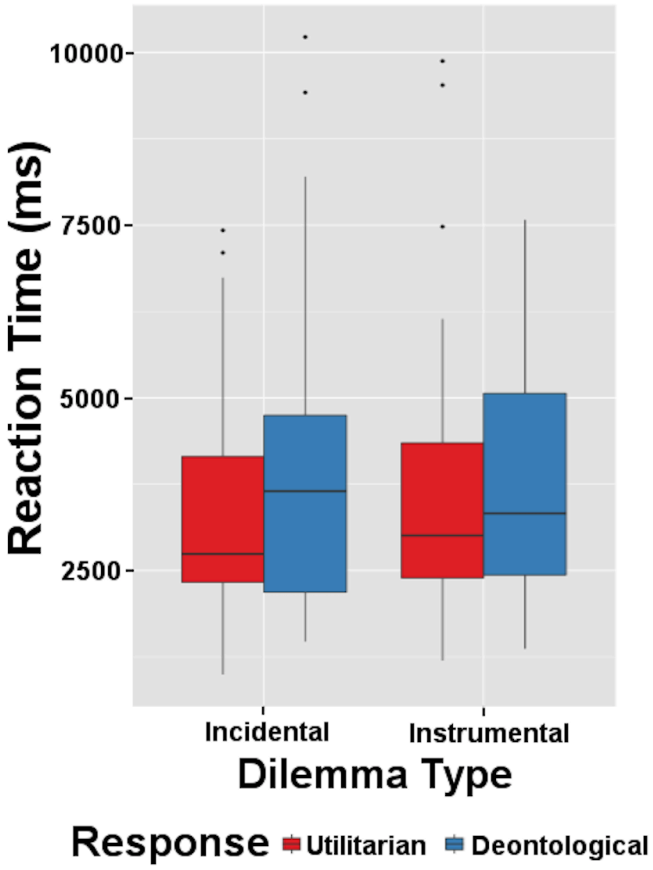

Figure 13. Reaction time by dilemma type and response for Experiment 2. Error bars represent 95% confidence intervals. Points represent outlier values. Results revealed that RTs for utilitarian and deontological decisions varied between incidental and instrumental dilemmas.

3.3.3. Reaching trajectory analysis.

LiftOff latency. As in Experiment 1 we began our analysis by examining the LiftOff latency between experimental conditions. An ANOVA revealed that there were no significant differences in the LiftOff latency between incidental (M = 2210.43ms) or instrumental dilemmas (M = 2293.92ms, $F(1, 27) = 1.59$, $p = .22$), utilitarian (M = 2255.75ms) or deontological responses (M = 2415.19ms, $F(1, 27) = -1.53$, $p = .23$) and low (M = 2263.19ms) or high load (M = 2241.17ms, $F(1, 27) = 0.08$, $p = .78$). There was however a significant interaction between dilemma type and response ($F(1, 27) = 4.79$, $p = .04$). As can be seen in Figure 14, LiftOff latencies for utilitarian and deontological decisions varied across dilemma type. Specifically, LiftOff latencies for utilitarian decisions to incidental dilemmas (M = 2143.12ms) were faster than deontological responses (M = 2530.32ms). While, LiftOff latencies for deontological decisions (M = 2376.35ms) to instrumental dilemmas were faster than utilitarian responses (M = 2517.89ms).

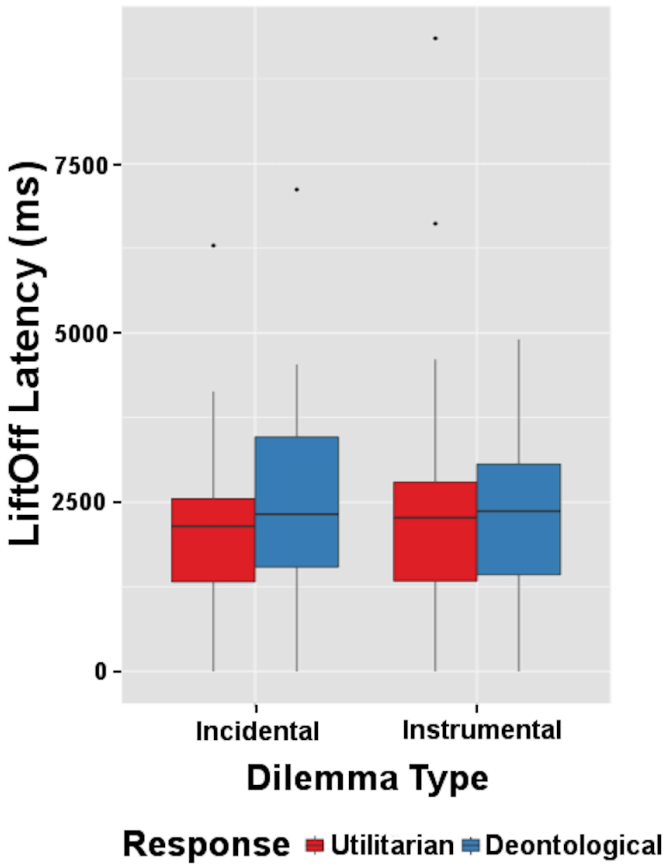

Figure 14. LiftOff latency by dilemma type and response for Experiment 2. Error bars represent 95% confidence intervals. Points represent outlier values. Results revealed a significant interaction in the LiftOff for utilitarian and deontological decisions to incidental and instrumental dilemmas. This suggests that some experimental effects were exhibited in the pre-movement window.

Response trajectories. As in Experiment 1 *x*-velocity was examined using LMM. Reliability of each effect of interest was evaluated using an incremental model of comparison approach in which goodness-of-fit statistics were used to determine which model best fit the data. Only terms that significantly improved the fit of the model were included. We originally analysed the initial 3 seconds of the reaching trajectory. However, the analysis did not produce any meaningful interpretations. As such we include an expanded analysis that accounts for all the data.

The model comparison procedure verified that the inclusion of load, $\chi^2(1) = 7.42$, $p = .006$, dilemma type, $\chi^2(1) = 73.41$, $p < .001$, involvement, $\chi^2(1) = 68.17$, $p < .001$, response, $\chi^2(1) = 31.24$, $p < .001$, and an interaction between load and response, $\chi^2(1) = 19.67$, $p < .001$, and dilemma type and response, $\chi^2(1) = 151.11$, $p < .001$, all significantly improved the fit of the model. Neither a two way interaction between load and dilemma, $\chi^2(1) = 0.75$, $p = .39$, or a three way interaction between load, dilemma and response, $\chi^2(1) = 2.85$, $p = .09$, significantly improved the fit of the model.

Inspection of coefficients revealed that there was no significant main effect of load ($b = -0.01$, $SE = 0.05$, $t = -0.28$) or dilemma type ($b = -0.07$, $SE = 0.05$, $t = -1.43$). There was a main effect of involvement ($b = 0.22$, $SE = 0.03$, $t = 8.24$). People were faster when responding to dilemmas that involved themselves, compared to others (see Figure 15).

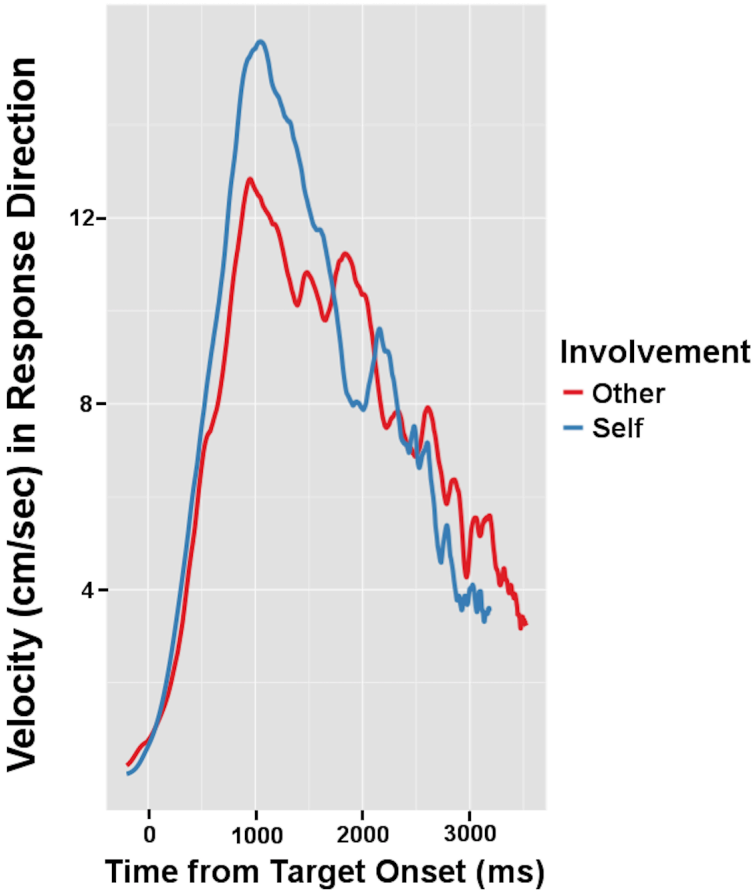

Figure 15. Involvement across time from Experiment 2. Velocity profiles revealed other and self-involved dilemmas to differ across time. People were faster to respond to self-involved dilemmas compared to other involved dilemmas.

There was also a main effect of response (b = -0.31, SE = 0.05, t = -6.55), where people made utilitarian responses earlier than deontological decisions (see Figure 16).

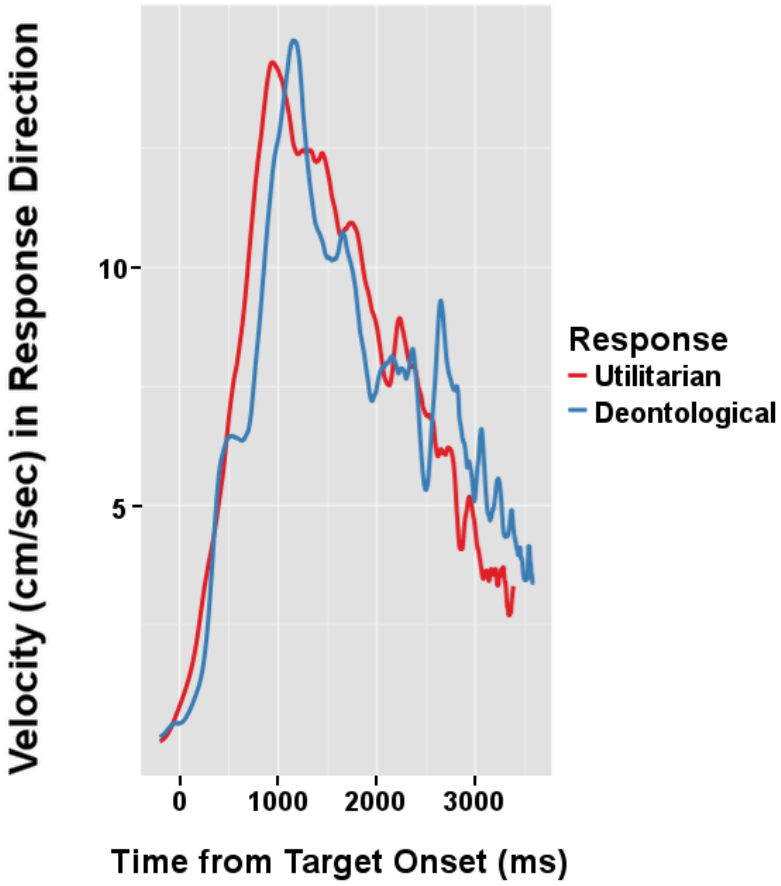

Figure 16. Response across time from Experiment 2. There was a significant main effect of response. Utilitarian and deontological responses varied across time. Utilitarian decisions were elicited earlier than deontological decisions.

Results revealed a significant interaction between load and response ($b = 0.25$, $SE = 0.05$, $t = 4.71$). As can be seen from Figure 17 however, it is difficult to interpret this interaction. It is unclear where in the *x*-velocity profile the statistical difference driving the LMM effect is located.

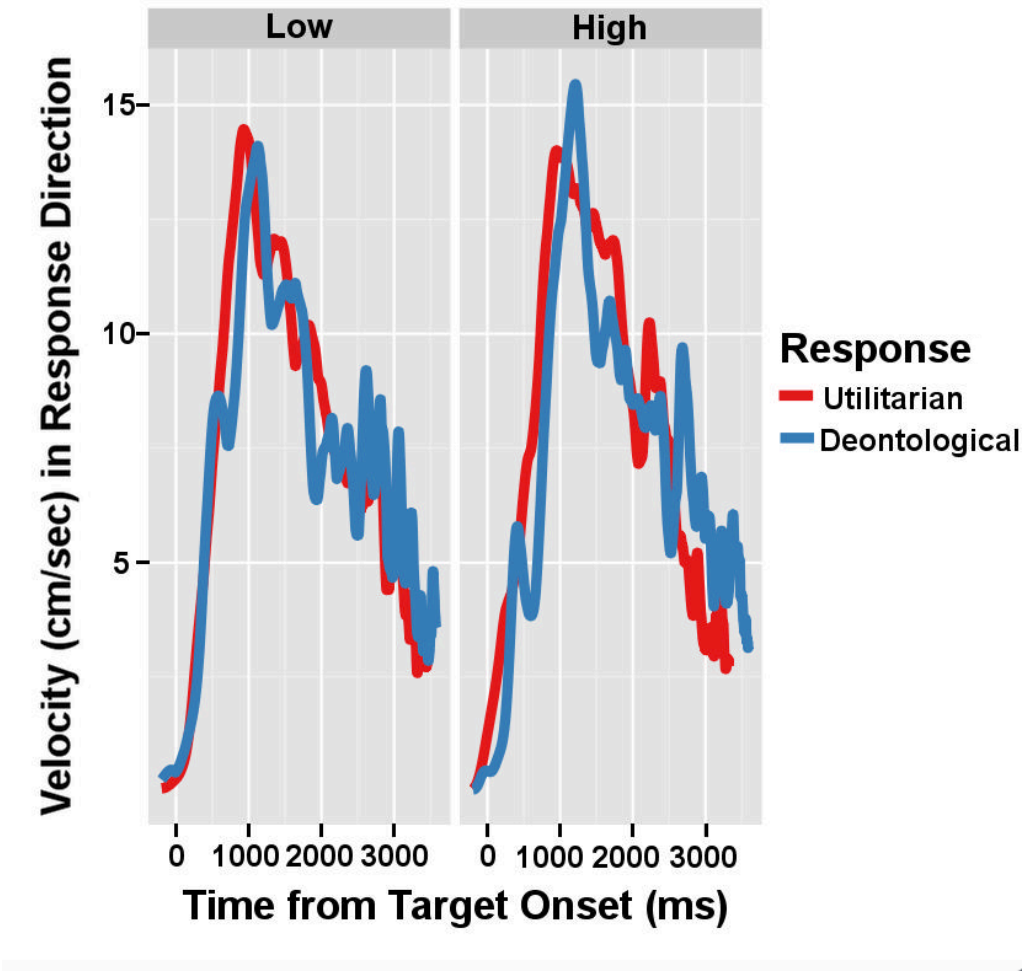

Figure 17. Interaction between load and response across time from Experiment 2. Results revealed a significant interaction between load and response. No interpretable pattern of results emerged from the velocity profile.

Results also revealed a significant interaction between dilemma type and response ($b = 0.66$, $SE = 0.05$, $t = 12.29$). Figure 18 demonstrates a similar difficulty in attempting to interpret this interaction.

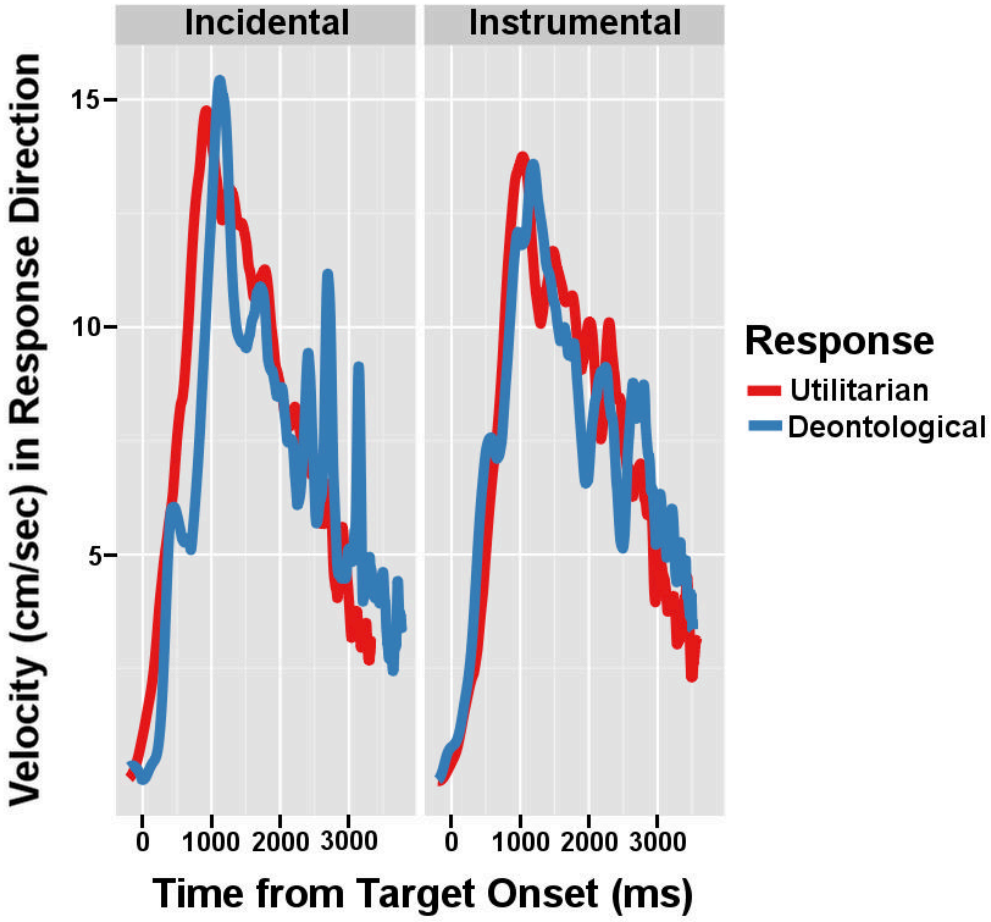

Figure 18. Interaction between dilemma type and response across time from Experiment 2. Results revealed a significant interaction between dilemma type and response. However no interpretable pattern of results emerged from the velocity profile.

Results did not reveal a significant three-way interaction between load, dilemma type or response. As can be seen in Figure 19 there are no significant effects across these conditions.

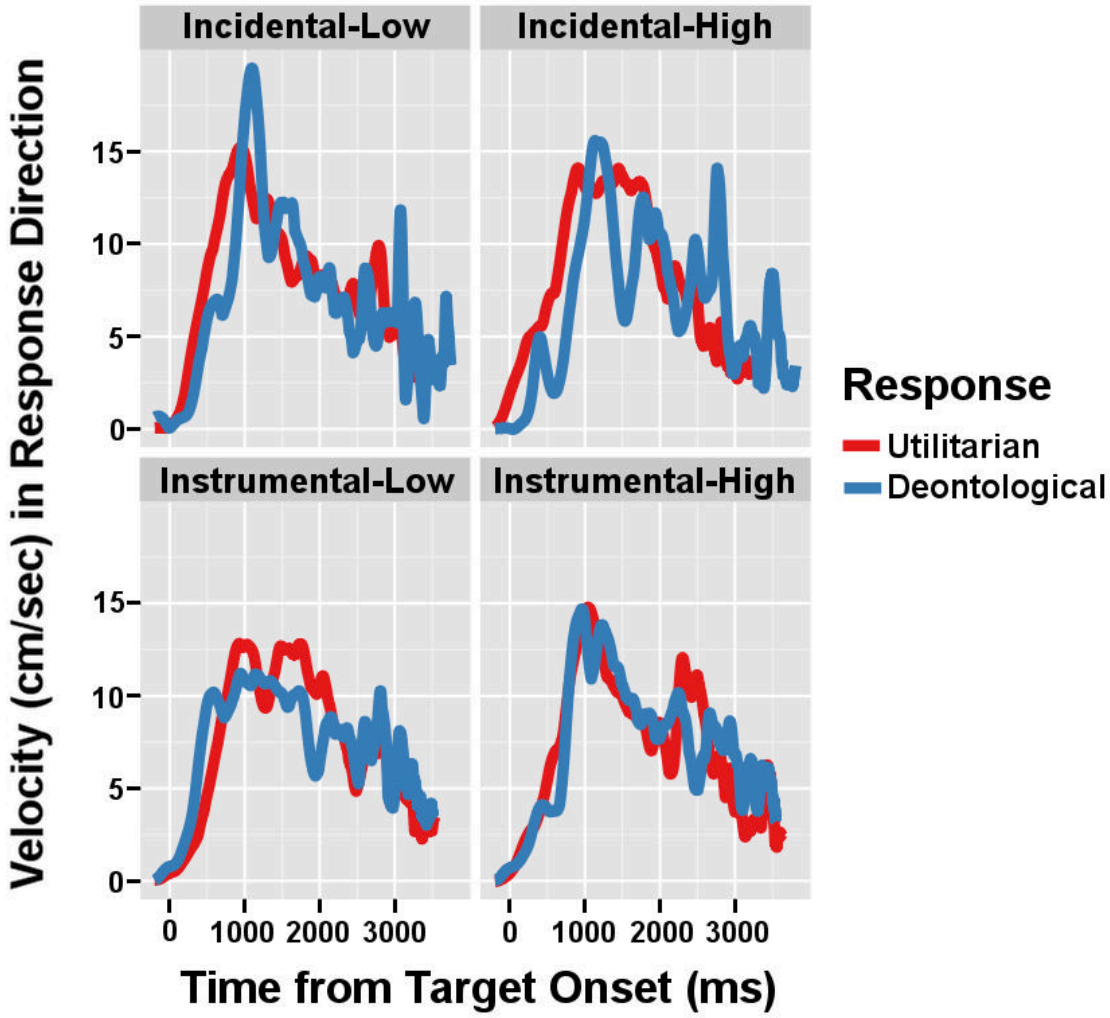

Figure 19. Non-significant interaction between dilemma type, load and response across time from Experiment 2. Results revealed no significant difference in the emergence of responses across dilemmas and load conditions.

3.4. Discussion.

The aim of Experiment 2 was to examine the interplay of intuition and cognition by assessing when and how working memory contributes to moral decision-making. With this in mind a cognitive load manipulation was introduced that specifically engaged working memory. Our results demonstrated a global impact of cognitive load across the entire task, making it difficult to draw meaningful conclusions.

Response choice data revealed a main effect of dilemma type only. People were more likely to answer utilitarian on incidental than instrumental dilemmas. Thus replicating both the findings of Experiment 1 and previous literature (Borg et al., 2006; Cushman et al., 2006; Hauser et al., 2007; Lotto et al., 2014; Moore et al., 2008; Sarlo et al., 2012). Unlike previous research, however, there was no significant effect of load on responses and no interaction between dilemma and load (Conway & Gawronski, 2013; Greene et al., 2008; Trémolière & Bonnefon, 2014; Trémolière et al., 2012).

Examination of LiftOff latency revealed some experimental effects to be exhibited in the pre-movement window. People varied in how long they took to begin moving for utilitarian and deontological responses differently for incidental and instrumental dilemmas. Unsurprisingly this difference was also exhibited in reaction times. If people began reaching earlier, they also completed their movement more quickly.

Our examination of reaching trajectories revealed a number of uninterpretable interactions. The critical three-way interaction between load, dilemma and response was not significant. Working memory manipulations did not significantly impact utilitarian or deontological responses to incidental dilemmas any differently from instrumental dilemmas.

The results suggest that introduction of the cognitive load manipulation had a global impact across task performance, such that experimental effects were not exhibited in

reaching trajectories across all conditions. We draw this conclusion from firstly, no significant difference between low and high load conditions, and secondly non-replication of Experiment 1. Given that the only difference between Experiment 1 and 2 was the introduction of a recall task, the findings from Experiment 2 suggest that both the hard and easy trials significantly impacted task performance. Possible explanations for the global effect of cognitive load are explored below.

3.4.1. Ability to interpret results.

Interpreting the results of Experiment 2 is only meaningful if; one, there is a reliable difference between the high and low conditions and; two, we have a reasonable understanding of how judgement progresses in the control condition so that sensible conclusions about the impact of the experimental manipulation can follow.

In regard to the first point, participants who failed to reach the minimum level of accuracy in the low load were replaced. This was done in an effort to ensure that all included participants had successfully shown a differentiation between low and high conditions. Although accuracy rates for the cognitive load task reflect this success, our subsequent analysis of responses to the moral dilemmas suggests that the inclusion of the working memory task yielded similar responses across all conditions. There was no significant effect of load on choice responses or reaction times. Load was also not predictive of differences in responding to incidental or instrumental dilemmas. The results therefore suggest that the remaining participants, who were able to achieve a minimum level of working memory performance on the low-load trials, were nevertheless affected to a similar level in their moral decisions by both the easy and hard recall task.

In response to the second point, in order to interpret the effects of the experimental manipulation, we must have a reliable control condition. The introduction of the cognitive

load task, however, fundamentally altered completion of the moral dilemmas across all trials. This conclusion is drawn from a number of results. It is possible that no significant difference between high and low trials resulted from a failure of the task to significantly engage working memory, or contrary to our hypothesis, for working memory not to be critically involved in the production of moral judgement. Although possible, our results do not support this interpretation. Instead, it is more likely that recall impacted performance across the entire task.

If working memory had no impact on reasoning, then responding to dilemmas should be comparable to Experiment 1, where there was no load task. Across both the low and high load conditions, however, introduction of our particular secondary task impaired the ability of participants to coincide their movement with an auditory cue. Contrary to Experiment 1, effects were therefore exhibited in the pre-movement window, instead of the reaching trajectory. That is, rather than consistently moving in response to an auditory signal across all trials, participants' LiftOff latencies for utilitarian and deontological responses varied by dilemma type. Given this, it is likely that reaching trajectories do not reliably reflect the reasoning process. This finding suggests that the introduction of our particular secondary task significantly altered the strategy used by participants to reason about dilemmas.

It follows, therefore, that we cannot confidently interpret the results of Experiment 2. As such, we cannot assess our original hypotheses. Interestingly however, the experiment reveals that a taxing secondary task has a *global impact* on the resolution of moral dilemmas. Possible explanations for this finding are explored below.

3.4.2. Global impact of cognitive load.

Our cognitive load manipulation was designed to selectively impact working memory. Working memory is often thought to be a core component of cognitive control (Hinson et al., 2003; Kane et al., 2001; Kane et al., 2005; Oberauer et al., 2005), however the precise role it plays in moral judgement is far from understood (Hauser et al., 2007; Moore et al., 2008). The results of Experiment 1 demonstrate that cognitive resources mediate the interplay between intuition and cognition. That is, the ability to override intuition and produce a utilitarian decision is variable. It seems logical that this variability may be due to changes in the availability of cognitive resources trial-by-trial. Past cognitive load studies, rather than specifically tax working memory, have tended to engage perceptual and spatial resources (Greene et al., 2008; Trémolière & Bonnefon, 2014). Unlike these studies our manipulation was designed to specifically assess the contribution of working memory to the production of utilitarian decisions. Given this, our task involved serial recall. The low load condition required participants to recall a single colour, while the high load required participants to recall the order of four colours. Although participants were more accurate at recalling the colour in the easy condition, our results in the moral dilemma task suggest that participants' performance was affected equally in both the low and high load trials. It is likely that recall altered the completion of the moral dilemma task across both difficulty levels.

We suggest a number of possible explanations for this finding. Firstly, it is possible that the engagement of working memory by the secondary task made it difficult for participants to comprehend the dilemma text. In order to accurately recall colours verbal rehearsal may have been necessary. Such rehearsal may have interfered with comprehension of complex dilemma scenarios. If participants were unable to accurately comprehend the subtle differences between dilemma categories, it is unlikely that default

systems and responses would be consistently engaged. Results across both the low and high tasks may therefore reflect initial confusion, rather than underlying judgement processes. It is possible given the amount of time participants had to reach final conclusions, that velocity profiles did not accurately capture decision-making, despite replication of choice rates (Borg et al., 2006; Cushman et al., 2006; Hauser et al., 2007; Moore et al., 2008).

It is also possible, however, that the introduction of a recall task changed the strategy participants used to complete reasoning. That is, rather than failing to comprehend dilemma differences, participants completed reasoning prior to movement onset. In contrast to Experiment 1, participants failed to coincide their movement consistently with the auditory signal across all trials, this resulted in some experimental effects being exhibited in the LiftOff latency measure. The only way for the LiftOff latency to be sensitive to our manipulations of moral dilemmas would be if participants were completing their decisions during the pre-movement window. It is possible that recall prevented participants from coinciding their movement with an auditory cue, and forced them instead to complete a portion of reasoning prior to movement. The pressure of having to accurately recall colours may have required participants to begin thinking about decisions substantially prior to movement onset. Although it is unclear as to why participants would adopt such a strategy when having to simultaneously complete two tasks, this process would result in similarly uninterpretable reaching trajectories.

In line with this explanation, it is also possible that participants varied greatly in the strategies employed to complete the reasoning task. Given the large amount of variability in accuracy within the high load condition, it is likely that participants had varied working memory ability. It is possible that a subset of participants, whilst having achieved the minimum accuracy on the low load, devoted significant resources toward accurately

completing the cognitive load task. This may have come at the cost of full comprehension of the moral dilemmas, or synchronisation of movement with auditory cues. It is also possible that another portion of participants were able to effectively engage in both the recall and dilemma task. When averaged across all participants a large amount of inconsistency in the responses might have made our measure of moral decision-making (i.e. the reaching trajectories) uninterpretable.

Although we cannot differentiate between these possibilities, our results demonstrate a particular sensitivity of decision-making to working memory. The low load condition was arguably, considerably easier than the high load condition, yet both had a significant and marked impact on the decision-making process. This finding highlights the importance of clarifying the role of specific "cognitive resources" and "executive functions" to moral decision-making, as well as highlighting the difficulty in doing so. Moral decision-making involves the coordination and reconciliation of a number of complex processes that are inherently linked. As Experiment 2 has demonstrated, it is likely that when one mechanism is selectively isolated, the highly complex and connected nature of higher order decision-making means that a multitude of processes are altered.

4. General Discussion

The purpose of this thesis was to examine the interplay between intuition and cognition during the resolution of moral dilemmas by examining the time course of judgement. To this end we utilised a behavioural paradigm capable of revealing experimental effects as they unfold across time. Critically, stimuli were selected that differed on one dimension only, intentionality. Experiment 1 provided, for the first time, a direct examination of the on-line judgement process. Experiment 2 assessed the impact of working memory on the resolution of moral dilemmas. These experiments established two key findings. Firstly, in an extension of previous research we have **provided on-line support for the assumptions of the dual process theory** (Greene et al., 2008; Greene et al., 2004; Greene et al., 2001). Early in the decision-making process emotionally engaging dilemmas are driven by a rapid and automatically elicited mechanism that favours deontological decisions, whilst utilitarian preferences are comparatively slower at this early stage. Secondly, we have demonstrated that **the process mediating utilitarian preferences is highly variable.** This final chapter will examine these two key findings and discuss the implications they carry for the characterisation of the interaction between intuition and cognition. The unexpected result of Experiment 2 will also be explored and a number of limitations and future research areas highlighted.

4.1. Key Finding: Temporal Support for the Dual Process Theory of Moral Reasoning

The dual process theory of moral reasoning assumes that moral decisions result from the interplay of two distinct processes. Emotionally engaging stimuli are thought to elicit an automatic initial response favouring deontological decisions. The stronger the affective engagement, the more cognitive control is necessary to overcome intuition and

engage in deliberate reasoning. This second process is conscious, effortful and cognitively mediated (Greene, 2007; Greene et al., 2008; Greene et al., 2004; Greene et al., 2001). Although widely assumed, there is little direct research examining this assumption. Discrete measures, for example, leave open the possibility that intuition and cognition interact in a number of possible ways (Conway & Gawronski, 2013; Greene et al., 2008; Suter & Hertwig, 2011; Trémolière & Bonnefon, 2014). ERP experiments are similarly unable to capture continuous reasoning and hence comment upon the qualitative characteristics of the interplay (Sarlo et al., 2012). In an extension of these previous studies Experiment 1 utilised a continuous reaching measure to examine the dynamics of *ongoing* decision-making. Our findings provide for the first time direct, temporal support for the dual process theory. Importantly, reaching trajectories reveal an *early* effect of dilemma type, where instrumental dilemmas selectively create a conflict between intuition and cognition. In an extension of prior studies, Experiment 1 revealed that at an *early stage* in the reasoning process deontological responses are mediated by a rapid, automatic and default mechanism, whilst utilitarian decisions are comparatively slower. These results strongly support the processing assumptions inherent within the dual process theory (Greene, 2007; Greene et al., 2008; Greene et al., 2004; Greene et al., 2001). That is, for emotionally engaging moral content, an aversion to action is elicited automatically and by default, while consequentialist decisions are more conscious and time-consuming.

4.2. Key Finding: A Variable Process Mediates Utilitarian Preferences

While the continuous data provided a direct examination of the dynamics of intuition and cognition during moral decision-making, they left open the possibility that these results were achieved in a number of different ways. It is generally assumed that utilitarian responses are a result of a time consuming and deliberate suppression of an

affective response. This follows from discrete measures, which reveal that these decisions are less likely to be produced, slower to be elicited or selectively impacted by manipulations in time (Suter & Hertwig, 2011) and load (Conway & Gawronski, 2013; Greene et al., 2008; Starcke et al., 2011; Trémolière et al., 2012; Youssef et al., 2012). Our results, in contrast, found that utilitarian decisions are highly variable. Slower velocity profiles during the early stage of reasoning for utilitarian responses to instrumental dilemmas are due to variability trial-to-trial. That is, on some trials rapid utilitarian preferences emerge from the earliest stage of reasoning. On others, a utilitarian preference does not emerge until later. Averaging across these varied response profiles yields an aggregate response that is relatively slower at each time point. Deontological decisions, in contrast, are consistently elicited rapidly during the early part of the reasoning process. The contrasting dynamics between deontological and utilitarian response preferences in the early stage of reasoning suggests that intuition is not continually suppressed by cognition throughout decision-making. If deliberative reasoning involved a time consuming and taxing suppression of the default response these decisions would be slower on average than deontological responses. Our results reveal that intuition need only be suppressed once by cognition, but that this process is strategic, deliberative and likely highly dependent on cognitive resources.

4.2.1. The role of cognitive resources.

It is likely that variability in utilitarian decisions results from the availability of cognitive resources on a trial-by-trial basis. Studies have consistently found that utilitarian decisions are more difficult to produce and slower to emerge if executive resources are limited (Conway & Gawronski, 2013; Greene et al., 2008; Starcke et al., 2012; Trémolière & Bonnefon, 2014; Trémolière et al., 2012). It is, therefore, reasonable to assume that the

variability in when cognition is able to effectively suppress intuition may be due to natural variation in the availability of cognitive resources. When participants are engaged and attentive, the deliberate mechanism is able to rapidly suppress our intuitive response and a utilitarian preference emerges from the earliest stage. In contrast when participants are distracted, tired or taxed, the deliberate mechanism takes longer to suppress intuition and therefore consequentialist preferences emerge at a later stage in the judgement process. Therefore the interaction between intuition and cognition during the resolution of emotional stimuli is unlikely to be a laboured suppression of intuition by taxing and time consuming cognitive control, rather a deliberate and efficient override that is strategic and highly dependent on cognitive resources.

4.3. Reconciling Experiment 2

Experiment 2 was conducted to assess the contribution of working memory to moral judgement. The results of our first experiment suggest that the effective suppression of intuition by cognition is mediated by the availability of cognitive resources. The process that produces utilitarian judgements was revealed to be strategic, deliberate and conscious. Given the importance of cognitive resources in the effective and early suppression of intuition, we sought to specify which "executive resources" were involved.

Working memory was manipulated as research suggests that it is critically involved in the ability to reason consciously (Hinson et al., 2003; Kane et al., 2001) and override prepotent responses (Kane & Engle, 2003; Kane et al., 2005). Rather than specifically target working memory, cognitive load manipulations tend to tax perceptual and spatial abilities (Greene et al., 2008; Trémolière & Bonnefon, 2014) or induce stressful states (Starcke et al., 2012; Trémolière et al., 2012; Youssef et al., 2012). Given this, we introduced a serial recall task. The introduction of this secondary task had a global impact

on performance. The low and high load manipulation significantly altered completion of the reasoning task. Participants exhibited a portion of their responding in the pre-movement window, rather than the reaching trajectory. No difference between the two manipulated load levels suggests that this effect occurred across all trials. It is likely that the recall task significantly disturbed or altered the strategy employed to comprehend and reason about dilemmas.

We suggest a number of possible explanations for this finding. It is likely that to accurately recall items, participants verbally rehearsed the presented colours. This rehearsal likely continued throughout the reading and comprehension phase of the dilemma task. It is possible, therefore, that ability to read and understand dilemmas was disturbed. As such, reaching trajectories, rather than reflecting ongoing judgement, capture confusion. Given participants had 20 seconds to complete their response, it is possible that velocity profiles did not accurately capture the decision-making process, despite final choices being consistent with prior research (Borg et al., 2006; Cushman et al., 2006; Hauser et al., 2007; Moore et al., 2008).

A second possibility is that participants fundamentally altered their approach to task completion. That is, the introduction of a secondary task prevented participants from synchronising their reaching movements to an auditory cue, and instead forced them to complete a portion of their reasoning prior to movement onset.

In line with this explanation is the possibility that participants approached the task in varied ways. That is, some participants may have devoted attention to accurate serial recall, at the cost of adequate comprehension of dilemma content. Other participants, in contrast, may have been able to simultaneously complete the recall task whilst comprehending subtle dilemma variations. While splitting focus across two tasks may have altered the importance participants placed on coinciding their movement with an auditory

cue. This inconsistency may have produced velocity profiles that were uninterpretable. Importantly, it is not clear how participants completed either the recall or reasoning task, and therefore we are limited in the conclusions that can be drawn from this experiment.

The results however do highlight the importance of working memory in completing reasoning tasks and it is perhaps unsurprising that the manipulation had such a profound impact. Reasoning is a highly connected and complex process that involves the competition and reconciliation of, not just intuition and cognition, but a variety of other mechanisms. These mechanisms are undoubtedly connected and play multiple roles. Experiment 2 suggests that working memory may be critically involved in both deliberation and comprehension.

4.4. Limitations and Future Directions

4.4.1. Ongoing, not initial reasoning.

Moral reasoning is a highly complex task that involves the competition and coordination of a number of different mechanisms. Past research has been limited in its ability to examine the continuous and ongoing nature of this process (Greene et al., 2004; Greene et al., 2001; Sarlo et al., 2012; Suter & Hertwig, 2011). It is particularly difficult to separate comprehension from deliberation. Previous studies have attempted to overcome this by measuring a designated deliberation phase (Koop, 2013; Sarlo et al., 2012). It is unlikely, however, that this research captures ongoing reasoning. Presentation format often necessitates exposure to response alternatives during the reading phase. It is therefore likely, given that intuitive responses are thought to occur automatically, that they fall outside the designated recording period. To address this limitation, we manipulated response alternatives to co-occur with an auditory cue. As far as was possible, participants were not exposed to response options during the reading phase. Participants were trained to

begin their movements during initial exposure in order for trajectories to capture the early interplay between mechanisms.

However, it is possible that reasoning began prior to the onset of response options. Given the nature of moral scenarios, it is likely that people begin considering, reacting and formulating responses during comprehension. Limiting exposure to response alternatives and capturing the initial three seconds of responding ensures that response trajectories capture an early and meaningful part of the deliberation process, but not necessarily the *initial* segment. In order to map the emergence of moral judgement, it is necessary to manipulate when reaching movements begin relative to target onset (Finkbeiner et al., 2014; Quek & Finkbeiner, 2013). The complexity of higher-order decision-making necessitates that strict control over movement initiation is not possible. Participants must comprehend dilemmas and response alternatives to ensure that their reaching movements are meaningful. Similarly, people must only be exposed to these stimuli once, in order for default and automatic reactions to be elicited. Our results therefore provide support for the dual process theory by demonstrating that at an *early* point deontological preferences are rapidly elicited, while utilitarian responses are slower. We cannot however; draw conclusions about how these mechanisms emerge in real stimulus processing time.

This finding highlights the importance of examining the entire judgement process. It is clear that comprehension is inherently linked to the formulation of judgement. Future studies must examine the competition and coordination of the entire reasoning process. A critical question for future research is to assess how lower order cognitions such as attention, memory and comprehension interact to produce reconciled judgement. It is likely that until experimental methods acknowledge that reasoning is continuous, highly complex and ongoing; understanding of the processes that underlie judgement will be too simplistic.

4.4.2. What do moral dilemmas tell us about moral reasoning?

Moral dilemmas are specifically designed stimuli that pit universal moral rules against consequentialist outcomes (Christensen & Gomila, 2012). Our selected stimuli differed only in terms of intentionality and involvement (Lotto et al., 2014). Although these stimuli allow us to broadly examine the interplay between intuition and cognition, the conclusions that can be drawn about real life moral reasoning are limited. Gold, Pulford and Colman (2015) found that when trolley and footbridge problems had real world economic consequences, there was no difference in the action people took. The scenarios created by dilemma stimuli may similarly fail to engage people in an ecologically valid way. In order to ensure standardisation and a large set of stimuli, moral dilemmas differed in believability. Scenarios, for example, could involve action on a space station or underwater submarine. Responses, therefore, reflect the dynamics of responding to dilemmas specifically. Real life moral decisions do not generally involve life or death consequences, rather a subtle competition between a number of competing egoistic and altruistic concerns. Moral action is similarly not restricted to two binary response options. Future research must examine the differences between dilemma judgement and real life decision-making. This includes examining the dynamics of spontaneous moral reasoning, rather than deliberation between two response alternatives.

4.5. Conclusion

Current research suggests that moral decisions result from the interplay between two distinct mechanisms. One is elicited by default, rapidly and automatically, while another is slow, conscious and deliberate. The ability for traditional measures to examine this interaction process is limited however. The aim of this thesis was to investigate the nature of the interplay between intuition and cognition during the resolution of moral

dilemmas. The thesis contributes to our understanding of moral reasoning in two key ways. Firstly, we have provided, for the first time, direct support for the temporal assumptions of the dual process theory. That is, for emotionally engaging stimuli, at an early stage in the reasoning process a rapid and default mechanism favours deontological decisions, whilst utilitarian preferences are comparatively slower. Secondly, we established that the mechanism mediating utilitarian decisions is highly variable. This finding suggests that cognition does not suppress automatic responses through a time consuming and laboured process; rather we can deliberately and strategically override intuitively driven decisions rapidly and instantly, but that this overriding process is limited by the availability of executive resources.

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6. Appendices

A. Experimental Stimuli

Incidental-Other Dilemmas

Plane
You are the pilot of a fighter jet on a mission in South East Asia. During the flight you realize that another fighter jet on the same mission has launched a missile by mistake and it is aimed at a six-seater light aircraft. You notice that in the area of the missile there is also another military reconnaissance aircraft.

REDIRECT THE MISSILE	DO NOT REDIRECT THE MISSILE
Light aircraft avoided.	Light aircraft hit.
Missile redirected to military aircraft.	Military aircraft avoided.
Pilot will die.	Six passengers will die.

Agent
You are a secret service agent on a mission overseas. You have discovered that a terrorist group is attempting to assassinate three diplomats. They are travelling in a car towards the embassy. They are being followed by one of the terrorists who will take advantage of the first red traffic light to kill them. As you follow, a tanker carrying oil slips between your car and the terrorist's.

SHOOT THE TANKER	DO NOT SHOOT THE TANKER
Stop the terrorists.	Terrorists will reach the car.
Tank driver will die.	Three diplomats will die.

Cargo
You are in charge of the Maritime Police. You have received a message that the captain and a seaman of a cargo ship are healthy carriers of a lethal and contagious virus. They do not know that they are infected, and are travelling towards a small gulf where fishermen live. The communications system of the cargo ship is not working and, therefore, they cannot be contacted.

DESTROY THE SHIP	DO NOT DESTROY SHIP
Stop spread of virus.	Allow spread of virus.
Captain and seamen will die.	Fishermen will die.

Crane
You are a building worker who is manoeuvring a crane on a building site. You have just started your day on the site, when you realise that the cable of the crane is about to break. Attached to the cable is an enormous steel beam which is directly above a crew of six who are working on the outside of a building in construction. There is one worker in an area

adjacent. The crane can only be moved in one direction.

MOVE THE CRANE	DO NOT MOVE THE CRANE
Beam will fall on worker.	Beam will fall on six workers.
Worker will die.	Six workers will die.

Fire

You are a fireman who is trying to save some people trapped in a fire which has broken out on the 20th floor of a skyscraper, which is luckily deserted. Six people are trapped in a room on the 21st floor and are already beginning to suffocate from the smoke, while one person is coming down alone from the 19th floor on foot. An automatic fire door can be used to block the smoke.

CLOSE FIRE DOOR	DO NOT CLOSE FIRE DOOR
Block the smoke.	Do not block smoke.
Trap the 19th floor worker.	19th floor worker escapes.
The worker will die.	Workers on 21st floor will die.

Nurse

You are a nurse who is in charge of a machine, which controls drug dosage levels in patients' blood. Because of a technical failure, the machine is supplying a lethal dose of the drug to four patients. Another patient, in a single room, is hooked up to the same machine and has not undergone any variation in dosage. It is possible to redirect supply.

REDIRECT SUPPLY	DO NOT REDIRECT SUPPLY
Single patient will receive the dose.	Four patients will receive the dose.
This patient will die.	Four patients will die.

Soldier

You are a soldier in the Gulf War. An armed group has taken four civilians hostage and threatens to kill them. You have been able to discover where the hostages are being held and you must act quickly before they are killed. You have discovered that a tanker transporting oil is about to pass in front of where the hostages are being held. Shooting the tanker will cause the kidnappers to leave their hideouts.

SHOOT THE TANKER	DO NOT SHOOT THE TANKER
Kidnappers leave.	Kidnappers do not leave.
Tank driver will die.	Four hostages will die.

Missile

You are a member of the Air Force and the commander of a squad of planes that is on a

reconnaissance mission. On one of these missions, while flying over an inhabited area, you realise that one of the planes has just launched a missile accidentally, and it is heading directly for a house in which a family of three lives. You are able to divert the missile to an occupied car.

DIVERT THE MISSILE	DO NOT DIVERT THE MISSILE
Avoid house, hit a car.	Hit the house, avoid a car.
Driver will die.	Three people will die.

Motor Boat

You are driving your motor boat in a small bay when your attention is drawn to cries of help from five people who are drowning at the end of a very narrow channel which is right in front of you. Between you and the people who are drowning is another person who is calmly swimming. It is possible to slowly manoeuvre around this person, however the people will drown unless you reach them quickly.

TRAVEL AT A HIGH SPEED	DO NOT TRAVEL AT A HIGH SPEED
Save the people at the end of Channel, but hit the swimmer with your boat.	Do not reach people at the end of the Channel.
Swimmer will die.	Five people will die.

Hospital

You work as the night caretaker in a small provincial hospital. During one of your rounds you realise that, because of a laboratory accident, some highly toxic fumes are spreading through the ventilation system towards a room in which there are five patients. In another room in the same ward there is just one patient. There is a switch that allows you to divert the fumes from one room into another.

PRESS THE SWITCH	DO NOT PRESS THE SWITCH
Divert the fumes.	Do not divert the fumes.
One person will die.	Five people will die.

Quarantine

The healthy carrier of a contagious and lethal disease is being held in quarantine in hospital. Suddenly the ventilation system breaks down and there is no longer a change of air in the room. The emergency system will shortly be activated and an internal window will be opened. This window opens into a ward in which five patients are being treated for various illnesses.

BLOCK EMERGENCY	DO NOT BLOCK EMERGENCY SYSTEM
Window stays closed.	Window will open.
One person will die.	Five people will die.

Ferris Wheel

You are the safety officer in charge of a fun park. One of the metal arms of the ferris wheel suddenly breaks because of a structural defect. Four people are stranded in a cabin 80 metres up in the air. Another person is in a cabin just a few metres from ground level and is able to get off alone. The whole structure is falling down rapidly.

MOVE FERRIS WHEEL	DO NOT MOVE FERRIS WHEEL
People in top cabin escape.	Person in bottom cabin escapes.
Person in bottom cabin will die.	Four people in top cabin will die.

Torpedo

You are the commander of a naval submarine which is currently navigating in the North Atlantic. The sonar reveals the presence of a torpedo which is heading at great speed towards a small boat with six people on board, which is offshore. Close by, there is also a naval patrol boat with two people on board. You are able to change the trajectory of the torpedo.

CHANGE THE TRAJECTORY	DO NOT CHANGE THE DIRECTORY
Torpedo will hit patrol boat.	Torpedo will hit small boat.
Two people will die.	Six people will die.

Shark

You are on holiday at the seaside and returning to shore in your motorboat. You are entering the mouth of a channel, which is narrow and quite shallow, when you notice a shark swimming fast towards the mouth. At the end of the channel is a swimmer, who is calmly bathing. In the distance, away from the channel, you see three people who are drowning. If you leave the mouth of the channel the shark will enter and attack.

LEAVE	DO NOT LEAVE
Shark enters the channel.	Shark cannot enter the channel.
Drowning people saved.	Cannot save drowning people.
One person will die.	Three people will die.

Trolley

You are in charge of a work crew who are doing repair work for the railways. In the distance you see a trolley and realise that the driver has lost control of it. If the trolley continues on, it will end up running into five workers who are working on the tracks. On a secondary track there is one worker. You can pull a lever to divert the trolley onto the second track.

PULL LEVER	DO NOT PULL LEVER
Trolley diverts to second track.	Trolley does not divert to second track.
One worker will die.	Five workers will die.

Incidental-Self Dilemmas

Motorway
You are travelling on the motorway with two other people, one of whom is driving. You are in the right-hand lane. Suddenly, the driver collapses onto the steering wheel and the car starts to gather speed. The truck in front of you brakes and the impact is unavoidable. To your right you notice a lay-by where there is a road worker.

SWERVE TO THE RIGHT	DO NOT SWERVE
Avoid truck.	Hit truck.
Road-worker in lay-by will die.	You and two others will die.

Bomb in Bank
You are in the head office of your bank together with four other people. Suddenly, the director calls you because he has discovered a bomb in an office on the ground floor. He knows you are a bomb disposal expert and asks you to defuse it. You realise immediately that there is not enough time to evacuate the people in the bank before the bomb explodes. It is possible to minimize the impact, by throwing the bomb into the bank's vault where a security guard is located.

THROW THE BOMB	DO NOT THROW THE BOMB
Explosion in vault.	Explosion in bank.
Security guard will die.	You and four others will die.

Underground Cave
A very large man is leading you and a group of five explorers out of an underground cave on the west coast of Scotland. Because of his large size, the man gets stuck in the narrow opening at the mouth of the cave. In a short time it will be high tide, and you will all drown except for the man, who has his head outside of the cave. You can use the explosives that you have with you to enlarge the opening to the cave and escape.

USE EXPLOSIVES	DO NOT USE EXPLOSIVES
Enlarge opening.	Opening not enlarged.
Man will die.	You and five others will die.

Electric Cable
A car accident causes a devastating explosion inside a long tunnel. You and another four survivors are finding your way through the debris to get out of the tunnel. Because of structural damage, a high tension electric cable has snapped and is beginning to swing towards you. The asphalt is soaked with petrol. In the opposite direction you see another survivor coming towards you. You are able to divert the electric cable in the opposite direction

DIVERT CABLE	DO NOT DIVERT CABLE

Man electrocuted.	Fire in tunnel.
Man will die.	You and four others will die.

Atomic Energy Plant

You are a worker in an atomic energy plant. Following an explosion, there has been a leakage of radioactivity in your work area, where there are another three people. The doors are blocked because the security system has activated, but the decontamination and communications system has broken down. If you remain exposed to the radiation you will die in a short time. It is possible to activate a ventilation system to divert the radioactivity toward another work division, where there is only one worker.

DIVERT RADIATION	DO NOT DIVERT RADIATION
Radiation enters other division.	Radiation enters your division.
Worker will die.	You and three others will die.

Dam

You are a specialist in underwater welding. You are working with your team of three other people in a small dam at a depth of 30m under water. Because of a problem with the flow regulator, about 100 cubic metres too much water has flowed into the dam. The pressure is too great and you are unable to surface. It is possible to open the gates of the dam so that water will flood a valley where an observatory is located containing a researcher.

OPEN GATES	DO NOT OPEN GATES
Water destroys observatory.	Welders unable to surface.
Researcher will die.	You and three others die.

Window

You are a fireman and you are trying to save five people from inside a burning building. The only window from which the people can be evacuated is jammed and will not open. The fire will reach you in a short time. Outside on the window ledge of the floor below, there is a person who is waiting to be saved. There is an axe which you can use to smash the window and get out.

SMASH THE WINDOW	DO NOT SMASH THE WINDOW
Glass hits the person below.	Unable to escape.
Person below will die.	You and five others will die.

Waterfront

You are a worker specialised in manoeuvring a crane and are part of a work team that is loading containers into a ship. You have just lifted a container from the wharf when you realise that the cable of the crane is breaking and that the container is about to crash down on you and the other workers in the team. There are two workers in an area adjacent. You

can only move the crane in this direction.

MOVE THE CRANE	DO NOT MOVE THE CRANE
Container falls in area with 2 workers.	Container falls on you and other workers.
Two workers will die.	You and other workers will die.

Body Guard

You are the bodyguard for an important politician. At the end of a rally, as you are getting into the car together with three other people, the secret services inform you that there is a terrorist heading towards you at high speed in a car filled with dynamite. With the binoculars you see a car at a distance of several hundred metres and a traffic policeman patrolling the area nearby.

SHOOT AT THE CAR	DO NOT SHOOT AT THE CAR
Petrol tank explodes.	Terrorist reaches you.
Policeman will die.	You and four others will die.

Rollercoaster

You are at Luna Park and you have decided to take a ride on the roller coaster. You get into the carriage together with four other people. After a couple of circuits, the speed starts to increase dramatically right at the point that the carriage does a loop the loop. The technician in charge tells you over the loudspeaker that the mechanism which controls the brakes is not responding. It is possible to divert the carriage onto another track where a man is working.

DIVERT THE CARRIAGE	DO NOT DIVERT THE CARRIAGE
Hit the worker.	Do not hit the worker.
The worker will die.	You and four others will die.

Orbiting Space Station

You are the commander of a group of astronauts in a space station orbiting the earth. Because of a breakdown, you have discovered a serious loss of pressurisation which in a short time will lead to the oxygen supply running out in the control cabin, where you and five other astronauts are. The emergency system is broken down and cannot be repaired immediately. It is possible to isolate the depressurisation to just one cabin where two astronauts are.

ISOLATE DEPRESSURISATION	DO NOT ISOLATE DEPRESSURISATION
No oxygen in other area.	No oxygen in your area.
Two astronauts will die.	You and five others will die.

Taxi and Snow

You are a taxi driver and you are carrying two passengers at night. It has been snowing already for a couple of hours and the roads are dangerously icy. You turn into a very narrow street and suddenly you find yourself in front of a truck which has overturned in the middle of the road. You start to brake, but you lose control of the taxi and it begins to slide on the icy road. There is a pedestrian off to the right side of the road. This is the only direction where the taxi can be moved.

SWERVE TO THE RIGHT	DO NOT SWERVE TO THE RIGHT
Hit the pedestrian.	Hit the truck.
Pedestrian will die.	You and two others will die.

Theatre

You and another five actors are taking part in rehearsals for a stage show. The lighting technician is adjusting the spotlights and is on the catwalks several meters above. Suddenly, a criminal armed with a gun comes into the theatre and threatens to kill you and the other actors. He is standing right under the catwalk. It is possible to open a trapdoor in the catwalks to cause heavy equipment to fall on top the criminal.

OPEN TRAPDOOR	DO NOT OPEN TRAPDOOR
Heavy equipment falls on criminal.	Criminal is not hit.
Technician will die.	You and five others will die.

Bull

You are at Pamplona with three colleagues and the Encierro has just finished, that is the running of the bulls through the streets of the city. While you are leaving, you realise that a bull has escaped and is heading towards you, attracted by your colleague's red bag. You have your shoulders to a wall and there is no time to escape. It is possible to throw the bag in the opposite direction, near another person.

THROW THE BAG	DO NOT THROW THE BAG
Lands near another person.	Bull attracted to colleague.
That person will die.	You and three others die.

Control Tower

You are an Air Force commander and you are in the control tower with another two officers to check some documents. During an exercise that is taking place in the surrounding air space, a plane has engine problems and is about to crash into the control tower. The pilot communicates by radio that he is about to eject from the plane. It is possible to change the plane's direction, but only by shooting down the plane immediately.

SHOOT DOWN THE PLANE	DO NOT SHOOT THE PLANE
Plane avoids tower.	Plane hits the tower.
Pilot cannot escape.	Pilot ejects.
The pilot will die.	You and two others die.

Instrumental-Other Dilemmas

Lift to Hell
You are in charge of a team of specialised technicians who are carrying out maintenance work on a very large lift. Six technicians are working in the lift well. You and another technician are on the top floor in the machine-room. Suddenly, the winch breaks and the lift cabin starts to plummet downwards. Blocking the cogs of the mechanism will stop the lift, but there is nothing but you and the technician on the top floor.

PUSH TECHNICIAN	DO NOT PUSH TECHNICIAN
Block the cogs.	Cogs not blocked.
Stop the lift.	Lift continues.
Technician will die.	Six technicians will die.

Circus
You are a lion-tamer on tour with a show of wild animals used in circus acts. During the show, you notice that one of the lions has suddenly become aggressive. You see that it is not responding to your commands, is baring its teeth and is about to launch into the front row audience. Near you there are two assistants. It is possible to prevent the lion attacking the audience, by diverting its aggression elsewhere.

PUSH ASSISTANT TOWARD LION	DO NOT PUSH ASSISTANT TOWARD LION
Lion attacks assistant.	Lion attacks the audience.
Assistant will die.	Audience members will die.

Footbridge
You are crossing a bridge which passes over the railway line and you see a train moving on the track below. You notice that the driver has lost control and that the locomotive will continue its course and end up running into five men who are working on the adjacent tracks. On the bridge next you is a person you do not know.

THROW PERSON OFF	DO NOT THROW PERSON OFF BRIDGE
Block the train.	Do not block the train.
Person will die.	Five workers will die.

Rubber Dinghy
You are at sea aboard a rubber dinghy with a friend and another two people whom you do not know. In the distance, you can see a boat in difficulty which has caught fire. The six people on board have jumped into the water and are drowning. To save them you must head towards them immediately, but the dinghy is too heavy to travel at the required speed.

PUSH OVERBOARD TWO PASSENGERS	DO NOT PUSH OVERBOARD TWO PASSENGERS

Lighten the load.	Do not lighten the load.
Two passengers will die.	Six people in the water will die.

Motorcross

You are a motorcyclist and you are taking part in a motocross race. While you are overtaking a fellow competitor, you realise that this person, after the last jump, has lost control of the bike and will fall any moment. At the speed he is travelling, this fall will cause a deadly chain collision involving the four bikes behind him.

PUSH HIM OFF THE TRACK	DO NOT PUSH HIM OFF THE TRACK
Motorcyclist will crash.	Motorcyclist will cause collision.
Motorcyclist will die.	Four motorcyclists will die.

Petrol Pump

You find yourself near a petrol pump and see the attendant fill up a car with four people on board. Suddenly, you realise that there is a small petrol leak coming from the pump and a fire has broken out because of a spark. It is about to spread quickly in the direction of the car. It is possible to block the flames, but the only thing near you is a passer-by.

PUSH A PASSER-BY INTO FLAMES	DO NOT PUSH A PASSER-BY INTO FLAMES
Block the spread of fire.	Do not block spread of fire.
Passer-by will die.	Five people will die.

Crushed in Door

You are on board a ship which is sinking. You are heading for the deck where the lifeboats are together with seven other people. You and another person have just crossed through a watertight door when it starts to close quickly. The other six people are behind the door, too far away to be able to pass through it in time. It is possible to block the door, but the only thing available to you is the other person.

BLOCK THE DOOR WITH PERSON	DO NOT BLOCK THE DOOR WITH PERSON
Everyone else able to escape.	Everyone else trapped.
Person crushed and will die.	Six people will die.

Press

You are in charge of the division of a factory where wood panels are made. Because of a malfunction in one of the main machines, three workers have been caught up in a roller which is pulling them quickly into a very large press. The emergency system which blocks

the machine has not activated and time is running out. It is possible to stop the rollers by blocking the cogs, but the only thing large enough available to you is another worker.

PUSH WORKER INTO COGS	DO NOT PUSH WORKER INTO COGS
System blocked.	System not blocked.
One worker will die.	Three workers will die.

Ranch

You have a small horse stud in Australia. You are heading towards the nearby town in a four-wheel drive together with a new client when you notice a bolting wild horse which is galloping like mad. It is heading towards three people who are walking near the edge of a gorge and soon it will run into them. You immediately follow and are able to catch up with it. You are able to make it change direction, but only toward your client.

CHANGE HORSES DIRECTION	DO NOT CHANGE HORSES DIRECTION
Moves toward client.	Continues toward three people.
Client will die.	Three people will die.

Savannah

You are carrying out research into the behaviour of lions in the Savannah of Central Africa. From an observation tower, you can see four people hiding behind a bush. They are being followed by a lion and are trying to get away from it. The lion has seen them and is heading for the bush. Another person has been able to climb the observation tower. The only way to stop the lion is to distract him with another person.

PUSH PERSON OFF TOWER	DO NOT PUSH THE PERSON OFF TOWER
Lion drawn to person.	Lion continues toward people in bush.
Person will die.	Four people will die.

Restaurant Shooting

You are having dinner with some friends in a restaurant in the centre of town. Suddenly, a criminal armed with a machine gun enters. He threatens to shoot at a table where a family of six is seated if his request for an outrageous amount of money is not met. You understand that the gunman has mental problems and any attempts to mediate would be in vain. The only way to prevent the gunman from shooting the family is to force him to redirect his attention.

PUSH ANOTHER MAN ON TO GUNMAN	DO NOT PUSH ANOTHER MAN ON TO GUNMAN
Gunman will shoot the man.	Gunman will not shoot the man.
Family will escape.	Family will not escape.
Man will die.	Six people will die.

Tram
You are on your way to work and are waiting at the tram stop with some other people for the next tram. Suddenly, you realise that the tram, which is approaching at high speed, does not have brakes and is about to run into a group of five people who are crossing the road distractedly, unaware of the danger. It is possible to slow down the tram so it will not hit the people.

PUSH A STRANGER IN TRAMS WAY	DO NOT PUSH A STRANGER IN TRAMS WAY
Slow down tram.	Do not slow down tram.
Stranger will die.	Five people will die.

Transplant
You are a young doctor working in the emergency surgery ward of your local hospital. Four of the patients under your care in your ward are dying from grave injury to vital organs as a result of a serious car accident. You have another patient in the ward, who is now in good health and ready to be sent home.

ANAESTHETISE HEALTHY PATIENT	DO NOT ANESTHETISE HEALTHY PATIENT
Use organs for other people.	Do not use organs for other people.
Healthy patient will die.	Four patients will die.

Vitamins
You are in charge of a medical team which is taking part in an expedition that will be isolated in the Sahara Desert. In the group, there is a family of five people who suffer from a serious genetic disease which causes vitamin deficiency. You have no drugs with you that can guarantee their survival, and rescue will not arrive in time. It is possible to extract the necessary vitamins from a healthy kidney.

EXTRACT KIDNEY FROM GROUP MEMBER	DO NOT EXTRACT KIDNEY FROM GROUP MEMBER
Extract vitamins.	Do not extract vitamins.
Group member will die.	Five people will die.

Zoo
You are the head zoo keeper and you are doing the rounds with another keeper. You realise that one of the cleaners has left the lions' cage open by mistake. You see that a lion is coming towards the open gate and you do not have time to close it. There are three visitors right in front of the gate. It is possible to prevent the lion from getting out by blocking it.

PUSH KEEPER AGAINST GATE	DO NOT PUSH KEEPER AGAINST GATE
Prevent lion from getting out.	Do not prevent lion from getting out.
Keeper will die.	Three visitors will die.

Instrumental-Self Dilemmas

Climbers
You are the fourth in a team of five mountaineers involved in a climb. The head of the team has just secured himself to the rock face when the second in the team starts to slide, pulling you, and the others, with him. You all fall for tens of metres and stop suspended above a crevasse. Your weight is too much and the rope is not going to resist for long.

CUT THE LAST CLIMBER	DO NOT CUT THE LAST CLIMBER
Lighten the load.	Do not lighten the load.
Last climber will die.	You and two others die.

Helicopter
You are the pilot of a helicopter taking four people on a sight-seeing trip in the French Alps, at an altitude of about 2,000 metres. At a certain point, the helicopter loses altitude and no longer responds to the commands. You send out a mayday signal and try various manoeuvres, but the helicopter continues to fall and risks crashing into a rock face. To gain altitude you need to lighten the load.

PUSH SOMEONE OUT OF HELICOPTER	DO NOT PUSH A PERSON OUT OF HELICOPTER
Load lightened.	Load not lightened.
One person will die.	You and four others will die.

Frisbee
You are in a field playing frisbee with three young people you have just met. Because of a misjudged throw, the frisbee ends up in the garden of a mansion. You decide to climb the wall to look for it. Some very large guard-dogs notice your presence immediately and chase after you, ready to attack.

PUSH ONE PERSON ON THE GROUND	DO NOT PUSH ONE PERSON ON THE GROUND
Dogs will attack one person.	Dogs will attack everyone.
One person will die.	You and three others will die.

Fireworks
You own a shop which sells fireworks. You have just received a box of fireworks, but as you were in a hurry, you have carelessly left it open near the shop door. Five customers are waiting. Another customer enters the shop. Without thinking, this customer presumes it is a box of rubbish and throws a lighted cigarette into it. The box is about to explode. In order to minimize the impact you must block the box, however the only thing large enough to do this is another customer.

PUSH CUSTOMER INTO	DO NOT PUSH CUSTOMER INTO BOX

Impact of explosion deadened.	Impact of explosion not deadened.
Customer will die.	You and six others will die.

Crocodile

You are in Africa on holiday with four other tourists and two local guides. One of the jeeps has broken down and the guide has left with the other to get help. While waiting, you decide to cross to the other side of the river in a small boat which you have found on the banks. Halfway across, you catch sight of two large crocodiles. The first violent flick of a tail almost tips the boat over. It is possible to prevent the crocodiles tipping the boat over by distracting them.

THROW ONE PERSON INTO WATER	DO NOT THROW ONE PERSON INTO WATER
Crocodiles will attack one person.	Crocodiles will tip boat over.
Everyone else will escape.	No one will escape.
One person will die.	You and five others will die.

Himalayas

You are on a trip to Nepal with some other tourists. Your aeroplane has crashed in the Himalayas and only five of you have survived. You have no food and the temperature is below zero. The only possibility of surviving is to go as quickly as possible on foot to a small village on the other side of the mountain. In these conditions if you are too slow you will freeze. One of the survivors is injured and is slowing you down.

SHOOT INJURED PERSON	DO NOT SHOOT INJURED PERSON
Reach the village.	Do not reach the village.
Injured person will die.	You and five others die.

Jeep

You are in charge of an expedition which is crossing the Sahara. A sand storm causes your jeep to swerve off the road and overturn in the middle of the desert. You know that the nearest oasis is a week's walk away. There are eight of you and a very limited amount of water, which will not allow you all to survive the scorching heat.

SHOOT TWO PEOPLE	DO NOT SHOOT TWO PEOPLE
Enough water for remaining group.	Not enough water for group to
to reach oasis.	reach oasis.
Two people will die.	You and seven others will die.

Hot air balloon

You are passing over the Swiss Alps in a hot air balloon together with four other people.

You have just reached an altitude of 2,000 metres. At a certain point you become aware of a malfunction which is causing you to lose altitude faster and faster. You are moving towards a very big mountain chain and if you cannot gain altitude quickly, the balloon will crash into the rock face. You need to lighten the load in order for the balloon to ascend.

THROW A PERSON OVERBOARD	DO NOT THROW A PERSON OVERBOARD
Avoid rock face.	Hit rock face.
One person will die.	You and four others will die.

Dangerous Platform

You are the foreman of a construction company and are checking on the work of a team on the top floor of a skyscraper. At a certain point, you realise that a steel cable is about to give way. This cable supports the external platform where you are, and the five men working on a support structure. It is possible to prevent the cable giving way by lightening the load.

THROW WORKER OFF PLATFORM	DO NOT THROW WORKER OFF PLATFORM
Cable does not give way.	Cable gives way.
One person will die.	You and five others will die.

Kidnap and Escape

You are travelling in Yemen. You and another six tourists are taken hostage by a group of terrorists. The terrorists think that one of you is a spy, even though this is not true. You are held hostage for days. One of the terrorists comes to you and reveals that they intend to kill you all at sunset, unless you eliminate the spy.

KILL ONE PERSON	DO NOT KILL ONE PERSON
Remaining people freed.	No one freed.
One person will die.	You and six others will die.

Sacrifice

You are the head of a group of five travellers who are exploring the remote regions of South America. During the trip, you inadvertently camp in the sacred cemetery of a local tribe. The members of the tribe capture you and condemn you all to death. After some negotiation, they propose a possible alternative in the form of a human sacrifice that will pacify their god who has been offended.

SACRIFICE ONE PERSON	DO NOT SACRIFICE ONE PERSON
Remaining people freed.	No one freed.
One person will die.	You and five others will die.

Trail of Blood
You are part of a team of six bomb disposal experts who are detonating an underwater mine. While you are underwater, a cable snaps causing a deep gash in one of the expert's hand. The blood in the water starts to attract some sharks which are in the area. The injured expert starts to swim towards the only shark-proof cage available, while the rest of you are some way behind. If the expert reaches the cage, the trail of blood will cause the sharks to attack you and the remaining team.

SHOOT THE EXPERT	DO NOT SHOOT THE EXPERT
Sharks will attack expert.	Sharks will not attack expert.
One person will die.	You and four others will die.

Life boat
You are in a ship which is crossing the Atlantic Ocean in the direction of South America. A fire has just broken out on board and everyone must immediately go to the lifeboats to be rescued. In the rush, too many people have climbed aboard some of the lifeboats, which are sinking. The life-boat you are on quickly starts to take on water.

THROW TWO PEOPLE OVERBOARD	DO NOT THROW TWO PEOPLE OVERBOARD
Load lightened, ship does not sink.	Load not lightened, ship sinks.
Two people will die.	You and others will die.

Chairlift
You are returning from a mountain hut by chairlift with three other people, when a storm breaks out. Lightning hits the cable. The chairlift stalls and you are stuck swinging in the air at a height of tens of metres. The mechanism which fixes your chair to the cable has been seriously damaged and is starting to disintegrate. The cable will not collapse if you lighten the load.

PUSH ONE PERSON OFF	DO NOT PUSH ONE PERSON OFF
Chairlift does not fall.	Chairlift falls.
One person will die.	You and three others will die.

Submarine
You are the commander of a Russian military submarine on a mission. You have been trapped for days at the bottom of the Pacific Ocean without energy. You have already asked for help several times, but there are no ships or submarines in the nearby waters and help is taking time to arrive. There are six crew members with you on board and your food supplies are getting low. The food supplies will not be enough for you and the rest of the crew to wait for help.

SHOOT ONE CREW	DO NOT SHOOT ONE CREW MEMBER

Food supplies last till help arrives.
One person will die.

Food supplies do not last.
You and six others die.

B. Additional Stimuli for Experiment 2

Incidental-Other Dilemma

Gas
You are a commander on a submarine travelling through the North Atlantic Ocean. During a routine check a worker has accidentally damaged the ventilation system in the maintenance compartment. This has caused poisonous gas to flood a neighbouring compartment where five people are asleep. It is possible for you to press a switch and shift the airflow back into the compartment where one worker stands.

PRESS THE SWITCH	DO NOT PRESS THE SWITCH
Poisonous gas floods maintenance compartment.	Poisonous gas stays in sleeping compartment.
One person will die.	Five people will die.

Incidental-Self Dilemma

Sidewalk
You are a policeman standing on a sidewalk with three other people. You notice that a truck driver has swerved to avoid hitting an oncoming car and has locked his wheels. If he continues on his current directory he will crash into you and the two other people. It is possible to change the direction of the truck, but only by shooting the wheels of the vehicle, which will cause the truck to flip.

SHOOT THE WHEELS	DO NOT SHOOT THE WHEELS
Truck flips.	Trucks continues its trajectory.
Pedestrians avoided.	Truck driver survives.
Truck driver will die.	You and three others will die

Instrumental-Other Dilemma

Bank Robber
You are a hostage negotiator working with a bank robber who has taken a group of five people hostage. In order for you to enter the building and free the hostages through the back door you must distract the robber. You notice a man walking along the front of the bank about to enter, unaware of the circumstances. This would distract the robber, but the man would be killed instantly.

ALLOW THE MAN TO ENTER	DO NOT ALLOW THE PERSON TO ENTER
Hostages will be rescued.	Hostages will not be freed.
One person will die.	Five people will die.

Instrumental-Self Dilemma

Soldier
You are the leader of a small group of soldiers. You are on your way back from a mission in enemy territory when one of your men steps in a trap that catches his leg, injuring him badly. You cannot free him without killing him. If you leave him behind enemy soldiers will torture him until he reveals the position of your camp.

SHOOT THE SOLDIER	DO NOT SHOOT THE SOLDIER
Cannot reveal location of camp.	Reveals the location of camp.
One person will die.	People in the camp will die.

C. Ethical Approval

MACQUARIE University

SAMANTHA PARKER <samantha.parker@students.mq.edu.au>

RE: Ethics Amendment 1 - Approved (Ref No. 5201300060)

3 messages

Fhs Ethics <fhs.ethics@mq.edu.au> 19 December 2013 at 15:56
To: Associate Professor Matthew Finkbeiner <matthew.finkbeiner@mq.edu.au>
Cc: Ms Genevieve Quek <genevieve.quek@mq.edu.au>, Miss Shahd Al-Janabi <Shahd.Al-Janabi@mq.edu.au>, Ms Marina Butko <marina.butko@mq.edu.au>, Mr Manjunath Narra <manjunath.narra@students.mq.edu.au>, Ms Daniell Steinberg <daniell.steinberg@students.mq.edu.au>, Ms Samantha Parker <samantha.parker@students.mq.edu.au>

Dear Ms Quek and Dr Finkbeiner,

RE: 'Attention, Intention and Automaticity ' (Ref: 5201300060)

Thank you for your recent correspondence regarding the amendment request. The amendments have been reviewed and we are pleased to advise you that the amendments have been approved.

This approval applies to the following amendments:

1. Change in personnel
a) Dr Brenda Ocampo, Mr Anthony Espinosa and Ms Lucy Shi removed from the project;
b)Ms Daniell Steinberg, Ms Samantha Parker, Ms Irene Chork added to the project;
2. Revised Information and Consent form.

Please accept this email as formal notification that the amendments have been approved. Please do not hesitate to contact us in case of any further queries.

All the best with your research.

Kind regards,

FHS Ethics
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Genevieve Quek <genevieve.quek@mq.edu.au> 19 December 2013 at 16:13
To: Associate Professor Matthew Finkbeiner <matthew.finkbeiner@mq.edu.au>
Cc: Miss Shahd Al-Janabi <Shahd.Al-Janabi@mq.edu.au>, Ms Marina Butko <marina.butko@mq.edu.au>, Mr