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THE INFLUENCE OF ACCOUNTABILITY ON MANAGERIAL MYOPIA

DOCTORAL DISSERTATION

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AUTHORSHIP STATEMENT

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»Great ideas need landing gear as well as wings«
(C. D. Jackson)

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SUMMARY

Today, organisations increasingly stimulate their employees with various implicit and explicit *social* incentives. However, the management accounting and the cognitive psychology literatures almost exclusively focus on the effects of monetary incentives on cognitive effort and performance.

The aim of this dissertation is to gain understanding of how accountability affect managerial cognition, decision-making, and myopic tendencies. Therefore, we analyse monetary incentives and several types of social incentives that affect the accountability systems in organisations.

Following recent developments in economics, management accounting, social and cognitive psychology, and neuroscience, the goal of the dissertation is to determine how imposing accountability affects fundamental executive functions denoted as cognitive control and whether it can successfully mitigate managerial short-sightedness.

This dissertation covers three research projects on monetary and social incentives to better understand their comparable and distinct effects in relations to cognitive control and delay and probability discounting as a direct measure of myopic behaviour. The dissertation's hypotheses were tested experimentally on students in two classroom experiments and also more directly on managers using functional magnetic resonance imaging (fMRI).

The PhD thesis is organised as follows: In the first chapter, we compare the effects of social pressure, i.e. transparency of results and their identifiability, and a monetary incentive on cognitive control. While the research shows that monetary incentives contribute to goal-oriented behaviour by activating a proactive control mode, there is much less evidence of how social pressure affects cognitive control and task performance. Of the students, 47 performed the AX-CPT task to compare the activation of cognitive control modes under social pressure and a monetary incentive beyond mere instructions to perform better. Our results indicate that instructing participants to improve their performance on its own leads to a significant shift from a reactive to a proactive control mode and that both social pressure and a monetary incentive further enhance performance.

In the second chapter, we investigate the neural bases of the social incentive effect. Specifically, we investigate whether two social incentives—charity donation and public ranking of participants' performance—invoke similar neuronal activity as the monetary incentives studied in the literature. 30 financial professionals performed the Flanker task during functional magnetic resonance imaging. The central subtask was to mobilise selective attention and inhibitory control. Overall, the results show that the effect of social incentives is comparable to monetary incentives and that they lead to improved cognitive performance, increased attention, improved motor and attentional control as well as conflict resolution and inhibition. Both social incentives have comparable effects.

In the third chapter, we examine the impact of accountability on managerial myopia that is measured as managerial tolerance of delay and risk-taking. We use a within-subjects experiment on 147 students with delay discounting and probability discounting choice tasks. We operationalise accountability as a justification pressure. The findings support our hypotheses about the mitigating effect of accountability on myopic behaviour. We find that accountability decreases excessive discounting of risky and delayed outcomes and contributes to the use of more consistent discount rates. Our findings indicate that in contrast to some performance evaluation mechanisms that exacerbate myopic behaviour, justification pressure reduces the excessive subjective discount rates for time delay and risk that makes it more consistent in priming the participants to think harder about their choices.

Overall, the results of this dissertation show that accountability in the form of various social incentives improves cognitive performance, induces proactive control, increases attention and inhibition and thus, due to enhanced cognitive control, successfully mitigates managerial short-sightedness. The findings of this dissertation contribute to the limited body of knowledge on the effectiveness of management accounting mechanisms to undo behavioural biases, that is, managerial myopia. The implication of its findings is that practising accountants and supervising managers should bring in more accountability, justification pressure, and other social incentives that have a positive influence on cognitive control and reasoning, and they should de-emphasise the short-term maximisation of bonuses.

Keywords: accountability, managerial myopia, cognitive control, delay and probability discounting, monetary incentive, social incentive, functional magnetic resonance imaging (fMRI)

POVZETEK

Danes organizacije vse bolj pogosto spodbujajo svoje zaposlene z različnimi implicitnimi in eksplicitnimi *družbenimi* spodbudami. Vendar se pri kognitivnem naporu in uspešnosti literatura poslovodnega računovodstva in kognitivne psihologije osredotočata skoraj izključno na učinke denarnih spodbud.

Namen pričujoče disertacije je razumeti, kako lahko uvedba odgovornosti vpliva na kognicijo managerjev, sprejemanje odločitev in tendence kratkovidnosti. Poleg denarne spodbude v prvem poglavju smo se odločili za proučevanje več vrst družbenih spodbud, ki so pomembne v okviru sistemov odgovornosti v organizacijah. Preučevali smo spodbude, kot so navodila nadzornika, zahteva po utemeljevanju, rangiranje in donacija, v smislu delati dobro za druge, ne za lastno korist.

Glede na najnovejši razvoj na področju ekonomije, poslovodnega računovodstva, socialne in kognitivne psihologije ter nevroznanosti, je cilj doktorske raziskave ugotoviti, kako uvedba odgovornosti vpliva na temeljne izvršilne funkcije, ki jih predstavlja kognitivni nadzor, in ali z uvedbo odgovornosti lahko ublažimo kratkovidnost managerjev v odločanju.

Disertacija zajema tri raziskovalne projekte o denarnih in družbenih spodbudah, da bi bolje razumeli njihov primerljiv in razločevalni učinek na kognitivni nadzor in časovno in verjetnostno diskontiranje kot neposredno merilo kratkovidnega vedenja. Hipoteze smo preverili v dveh laboratorijskih eksperimentih na študentih ter z eksperimentom na izkušenih strokovnjakih s področja financ in računovodstva z uporabo funkcijskega slikanja možganov v magnetni resonanci (fMR).

Doktorska disertacija ima naslednjo strukturo: V prvem poglavju nas zanima, kako družbeni pritisk, izražen kot zahteva po transparentnosti rezultatov in njihovi opredeljivosti, bolj kot preprosta navodila za večjo učinkovitost, vpliva na način kognitivnega nadzora in kognitivno uspešnost v primerjavi z denarnimi spodbudami. Zasnovali smo preizkus, kjer je 47 študentov opravljalo nalogo vzdrževane pozornosti (AX-CPT naloga), ki omogoča merjenje načina kognitivnega nadzora. Iz rezultatov je razvidno, da navodilo udeležencem, "delaj bolje", vodi do znatnega premika od reaktivnega do proaktivnega načina nadzora, ter da družbeni pritisk in denarne spodbude dodatno izboljšujejo učinkovitost.

V drugem poglavju preučujemo nevrološke osnove učinka družbene spodbude. Posebej nas zanima, ali dve družbeni spodbudi – dobrodelna donacija in javno razvrščanje udeležencev po uspešnosti – sprožijo podobno dejavnost nevronov kot denarne spodbude, proučevane v obstoječi literaturi. 30 finančnih strokovnjakov je med funkcionalno magnetno resonanco opravljalo nalogo selektivne pozornosti (Flanker naloga), ki omogoča merjenje kognitivnega napora, načina kognitivnega nadzora in sposobnost inhibicije pred motečimi dražljaji. Na splošno rezultati kažejo, da so družbene spodbude po učinku primerljive z denarnimi spodbudami in da vodijo do boljše kognitivne učinkovitosti, povečane pozornosti,

izboljšanega nadzora motorike in pozornosti pa tudi do reševanja in omejevanja konfliktov. Obe družbeni spodbudi imata primerljive učinke.

V tretjem poglavju proučujemo vpliv odgovornosti na kratkovidnost managerjev v odločanju, merjeno kot naklonjenost do časovnega odloga in tveganja. Izvedli smo eksperiment na 147 študentih in pri tem uporabili nalogo za merjenje časovnega in verjetnostnega diskontiranja. V tej raziskavi smo kot odgovornost vpeljali zahtevo po utemeljitvi sprejetih odločitev. Ugotovitve podpirajo naše hipoteze o uspešnem učinku uvedbe odgovornosti na kratkovidno usmerjeno vedenje. Ugotovljeno je, da odgovornost zmanjšuje pretirano diskontiranje tveganih in odloženih izidov in prispeva k uporabi bolj doslednih diskontnih stopenj. V nasprotju z nekaterimi mehanizmi ocenjevanja učinkovitosti, ki krepijo kratkovidnost managerjev, naše ugotovitve kažejo, da zahteva po utemeljitvi zmanjšuje pretirane subjektivne diskontne stopnje za časovni odlog in sprejemanje tveganj ter poveča njihovo doslednost na način, da preko izboljšanega kognitivenga nadzora odločevalca usmerja v intenzivnejše razmišljanje o svojih izbirah.

Rezultati vseh treh raziskovalnih projektov na splošno kažejo, da odgovornost kot družbena spodbuda izboljša kognitivno učinkovitost, aktivira proaktivni nadzor, poveča pozornost in inhibicijo in s tem uspešno blaži kratkovidnost managerjev. Ugotovitve disertacije prispevajo k omejenemu znanju o učinkovitosti sistemov odgovornosti namenjenih za usmerjanje managerskega vedenja pri odpravljanju vedenskih pristranskosti kot je kratkovidnost v odločanju. Uporabnost naših ugotovitev za prakso je v vzpostavitvi večje odgovornosti, uvedbi zahteve po utemeljitvi in drugih družbenih spodbudah, ki imajo pozitiven vpliv na kognitivni nadzor in sklepanje ter zmanjšajo osredotočenost na kratkoročno maksimiziranje bonusev.

Ključne besede: odgovornost, kratkovidnost managerjev, kognitivni nadzor, časovno in verjetnostno diskontiranje, denarna spodbuda, družbena spodbuda, funkcionalna magnetna resonance (fMR)

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INTRODUCTION

Managers frequently make decisions that essentially require a comparison of immediate, relatively certain, consequences with future relatively uncertain ones. A vast number of studies indicates that managers are myopic in making those decisions. *Managerial myopia* denotes the tendency of managers to redirect resources from sustainable long-term value maximising projects to short-term projects (e.g., Chowdhury, 2011; Narayanan, 1985). This short-sightedness of managers is a well-known phenomenon and is an example of dysfunctional managerial decision-making. At the same time, the tendency is not well understood. This dissertation aims to enhance the understanding of myopia, in particular, to find effective remedies for this behaviour.

The management accounting and behavioural economic research have provided pervasive evidence on the characteristics of performance evaluation systems that may aggravate myopic behaviour instead of alleviating it (Bernatzi & Thaler, 1995; Bhojraj & Libby, 2005; Edmans, Heinle, & Huang, 2016; Gigler, Kanodia, Sapra, & Venugopalan, 2014; Graham, Harvey, & Rajgopal, 2005; Hermalin & Weisbach, 2012; Kraft, Vashistha, & Venkatachalam, 2018; Thaler, Tversky, Kahneman, & Scheartz, 1997). Frequent performance evaluations, overemphasis on financials, and aggressive performance-based incentives are such examples. Myopia, however, can also be a cognitive constraint that stems from human evaluation of the distant future (Ardila, Rosselli, & Strumwasser, 1991; Bickel, Yi, Landes, Hill, & Baxter, 2011; Chi & Fan, 1997; Simon et al., 2002; Tversky & Kahneman, 1974).

The current understanding of myopia suggests that it is a form of behavioural bias that uses a time-inconsistent discounting factor and an overestimation of risk. When choosing between two projects that deliver profits at different points in time, individuals (not just managers) are likely to prefer the soonest option, even if the economic value is lower. This is called the delay aversive behaviour. Decision-makers also typically prefer smaller certain outcomes over economically more attractive but riskier outcomes, which is known as risk aversion. Both effects describe the myopia phenomenon but do not provide an explanation for such behaviour.

Fundamental drivers of myopia can be found in the role of impulsivity, the fear associated with uncertainty, the involvement of emotions in decision-making, the use of intuition to recognise patterns, the use of heuristics in complex decisions involving time and limited cognitive resources needed to fully and objectively evaluate future outcomes. In traditional economics these factors are all labelled as ‘irrational decision-making’ that deviates from value maximising decision-making, but the underlying causes are not uniform and require a more thorough examination of human cognition.

Neuroeconomics increasingly acknowledges that rational decision-making is the exception rather than the rule and that emotions are frequently involved in almost every decision (Forgas, 1995). According to Loewenstein, Lerner, Davidson, Goldsmith, and Scherer (2003), human decisions are to a large extent intuitive rather than analytical and are heavily influenced by emotions and by cognitive processes that are far more complex than the assumption of rationality allows for. Kahneman (2011) in his dual process theory postulates that thoughts arise in two distinct ways. The author argues that these two systems underlay thinking and reasoning—system 1 is fast, instinctive, emotional, and subconscious; system 2 is slower, more deliberative, logical, and conscious. Even though normative theory assumes rational decision-making, according to Kahneman (2011) people make most of their decisions in system 1 and only certain events can make them temporarily switch to system 2. There is no simple solution that controls this switch. Moreover, rationality is not always helpful. Good managerial decisions are not only a result of cold cognition and activation of system 2 but are the outcomes of a complex mix of rational and affective reactions.

Neuroeconomics has typically studied decision-making in systems 1 and 2 as the activation of the so-called emotional brain, that is, the limbic system versus the activation of the prefrontal cortex. Yet, this is based on the outdated concept in the neuroscience from the middle of the twentieth century on how a brain functions. Contemporary approaches focus on cognitive control. Cognitive control represents executive functions that enable flexible goal-directed behaviour via maintaining information, monitoring the environment, switching between task goals, utilising relevant information that supports accomplishment of a task, and providing resistance to task-irrelevant information (Banich, 2009; Botvinick et al., 2001). It is related to number of processes such as goal setting, attentional and inhibitory control, activation of working memory, reasoning, problem-solving, and planning and execution. Cognitive control facilitates the flexible regulation of thoughts and actions in pursuit of behavioural goals and suppresses habitual behaviour if not in the scope of the goal (Braver, 2012; Chiew & Braver, 2011; Cohen, Braver, & O'Reilly, 1996; Miller & Cohen, 2001). Cognitive control is executed by the network of functionally connected brain regions. Thus, our focus in the dissertation is on *cognitive control*, a fundamental mechanism of cognition.

Understanding how myopia can be counteracted requires a better knowledge of how managers can be made *accountable* for their decisions, such that their decision quality is improved through the enhancement of cognitive control.

Accountability, or the expectations of decision-makers that they will be called on to justify their behaviour to others (Lerner & Tetlock, 1999), is a constitutive element of every form of human organisation. A potential evaluation by others is one of the most powerful factors that influences human decision-making (Tetlock, 1985). People's natural tendency is to behave in conformity with the expectations of those to whom they are accountable. In the management literature, accountability is described as the system by which individuals report to a recognised authority and are held responsible for their actions (Edwards & Hulme, 1996;

Fox & Brown, 1998). These systems heavily rely on management accounting tools and processes and the control cycle of planning for desired results: budgeting, performance evaluation, and allocating rewards for specific results. A common belief stresses that accountability makes an individual think more carefully that in turn enhances their cognitive effort (Simonson & Nye, 1992) and thus leads to better decision-making (Vieider, 2009, Parker, Carvalho, & Rohwedder, 2013; Pahkle, Strasser, & Vieider, 2015) and improved performance (Latham & Locke, 2006; Samuel, 2006). However, in practice opposite effects often occur (e.g., Curley, Yates, & Abrams, 1986; Trautmann, Vieider, & Wakker, 2008; Baltussen, van den Assem, & van Dolder, 2010; Weigold & Schlenker, 1991, Collins & Collins, 2002; Sen, 2008), which indicates that the effects of accountability are also theoretically not well understood. This lack of understanding of the consequences of different accountability systems is in stark contrast with the trend to implement various mechanisms wherever they seem needed to control human behaviour. To fully understand and to properly and effectively implement accountability, further research on its effects on cognitive control is clearly needed.

Although accountability mechanisms can be designed in various ways, they all fundamentally rely on the use of positive and negative *incentives*, which are often monetary or *social*. While management accounting and cognitive psychology have copious studies on monetary incentives, the effect of social incentives on cognitive control and behavioural performance has received little attention despite their significant role in organisations. Organisations should have a critical need to implement an appropriate accountability system to enhance cognitive control and, thus, control managers' propensity to optimise the present at the expense of the future.

Following recent developments in psychology, neuropsychology, and neuroeconomics, the objective of this research project is to determine how imposing accountability in the form of various social incentives affects cognitive control and how it ultimately mitigates managerial myopia. In three research projects, we study several different social incentives to better understand their comparable and distinct effects on the cognitive control mode, inhibition, and attention by using delay and probability discounting as direct measures of myopic behaviour. Our hypotheses were tested experimentally on students in classroom experiments and more directly on managers using functional magnetic resonance imaging (fMRI). To analyse the research problem thoroughly, we focus on three different, although related, topics. We provide the following brief outline of the three chapters below.

In the first chapter, we investigate how *social pressure* influences the cognitive control mode compared to a monetary incentive beyond simple authority instructions to perform better. In the second chapter, we investigate the neural bases of the social incentive effect by using the fMRI. The main objective is to provide neuroscientific evidences for the effects of social incentives on the reinforcement of cognitive control. We focus on the question of whether two social incentives — *charity donation* and *public ranking* of participants' performance — invoke similar neuronal activity as the monetary incentives studied in the literature. In the third chapter, we focus on the question of how to mitigate myopic tendencies with *justification pressure*. Such pressure also belongs to the class of social incentives that is frequently used by organisations either on a standalone basis or in combination with monetary incentives. The main objective of the third study is to understand to what extent accountability through the enhancement of cognitive control can mitigate persistent psychological patterns that encourage myopic behaviour.

This dissertation is aimed to be interdisciplinary: in the search for novel insights it fruitfully combines several disciplines. It does not only address accounting questions from a different perspective, but it also brings accounting context to other disciplines. The first and the second chapter heavily lean on the knowledge and methods from cognitive psychology and neuroscience. The third chapter is intended to highlight the problem of managerial myopia by investigating delay and probability discounting, a well-known phenomenon not only in behavioural economics but also in psychology. All three chapters of the doctoral dissertation are prepared as individual papers within guidelines of targeted journals, which is why the structure, the style of writing and citing slightly differ.

1 THE IMPACT OF SOCIAL PRESSURE AND MONETARY INCENTIVE ON COGNITIVE CONTROL[1]

Abstract

We compare the effects of two prominent organizational control mechanisms— social pressure and monetary incentive —on cognitive control. Cognitive control underlies the human ability to regulate thoughts and actions in the pursuit of behavioural goals. Previous studies show that monetary incentives can contribute to goal-oriented behaviour by activating proactive control. There is, however, much less evidence of how social pressure affects cognitive control and task performance. In a within-subject experimental design, we tested 47 subjects performing the AX-CPT task to compare the activation of cognitive control modes under social pressure and monetary incentive beyond mere instructions to perform better. Our results indicate that instructing participants to improve their performance on its own leads to a significant shift from a reactive to a proactive control mode and that both social pressure and monetary incentive further enhance performance.

Keywords: monetary incentives, social pressure, cognitive control, proactive index, AX-CPT

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[1] The paper is co-authored with Sergeja Slapničar, Grega Repovš (University of Ljubljana) and Frank Hartmann (Erasmus University Rotterdam) and has been published in Frontiers in Psychology (IF = 2.089) in February 2016. https://doi.org/10.3389/fpsyg.2016.00093

1.1 Introduction

Organizations often implement formal control mechanisms to enhance the performance of their employees. Although such mechanisms can be designed in various ways, they all fundamentally rely on the use of positive and negative incentives, which are often monetary or social. Their positive effect on performance is thought to occur because they induce increased cognitive effort in employees (Curley et al., 1986; Trautmann et al., 2008; Vieider, 2009). However, the limited effectiveness of incentive-based organizational control systems is increasingly acknowledged in the management control literature. The reason may lie in the fact that control systems are predominantly designed to stimulate goal-oriented behaviour with performance contingent incentives, whereas in a growing number of tasks the best performance is achieved by flexible adaptation to a changing environment. Performance contingent incentives may, for example, suppress learning and creativity at the individual level, thereby hampering social and economic innovation in organizations and society (Collins & Collins, 2002; Sen, 2008). Thus far, no simple control solution has been found to regulate this. Mainstream management control literature still associates human decisions that deviate from goal-oriented behaviour, those that are flexible and influenced by emotions (Loewenstein & Lerner, 2003) with weaker impulse, emotional and cognitive control.

This lack of understanding of the consequences of different incentives is in stark contrast with the trend to implement various mechanisms wherever they seem needed to control human behaviour. To fully understand and to properly and effectively implement management control, further research on their effects on fundamental cognitive processes is needed. In this study, we focus on the ability to engage cognitive control and to change cognitive control strategies in response to monetary incentives and social pressure. Social pressure arises from mere identifiability of results and performance evaluation by others (Lerner & Tetlock, 1999), which in turn may create anxiety or a fear of failure. The effect of social pressure on performance is not straightforward. For example, Schmid et al. (2015) report that fear of public embarrassment and negative evaluation, born out of the need to perform well in front of others may, paradoxically, impair performance. On the other hand, transparent performance evaluation in organizations is found to positively affect performance (Latham & Locke, 2006). Given the ever-increasing amounts of money spent to incentivize managers, we were specifically interested in the effect of social pressure compared to monetary incentives on cognitive control and the enhancement of cognitive performance. While the effect of monetary incentives has been extensively documented in cognitive psychology (Locke & Braver, 2008; Braver et al., 2009; Dambacher et al., 2011; Padmala & Pessoa, 2011; Chiew & Braver, 2013, 2014; Fröber & Dreisbach, 2014), the effect of social pressure on performance in cognitive tasks has received little attention. To the best of our knowledge, these two types of incentives have not yet been directly compared within a single study. To account for their specific effects, we contrast them to the effects of mere instructions.

Cognitive control denotes the ability to manage one's own cognitive processes and is typically related to a number of processes such as working memory, reasoning, problem-solving, task flexibility, planning, and execution (Cohen et al., 1996; Braver & Barch, 2000; Botvinick et al., 2001; Miller & Cohen, 2001; Braver et al., 2002). It enables the regulation of thoughts and actions in pursuit of behavioural goals (Braver, 2012). It is essential in directing attention to a stimulus, shifting response strategies according to changes in the environment, and inhibiting more automatic or habitual response tendencies (Robertson et al., 2015). Cognitive control is exerted to supersede self-serving impulses and engage in socially desirable behaviour (Pitesa et al., 2013). It is, hence, one of the most important determinants of efficient goal directed cognitive and behavioural performance.

According to the Dual Mechanism of Control theory (DMC; Braver et al., 2007), cognitive control operates through two distinct operating modes: proactive and reactive control (Braver & Barch, 2002; Braver et al., 2009; Braver, 2012). The proactive mode is future-oriented, helping to prepare the cognitive system for forthcoming events through the predictive use of current context. The processing of information occurs in a sustained, goal-oriented way. In contrast, reactive control is retrospective, backward-looking and reacts to the presence of urgent events by engaging control only if needed. Thus, the processing of information occurs in a more automatic, stimulus-driven, transient, and reflexive fashion (Braver, 2012). Whereas proactive control is based on anticipating and preparing for certain situations and events before they occur, reactive control is based on detecting conflict and implementing a response after its onset. Braver et al. (2007) hypothesize that a cognitive system's default mode is reactive control since it is usable in more situations and has lower demands on metabolic resources. In contrast, the proactive control mode is only temporarily invoked in more complex situations that demand more cognitive effort. DMC presents a useful framework for explaining dynamic shifts in the use of cognitive strategies in response to various stimuli.

Extensive research provides robust evidence that monetary incentives activate the proactive control mode (Locke & Braver, 2008; Braver et al., 2009; Engelmann et al., 2009; Jimura et al., 2010; Padmala & Pessoa, 2011; Chiew & Braver, 2013, 2014; Fröber & Dreisbach, 2014). Neuroscientific studies suggest that proactive and reactive control can be clearly distinguished in the activity of different brain regions (Braver et al., 2007, 2009). Proactive control, directed to reward maximization, is associated with increased sustained activity in the dorsolateral prefrontal cortex (DLPFC), which is believed to be central in actively maintaining goals and instructions. It influences information processing in other brain regions in line with maintained information. The DLPFC is interconnected with the midbrain dopamine (DA) system, the anterior cingulate cortex (ACC) and the medial temporal lobe complex. The constant firing of the DA system that signals reward-related salience of predictive cues ensures a sustained activity of the DLPFC. Reactive control, on the other hand, is not oriented to maximizing rewards but to resolving interference. The dorsal ACC (dACC) is associated with conflict monitoring. When detecting a response conflict or an impending error, it rapidly signals the need for increased control to the DLPFC on the current trial and is only transiently activated (Sawaguchi et al., 1988; Sawaguchi & Goldman-Rakic, 1991; Arnsten et al., 1994; Schmid et al., 2015).

There is contradictory evidence of how social pressure contributes to goal-oriented cognition and behaviour. The identifiability of results is known to be influential in directing agents' behaviour. As argued by Lerner and Tetlock (1999), the mere presence of a superior and knowledge of his/her expectations elicits conforming behaviour. Moreover, setting ambitious goals, which are accepted by the employee, can be a powerful driver of performance improvement (Latham & Locke, 2006). People's natural tendency to behave in conformity with the expectations of those they are accountable to, albeit without an explicit monetary incentive, has been documented by a large body of research (Cialdini et al., 1976; Tetlock, 1983; Tetlock et al., 1989; Klimoski & Inks, 1990; Quinn & Schlenker, 2002). The reason for such behaviour may lie in a broader definition of motivation according to which both the anticipation of a possible reward or the avoidance of sanctions facilitate behaviour (Taylor et al., 2004).

According to other accounts (e.g., Hickman & Metz, 2015; Schmid et al., 2015) the transparency of results and their identifiability may be perceived as a socially threatening stimulus, which requires conflict processing during task execution. Schmid et al. (2015) report that individuals who are more sensitive to such pressures rely more heavily on a reactive control strategy driven by conflict-processing dACC activity and that socially anxious individuals show poorer performance compared to less anxious ones in cognitive tasks that require goal-directed behaviour. Hickman and Metz (2015) analysed a phenomenon common in sport, but also in other contexts, whereby large rewards and expectations create such psychological pressure that the performance eventually worsens (known as choking). They recognize that the intertwining effects of explicit monitoring and high rewards are difficult to disentangle, but after controlling for them, they provide evidence of a negative relationship between the size of the reward and the performance.

To investigate how social pressure influences cognitive control modes and cognitive performance compared to monetary incentive beyond simple instructions to perform better, we employed a within-subjects experimental design in which 47 students performed the AX-Continuous Performance Task (AX-CPT; Cohen & Servan-Schreiber, 1992; Servan-Schreiber et al., 1996; Braver et al., 2001) under social pressure, monetary incentive, and a control condition (instructions only). This cognitive task measures goal representation, maintenance, and information updates, and has often been used to examine underlying modes of cognitive control (Barch et al., 1997; Braver et al., 2001, 2005; Braver & Bongiolatti, 2002; McDonald & Carter, 2003; Paxton et al., 2006, 2008; Locke & Braver, 2008). Due to conflicting evidence regarding social pressure on cognitive performance, we did not have strong *a priori* predictions related to its effect on cognitive control strategy and performance.

1.2 Materials and methods

1.2.1 Participants and task

Fifty-six undergraduate students (age *M* = 21.96, *SD* = 1.76, range = 18–27 years; 19 male) majoring in Accounting, Management, and Finance at the Faculty of Economics at the University of Ljubljana took part in the study. Their work experience ranged from 0 to 9 years (*M* = 2.95, *SD* = 2.36). Participants were invited to participate in the study as an opportunity to earn course credits. Linked to their task performance, students could also earn monetary reward ranging between EUR 0 and EUR 6. The average amount earned was EUR 3.7 for 45 min of activity, which approximately corresponds to the hourly rate for student work. All participants were informed that their participation was voluntary and that they were free to withdraw from the study at any point. They gave written informed consent prior to participation in the study. The study and the procedures followed were in accordance with the Helsinki Declaration as revised in 2013.

Nine participants (16.07%) were eliminated from further analysis due to the lack of correct responses in the AY trials in one or more manipulated incentive conditions[2]. Our final analysis included 47 participants (16 male, age *M* = 21.92, *SD* = 1.84, range = 18–27 years; work experience *M* = 2.92, *SD* = 2.27, range = 0–9 years).

We used the AX-CPT task developed to measure proactive and reactive control modes (Braver, 2012). The task was the following: Pairs of letters were displayed sequentially on a computer screen. The first letter, either A or B, appeared as a cue. The second letter, either X or Y, was considered the probe. In combination, there were four types of trials, i.e., AX, AY, BX, and BY trials (Kam et al., 2012). The participants' task was to respond as quickly and accurately as possible to each probe following the cue. Specifically, participants had to press the letter N with their index finger when A was followed by a target probe X (target trial). The three other trial types were non-target trials in which A was followed by Y, or B was followed by either Y or X (AY, BY, and BX). In the case of a non-target trial, participants had to press the letter M with their middle finger. In the calibration phase, participants performed a block of 30 trials to calibrate the criterion for the response speed for each individual. Then, four blocks of 30 trials were presented for each of the three different incentive conditions. Thus, overall the participants performed 390 trials. Within each block, the most common trial presented was the AX target trial, which occurred in 70% of the trials, with the remaining 30% equally distributed among the other three non-target trials (AY, BX, and BY). These pairs were presented in random order. After each trial,

[2] As we computed reaction times for correct responses only, we excluded these subjects from reaction time analyses due to missing values. To keep the same set of subjects in all analyses, these subjects were also excluded from analyses of error rates. Due to a concern that the absence of correct responses in AY trials might reflect an extreme use of proactive control strategy, we repeated the error rate analyses including all subjects. The results remained stable with no change in the observed effects (both the significance and the sign of the effects remained the same). In the interest of clarity, we report only the results of subjects with complete data.

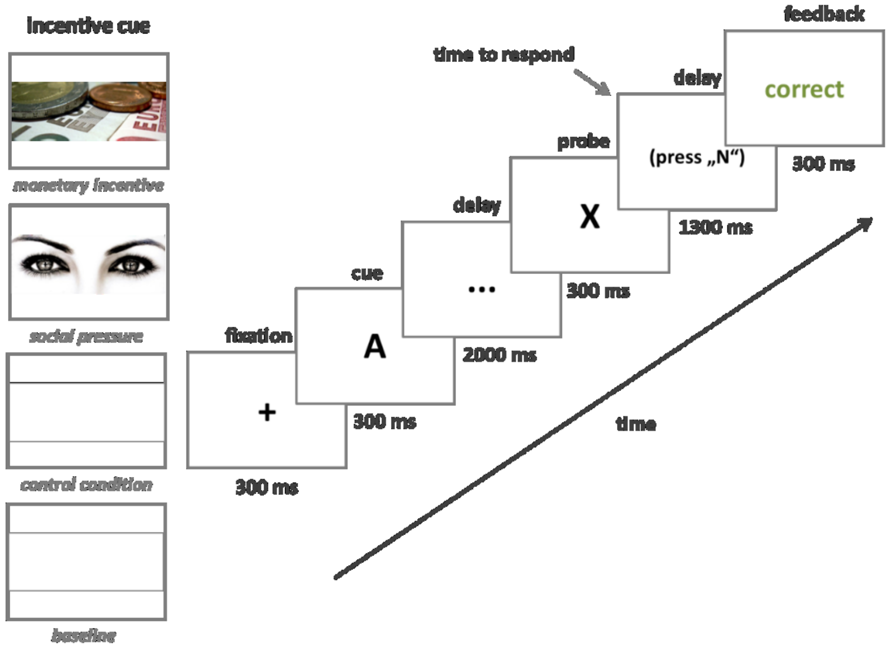
feedback was given to participants informing them whether their answer was correct and fast enough (see Section 1.2.2).

Because the target trial AX occurs with a high frequency, it not only creates a strong preparatory attentional expectancy triggered by the contextual cues (A = target; B = non-target), but also creates a target response bias linked to the X probe. Thus, the utilization of proactive control can be indexed on AY trials (Chiew & Braver, 2013). The AY trial type requires inhibition of a prepotent response, as a subject is primed to make an incorrect target response as soon as they see cue A (Kam et al., 2012). Thus, the AY trial type requires subjects to alter their usual action plans and press the letter “M” instead of the letter “N”. According to Chiew and Braver (2013), stronger interference in these trials (in terms of greater errors and slower reaction times) can be interpreted as the activation of strong proactive control. Alternatively, reactive control can be indexed on BX trials. The BX trial type requires subjects to actively maintain a representation of the context provided by the cue stimulus in their working memory in order to press the correct button when seeing probe X (Kam et al., 2012). In this condition, a subject has to keep in mind that cue B, and not A, was shown before X. Stronger interference in these trials (in terms of greater errors and slower reaction times) can be interpreted as the engagement of reactive control/lack of proactive control (Chiew & Braver, 2013). Relative performance in AY vs. BX trials therefore provides an indication of whether proactive or reactive control is dominant (Kam et al., 2012; Chiew & Braver, 2013; Lamm et al., 2013).

The AX-CPT task was programmed in the E-prime 2.0 software running on Windows 7 OS. The stimuli were presented on a 19-inch LCD display. To familiarize themselves with the task, participants first performed 10 practice trials during which their performance was not recorded.

Performance feedback was provided after each trial. It was presented for 300 milliseconds (ms). Trials lasted 4.5 s and consisted of the following sequence of events (see Figure 1): fixation (300 ms), cue (300 ms), delay 1 (2000 ms), probe (300 ms), delay 2 (1300 ms), and feedback (300 ms).

Figure 1: Trial structure and timing



Note: An example of an AX (target) trial is shown with both a non-incentive (baseline and control condition – no picture) and an incentive (monetary incentive – a picture of money; social pressure – a picture of eyes) cues. One of these three cues was shown on the screen during each condition block, indicating the incentive type.

1.2.2 Procedure and manipulation

To individually calibrate the criterion speed of response to the probe stimuli in the incentive conditions, the procedure started with a baseline condition in which participants were told to perform the tasks as fast and as accurately as possible. Subjects performed the baseline block without any knowledge of the subsequent procedure and incentives. We then introduced three conditions in randomly interchangeable blocks. In all three conditions, participants were asked to improve their speed of response while still responding correctly. Participants in the monetary incentive block, which was cued by a picture of money (see Figure 1), were told they could earn EUR .05 for each fast and correct response, but could be penalized with a deduction of EUR .05 for each incorrect response. The speed criterion was set so that participants had to match or exceed the speed of the fastest third of all responses in the baseline condition. In the social pressure condition, participants were told that their results and ranking within the group of participants would be publicly announced. This block started with a picture of eyes on the screen (see Figure 1). The control block started with no cue. This condition was introduced to account for the effect of mere instructions.

The experimental design was block-based with counterbalanced order of condition blocks across participants. The advantage of a block-based experimental design is that it allows the examination of a sustained motivational effect on cognitive control dynamics rather than a transient effect (Chiew & Braver, 2013; Lamm et al., 2013). The experiment was conducted in small groups of 16 participants in a quiet, well-lit room. After the task was completed, participants filled out a demographics questionnaire and were informed about how much money they had earned.

1.2.3 Data analysis

To eliminate automatic button pressing and extreme outliers from the analysis, we excluded responses faster than 200[3] ms and slower than 2000 ms (2.26%; Schouppe et al., 2015) and all incorrect responses[4] (.04%). In addition, responses that deviated by more than two standard deviations from the conditions' mean were removed from reaction time analyses as outliers (4.20%; Lamm et al., 2013). We tested for and found no significant effect of age on performance. Task performance was measured and expressed as the mean reaction time for correct responses, mean error rate (percentage incorrect), and mean percent of fast responses. The responses were considered fast enough and correct if they matched or exceeded the speed of the fastest third of all responses in the baseline condition. To estimate the statistical significance of the behavioural performance data, we performed a repeated measure analysis of variance (ANOVA). In cases where the assumption of sphericity was violated, indicating that the variance of the differences between all combinations of related groups was not equal, we adjusted the degrees of freedom using the Greenhouse-Geisser correction method (Field, 2009).

To examine the underlying mode of cognitive control under manipulations, we performed an additional analysis on a direct measure of a cognitive control shift – a so-called proactive index (Braver et al., 2009). The index was computed from reaction times and error rates in the AY and BX trials as $(AY - BX)/(AY + BX)$ and measures the relative tendency for proactive control (Braver et al., 2009). The proactive index calculation yields a score between −1 and +1: the closer the score is to +1, the more proactive is the cognitive control (Braver et al., 2009; Chiew & Braver, 2014). Namely, if subjects are more alert to the preceding cue and prepare their responses proactively, they will find it harder to inhibit the inappropriate response in the AY trials and will be even faster/make fewer errors in the BX trials, both leading to a higher value of the proactive index. As in some cases participants performed at ceiling, which resulted in a zero error rate, we used a corrected error rate, computed using the formula: (number of errors + 0.5)/(number of trials + 1) (Hautus, 1995).

[3] Due to a concern that in some conditions (BX and BY) fast response times might reflect valid anticipatory responses, we repeated the analyses without excluding reaction times faster than 200ms. This did not alter the results as neither the significance nor the sign of the effects changed.

[4] Responses where neither the letter »N« nor »M« was pressed. Subjects mistakenly pressed the letter B in eight cases.

1.3 Results

The effect of the manipulations on task performance may be expressed in terms of improved reaction time and/or accuracy. We analysed both, as well as any possible trade-off between them.

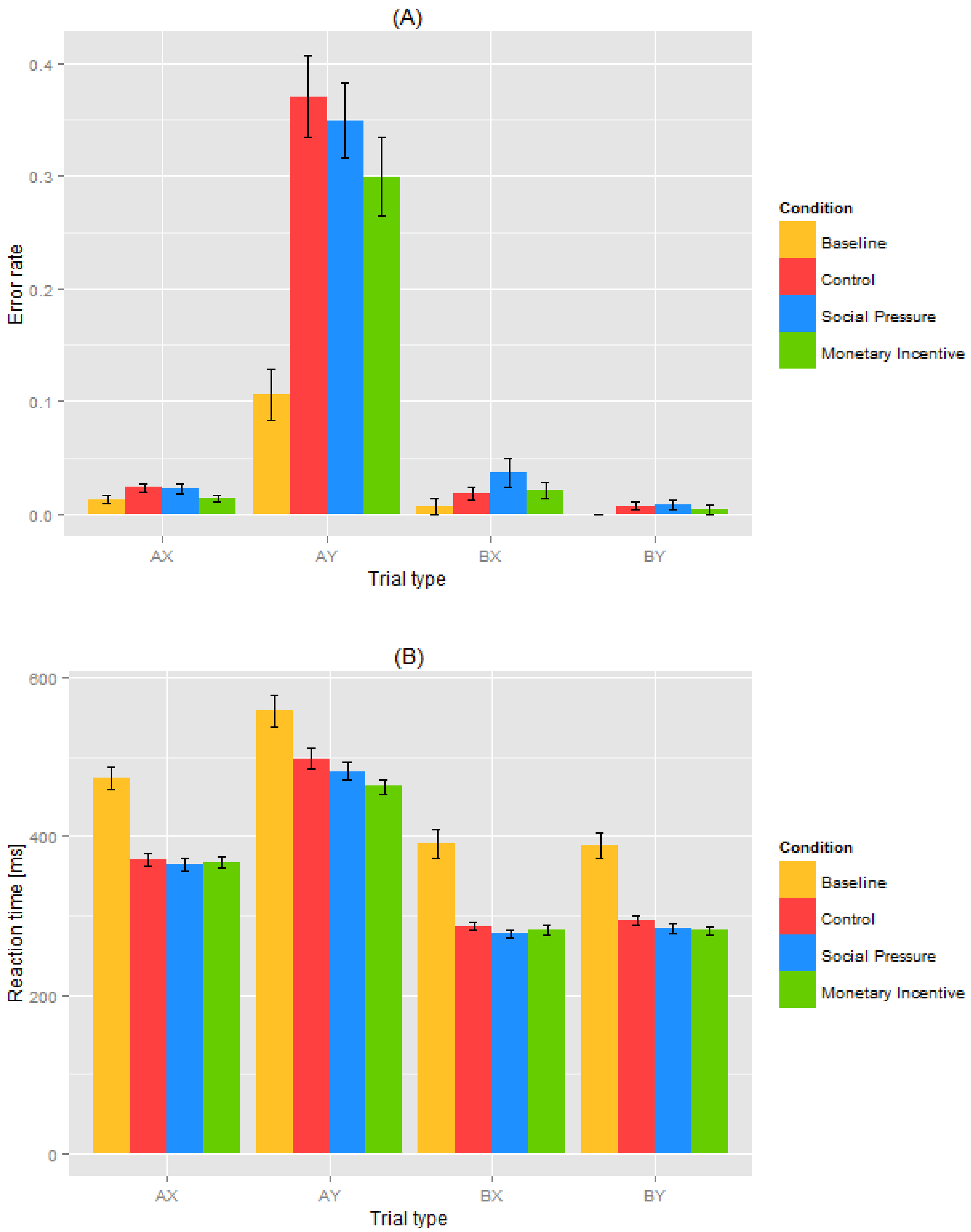
1.3.1 Global incentive effect

Under all incentive conditions, participants were asked to improve the speed of their responses while still responding correctly. The cut-off for correct and fast enough responses was calculated for each participant as the speed of the upper third correct responses for all trial types in the baseline condition. There were 64.3% of such responses in the control condition, 67.6% in the social pressure condition, and 68.3% in the monetary incentive condition vs. the expected rate of 33.3%, had the performance remained at the baseline level. Similar results were reported by Chiew and Braver (2013, 2014), but only for the monetary incentive condition. Overall, the results show that the incentive manipulation was successful in improving performance. In accordance with the given instructions, participants achieved a higher rate of fast and correct responses in the control condition and in both incentive conditions.

1.3.2 Baseline vs. control condition

To further assess the effect of the experimental instructions on task performance, we conducted a two-way repeated measures ANOVA with the within-subject factors condition (baseline, control) and trial type (AX, AY, BX, BY). The analysis of *error rates* showed a significant main effect of the condition, $F(1, 46) = 54.7$, $p < .001$, reflecting an overall increase in error rates in the control condition (see Figure 2A), a significant main effect of trial type, $F(1.08, 49.5) = 81.7$, $p < .001$, reflecting larger error rates in AY trials compared to AX, BY, and BX trials, and a significant condition × trial type interaction, $F(1.19, 54.6) = 48.6$, $p < .001$, reflecting a larger increase in error rates from the baseline to the control condition in AY trials compared to AX, BY, and BX trials. To formally test the observed pattern of results, we conducted follow-up paired *t*-tests that showed significant increases in the control vs. the baseline condition error rates for AX, $t(46) = 2.16$, $p = .036$, AY, $t(46) = 7.41$, $p < .001$, and BY, $t(46) = 2.07$, $p = .044$, but not BX, $t(46) = 1.17$, $p = .249$, trials. Furthermore, comparing the extent of increases between AY and other trial types using paired *t*-tests revealed significantly higher increases in error rates from the baseline to the control condition for AY trials compared to AX, $t(46) = 7.13$, $p < .001$, BX, $t(46) = 7.30$, $p < .001$, and BY, $t(46) = 7.19$, $p < .001$, trials, suggesting increased reliance on proactive control. No other comparison in the extent of increases between different trial types revealed significant differences (all $p > .65$).

Figure 2: Error rates (A) and reaction times (B) in different trial types and conditions



Note: Error rates (**A**) and reaction times of correct responses (**B**) for each of the trial types (AX, AY, BX, and BY) are shown for each condition.

The analysis of *reaction times* also revealed a significant main effect of the condition, $F(1, 46) = 55.3$, $p < .001$, reflecting an overall reduction in reaction times from the baseline to the control condition (see Figure 2B), trial type, $F(2.05, 94.3) = 179.2$, $p < .001$, reflecting longer reaction times in AX and AY compared to BX and BY trials, and a significant condition × trial type interaction, $F(2.33, 107.3) = 3.2$, $p = .037$, reflecting larger reductions in reaction times in AX, BX, and BY than in AY trials. A pairwise comparison of the extent of reaction time reduction between the different trial types revealed significantly smaller decreases in reaction times from the baseline to the control condition in AY compared to AX, $t(46) = 3.09$, $p = .003$, and BX, $t(46) = 2.12$, $p = .039$, but not BY, $t(46) = 1.82$, $p = .074$, trials, again suggesting increased reliance on proactive control. Significant improvement in reaction times in the control condition relative to the baseline may be interpreted as conformance to instructions, even in the absence of a direct incentive.

1.3.3 Practice effect at baseline

Due to the within-subject block design of the study, there is a potential concern that differences between blocks reflect practice effects rather than experimental manipulations. To address this concern, we conducted a logistic regression on error rates and a linear regression analysis on reaction times in the baseline condition to test for the presence of performance improvement with the task progression reflecting the practice effect. The analysis was only conducted on the AX trials since they occurred in 70% of the trials. As the trials were manipulated within-subjects, the subjects were treated as a random factor and intercepts were modelled for each subject separately. Statistical significance was estimated using likelihood ratio χ^2 tests.

Results of *logistic regression* of response accuracy (0 for an incorrect and 1 for a correct response) on a trial number revealed a significant positive effect, $\beta = .08$, $\chi^2(1) = 5.36$, $R^2 = .04$, $p = .021$, suggesting that subjects improved their accuracy within the baseline block. However, as on average subjects only made 1.32% of errors in the baseline condition and mostly performed at ceiling, we conclude that differences in performance cannot be attributed to practice effects. Results of a *linear regression* of reaction times on a trial number revealed a non-significant positive effect, $\beta = 0.18$, $\chi^2(1) = 0.28$, $R^2 = .54$, $p = .598$, suggesting the absence of the practice effect on reaction times in the baseline condition.

We extended the analysis of practice effects to the experimental blocks, but did not find any significant effect on accuracy and reaction times in any of the experimental conditions. We did find a small effect of fatigue reflected in reaction times in the social pressure condition (for detailed results see Appendix 2, Supplementary Figure 1).

Taken together, no or minimal practice effect in the baseline condition and no evidence of practice effect in the experimental conditions reduces the possibility that the observed differences between experimental conditions reflect practice effect. As the purpose of the baseline condition was primarily to ascertain individual criterion reaction time, all further analyses focus on direct comparisons between the three experimental conditions.

1.3.4 Comparison of experimental conditions

To investigate the effect of experimental conditions on error rates and reaction times, we conducted a two-way repeated measures ANOVA with the within-subject factors condition (control, social pressure, monetary incentive) and trial type (AX, AY, BX, BY). The analysis of *error rates* showed an expected significant main effect of trial type, $F(1.06, 48.9) = 121.2$, $p < .001$, revealing significantly higher error rates in AY trials (see Figure 2A). Results also showed a significant main effect of the condition, $F(2, 92) = 3.6$, $p = .030$. A follow-up paired *t*-test between conditions collapsed over all trial types revealed significantly lower error rates in the monetary incentive condition compared to both the control, $t(46) = 2.26$, $p = .029$, and the social pressure conditions, $t(46) = 2.54$, $p = .015$, but no significant differences between the social pressure and the control conditions, $t(46) = .09$, $p = .932$. Though the pattern of error rates differed across trial types and seemed to be driven mostly by differences in AY trials, the absence of a significant condition × trial type interaction, $F(2.20, 101.2) = 2.4$, $p = .096$, did not warrant further post-hoc exploration. These results suggest that the monetary incentive was the most successful in reducing error rates.

The analysis of *reaction times* also showed an expected significant main effect of trial type, $F(1.87, 86.2) = 452.6$, $p < .001$, reflecting the shortest reaction times in BX and BY trials, somewhat longer reaction times in AX trials, and the longest reaction times in AY trials (see Figure 2B). ANOVA revealed a significant main effect of the condition, $F(2, 92) = 7.7$, $p < .001$. Post hoc paired *t*-tests collapsed over trial types revealed significantly shorter reaction times in both the social pressure, $t(46) = 2.46$, $p = .018$, and the monetary incentive condition, $t(46) = 3.74$, $p < .001$, compared to the control condition, and no significant differences between the social pressure and monetary incentive conditions, $t(46) = 1.23$, $p = .226$. The presence of a significant condition × trial type interaction, $F(3.19, 146.7) = 3.5$, $p = .015$, warranted further investigation of experimental manipulation on each of the trial types by means of follow-up one-way repeated measures ANOVAs with factor condition (control, social pressure, monetary incentive). These revealed a significant effect of the condition in AY, $F(2, 92) = 6.4$, $p = .003$, and BY trials, $F(2, 92) = 4.3$, $p = .017$, but not in AX, $F(2, 92) = 0.97$, $p = .382$, or BX trials, $F(2, 92) = 2.3$, $p = .110$. Additional pairwise *t*-tests showed that reaction times in AY trials in the monetary incentive condition were significantly shorter than in the control condition, $t(46) = 3.46$, $p = .001$, and in the social pressure condition, $t(46) = 2.24$, $p = .030$. Reaction times in BY trials under monetary incentive were again significantly shorter than in the control condition, $t(46) = 2.90$, $p = .006$, whereas the differences with the social pressure condition were not significant, $t(46) = 0.732$, $p = .468$. The reduction in reaction times under social pressure compared to the control condition approached statistical significance, $t(46) = 1.96$, $p = .056$. These findings indicate that while monetary incentive led to the strongest reduction in reaction times, social pressure had a similar effect in stimulating performance. In line with prior studies (Kam et al., 2012; Lamm et al., 2013; Chiew & Braver, 2014), participants had the slowest reaction time in AY trials compared to AX, BX, and BY trials, indicating the prevalence of proactive cognitive control.

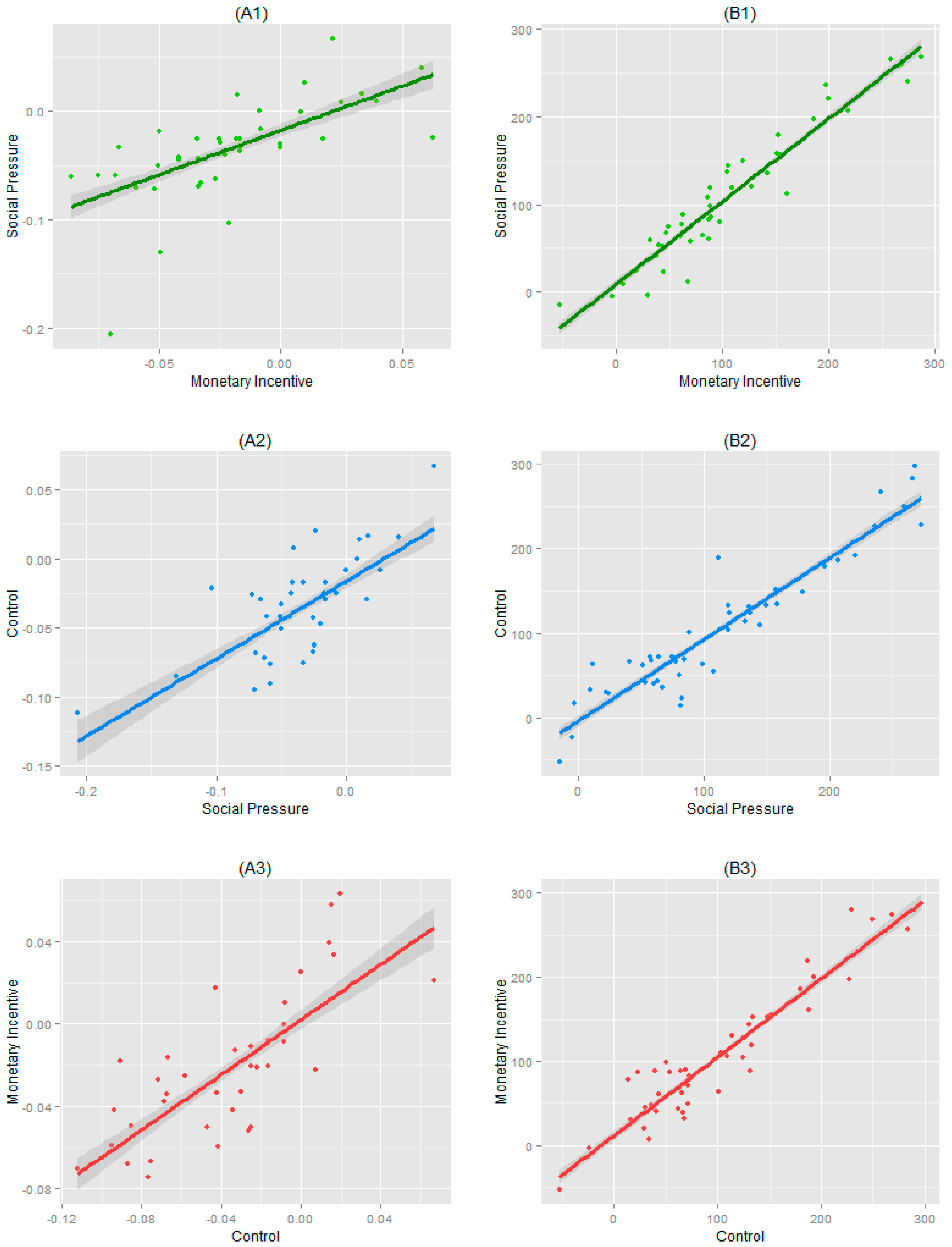
1.3.5 Speed accuracy trade-off effect

To exclude the possibility that the observed changes in performance were due to a speed-accuracy trade-off rather than an actual performance improvement, we conducted a correlation analysis between the *change in error rates* and the *change in reaction times* in the baseline vs. the incentive conditions. This was of a particular concern since we observed higher speed, but also higher error rates under the experimental conditions. The results show a non-significant negative correlation between changes in speed and error rates in the monetary incentive, $r = -.02$, $p = .808$, a non-significant positive correlation in the control condition, $r = .12$, $p = .107$, and a small but significant positive correlation under social pressure, $r = .15$, $p = .036$, indicating that subjects in the social pressure condition managed to improve both accuracy and reaction times (see Appendix 2, Supplementary Figure 2). We can therefore dismiss the concern that subjects achieved a faster reaction time on account of significantly higher error rates. On the contrary, participants improved their response speed without any significant loss of accuracy, arguably by shifting to the proactive control mode.

1.3.6 Correlation between incentive conditions

Some people are more stimulated, have greater motivational orientation and better cognitive resources than others. They might be equally sensitive to monetary and social incentives, while others are less sensitive to both. To analyse this issue, we conducted a correlation analysis between the differences among error rates and reaction times relative to baseline in incentive conditions. The results show strong and significant positive correlations between error rates and reaction times, respectively, across all pairs of comparisons; between monetary incentive and social pressure, $r = .63$, $p < .001$, $r = .96$, $p < .001$ (see Figure 3A), the control condition and monetary incentive, $r = .72$, $p < .001$, $r = .95$, $p < .001$ (see Figure 3B), and between the control condition and social pressure, $r = .68$, $p < .001$, $r = .94$, $p < .001$ (see Figure 3C). The high degree of correlation between effects in the different incentive conditions suggests that the subjects were similarly sensitive to the incentives.

Figure 3: Correlation between experimental conditions in the performance change relative to baseline as measured by error rates (A) and reaction times (B)



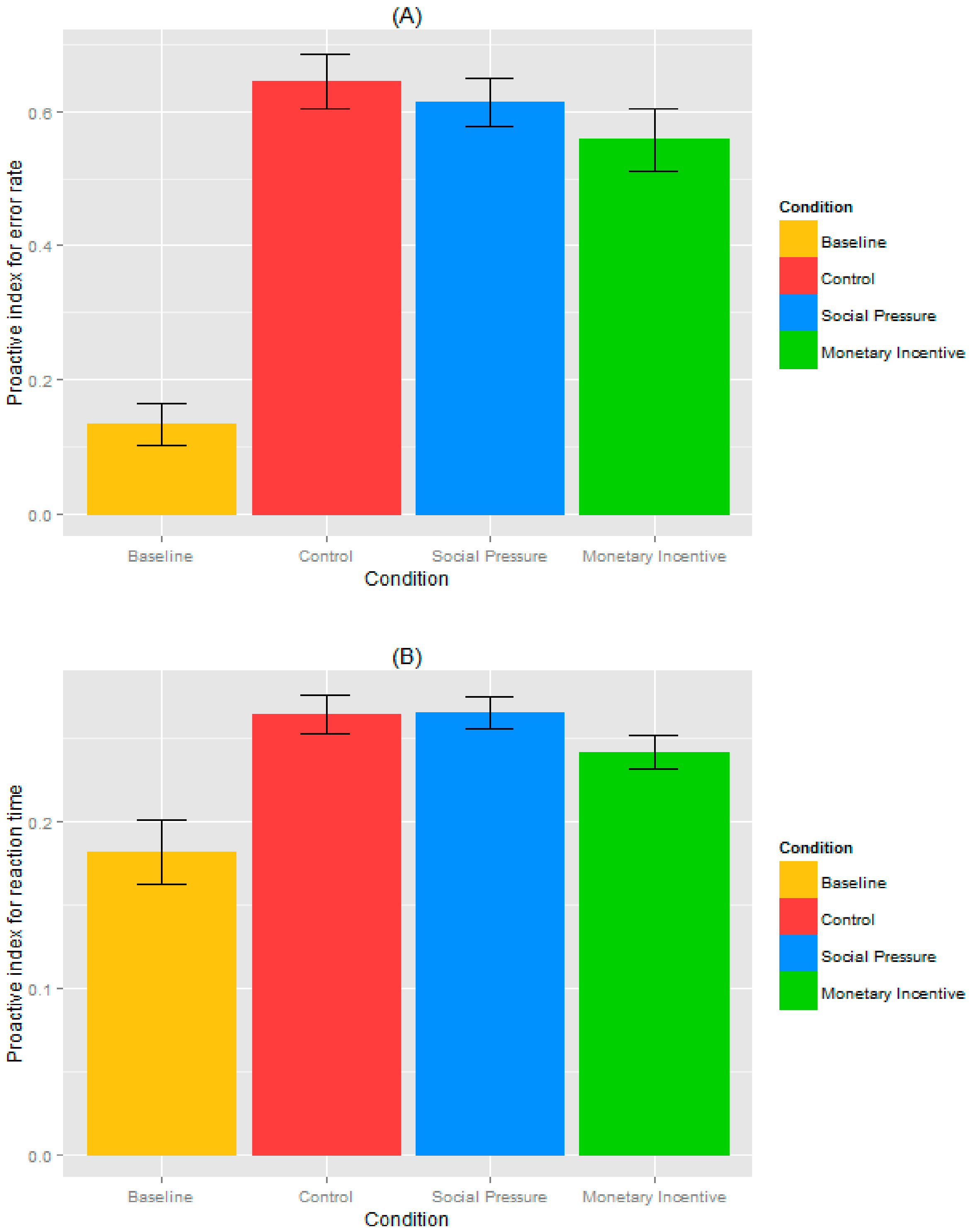
Note: Performance in terms of error rate (**A**) and reaction time of correct responses (**B**) under experimental conditions relative to baseline collapsed over the trial type are plotted between the monetary incentive and social pressure conditions (1), between the social pressure and control condition (2), and between the control and monetary incentive conditions (3). A positive correlation indicates that subjects were equally sensitive to both compared incentive conditions.

1.3.7 Analysis of the proactive index

To specifically focus on the possible effect of the experimental conditions on cognitive control, we analysed a proactive index (Braver et al., 2009), computed for error rates (see Figure 4A) and reaction times (Figure 4B). To examine the effect of the experimental conditions on the prevailing cognitive control strategy, we conducted a one-way repeated measures ANOVA with a within-subject factor condition (baseline, control, social pressure, monetary incentive). Results of the *proactive index for error rates* showed a significant main effect of the condition, $F(3, 138) = 49.5$, $p < .001$, reflecting substantial increases in proactive control in all three conditions compared to the baseline. Post-hoc paired *t*-test indicated significantly higher value of the proactive index for error rates in the control, $t(46) = 11.3$, $p < .001$, social pressure, $t(46) = 13.1$, $p < .001$, and monetary incentive conditions, $t(46) = 8.6$, $p < .001$, compared to the baseline. When comparing the three experimental conditions, a slight reduction in the proactive index in the monetary incentive condition compared to the control condition was not found to be significant, $t(46) = 1.7$, $p = .095$, neither were all other comparisons (all $p > .30$).

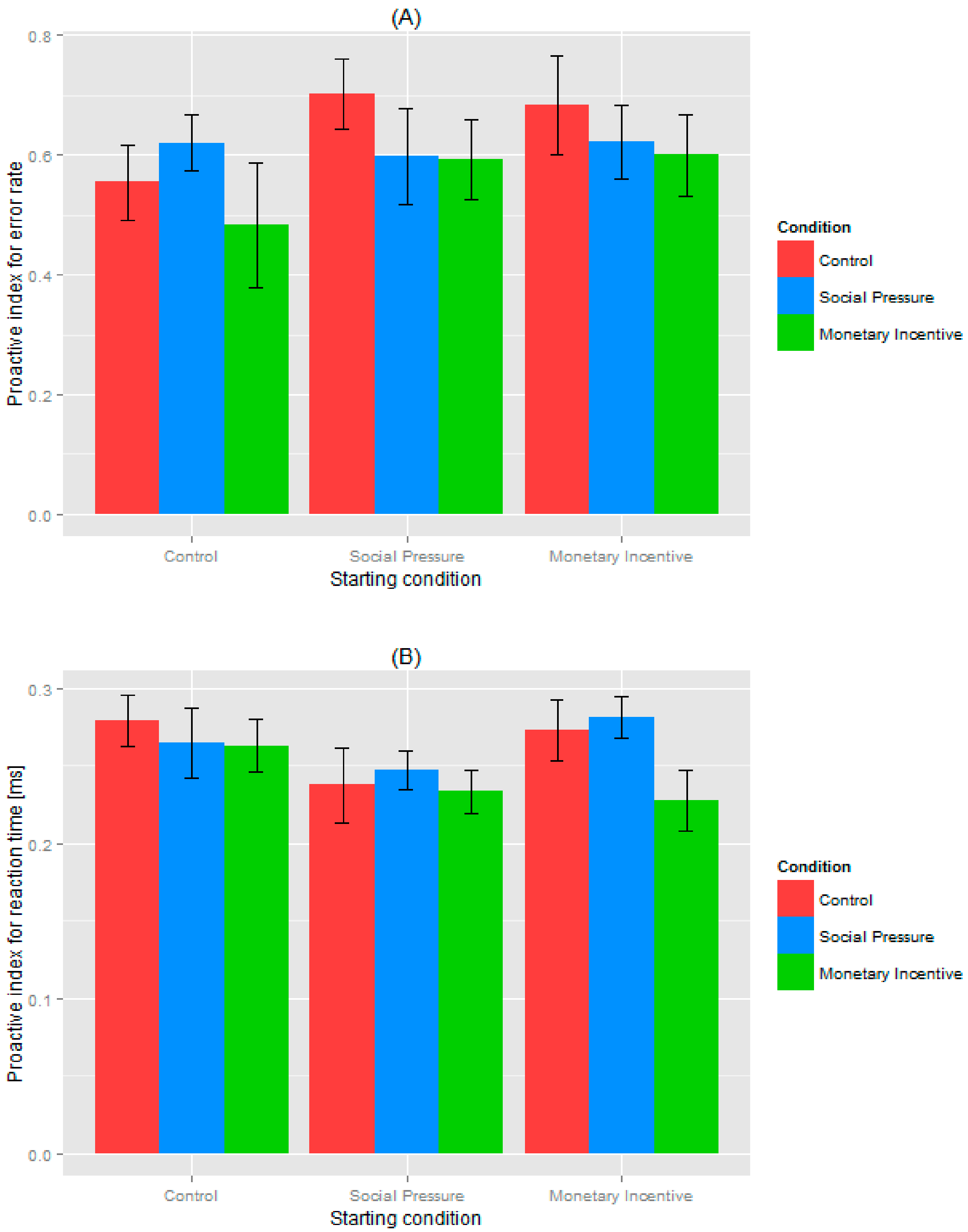
Similarly, results of the *proactive index for reaction times* showed a significant effect of the condition, $F(1.96, 90.2) = 11.2$, $p < .001$, again reflecting substantial increases in the proactive index in the control, $t(46) = 3.9$, $p < .001$, social pressure, $t(46) = 4.2$, $p < .001$, and monetary incentive conditions, $t(46) = 3.0$, $p = .004$, compared to the baseline, indicating a shift to proactive control in all three manipulated conditions. Paired comparisons between the experimental conditions revealed a significantly lower value of the proactive index in the monetary incentive condition compared to the social pressure condition, $t(46) = 2.5$, $p = .015$. The difference between the monetary incentive and the control condition approached significance, $t(46) = 1.8$, $p = .080$, whereas the value of the proactive index did not differ between the social pressure and the control condition, $t(46) = 0.1$, $p = .941$. This indicates that social pressure and mere instructions shift cognitive control to a stronger proactive mode than monetary incentive. The lower proactive indices under the monetary incentive condition could be attributed to the possibility of being penalized for incorrect responses, which forces an individual to make fewer errors and have a slower reaction time in the AY trials compared to the social pressure and control conditions.

Figure 4: Proactive index for the error rate (A) and reaction time (B) in different conditions



Note: The proactive index based on error rates (**A**) and reaction times (**B**) is shown for each of the incentive conditions: baseline, control, social pressure, and monetary incentive. The closer the score of the proactive index is to +1, the more proactive is the cognitive control.

Figure 5: The effect of the experimental condition order on the proactive index for error rates (A) and reaction times (B) in different conditions



Note: The proactive index for error rates (**A**) and reaction times (**B**) is shown for each of the incentive conditions: control, social pressure, and monetary incentive depending on the starting condition as a between-factor.

A possible concern in the presented analysis is that a change in cognitive control in one condition might persist in subsequent blocks, confounding the observed results. As the order of the experimental conditions was counterbalanced across participants, we were able to address this concern directly. We conducted a two-way repeated measures ANOVA with the within-subject factors condition (control, social pressure, monetary incentive) and a between-subject factor starting condition (control, social pressure, monetary incentive). The results of the analysis on *the proactive index for error rates* failed to show a significant effect of either condition, $F(2, 88) = 1.4$, $p = .243$, starting condition, $F(2, 44) = 0.8$, $p = .437$, or their interaction, $F(4, 88) = 0.5$, $p = .705$ (see Figure 5A). Results therefore indicate a similar shift to proactive control regardless of which condition was presented first. The analysis of the *proactive index for reaction times* also failed to reveal a significant main effect of the condition, $F(1.73, 76.1) = 2.4$, $p = .103$, starting condition, $F(2, 44) = 1.2$, $p = .323$, or their interaction, $F(4, 88) = 1.1$, $p = .342$ (see Figure 5B).

These results show that the order of experimental conditions does not affect the observed proactive control indices. We can therefore conclude that social pressure and instructions to perform better indeed independently increase proactive control rather than just continue the strategy adopted under the previous task condition. Overall, the results show an increase in the proactive control index in all three conditions, but it was least pronounced under the monetary incentive condition, irrespective of which incentive was presented first.

1.4 Discussion

Incentives improve performance beyond instructions

To enhance our understanding of what makes incentives effective, we need to examine how they affect the fundamental drivers of cognition. It is increasingly recognized that different incentives trigger distinctive cognitive coping strategies (Lerner & Tetlock, 1999; Vieider, 2011). Our goal was to understand how two prominent formal control mechanisms—social pressure and monetary incentives—affect cognitive control strategies to enhance performance beyond the effect of plain instructions to perform better. Our results indicate that instructing participants to improve their performance on its own leads to a significant shift toward proactive control and performance improvement compared to the baseline. Both monetary incentive and social pressure lead to further improvements in performance. The best performance in terms of the highest accuracy and the shortest reaction times is achieved under monetary incentive.

Our findings confirm prior results that monetary incentives improve cognitive performance, specifically by activating the proactive control mode, which enables participants to better update and preserve goal-relevant cue information throughout task performance (Locke & Braver, 2008; Jimura et al., 2010; Chiew & Braver, 2013, 2014; Fröber & Dreisbach, 2014).

Interestingly, monetary incentive did not lead to the highest proactive control index, but to increases in both proactive and reactive control, an issue we specifically address below.

Social incentives elicit proactive control and enhance performance

A specific contribution of our study to the existing research into factors influencing cognitive control is its examination of social incentives. The finding that social pressure also elicits proactive control and enhances performance contrasts with studies, which found that social anxiety and psychological pressure adversely affect performance (Hickman & Metz, 2015; Schmid et al., 2015). These opposing results may arise from a different approach: the study by Hickman and Metz (2015) is an event study investigating the psychological pressure invoked by high prizes in sports designed to elicit maximum performance. They found that such pressure negatively affects performance, but that less experienced athletes are more affected than their more experienced counterparts. Schmid et al. (2015) analysed social anxiety as a personal trait rather than as a response to a socially threatening stimulus. For socially anxious people, compared to a healthy control group, such a stimulus represents a stronger conflict, which has to be processed by relying on reactive control. In cognitive tasks in which goal representation, maintenance, and information updates are required, the reactive mode leads to a worse performance than the proactive mode.

Pessoa (2009) explains that a low-threat stimulus enhances target processing as emotionally laden stimuli are prioritized. In contrast, a high-threat stimulus diverts cognitive resources toward processing the stimulus, which impairs performance. In the latter case, the focus is on monitoring a conflict and resolving interference, typical of reactive control. What also matters is the task relevance of a stimulus: a task-relevant stimulus improves performance as it directs more resources to the task, whereas a task-irrelevant stimulus impairs performance. Our findings indicate that social pressure may have been perceived as a low-threat, high-relevance stimulus by the participants. It is worth noting that Pessoa (2009) refers to stimulus-driven threat effects elicited by trial-by-trial manipulations, whereas our manipulation is block-based and gives rise to a sustained activity. The differences between transient and sustained effects will have to be analysed in future studies as the present evidence in the literature does not systematically examine them.

Instructions in the absence of specific incentives improve performance

Experimental studies tend to neglect the effect of the lab environment on participants. As revealed in our control condition, performing better when being asked to may in itself have a positive effect on performance through a natural inclination to obey authority (Milgram, 1974). In several of our analyses, we found similar effects between the two incentives and the control condition. This implies that, when participating in an experiment, mere instructions to improve performance have similar effects to instructions that announce social or monetary consequences. The studies that do not control for such a global effect of instructions might falsely attribute the entire effect to monetary incentives.

In contrast, the AX-CPT study by Chiew and Braver (2013, partly replicated in 2014) employed an experimental design comparable to ours. They directly compared block (sustained) reward manipulations (non-incentive trials within the reward block with non-incentive trials in the baseline condition) and trial (transient) reward manipulations (incentive to non-incentive trials within the reward block). Another valuable source of comparison is Fröber and Dreisbach (2014) who partly replicated the experimental design of Chiew and Braver (2013) with respect to performance-contingent reward manipulation. The results of all three studies are substantially similar to ours: they showed a shift to proactive control for non-incentive trials within the reward block compared to the non-incentive baseline block.

While the analysis of trial reward manipulation in the cited papers (Chiew & Braver, 2013, 2014; Fröber & Dreisbach, 2014) focused on the transient vs. the sustained effects of incentives, the non-incentive trials within the reward block could be affected by instructions that activated proactive control in the block. By this design, the authors managed to isolate the effect of incentives without confounding it with the effect of instructions, similar to our control and monetary incentive conditions, with the difference that their manipulation was transient while ours is sustained. This difference is not negligible as proactive control requires context representations to be sustained over extended periods, whereas in the reactive mode, the representation of the context is transient and maintained only when needed. Non-incentive trials in the reward block may thus be affected by a sustained proactive control mode, triggered by incentive trials. In our design, these two blocks are separate and there is less interference in terms of sustained cognitive control activity between one and the other, leading to clearer estimates of the instruction without incentive effect. All three studies found a further significant shift to the proactive mode for incentive trials (and significantly decreased accuracy for AY trials) when comparing behavioural performance in incentive and non-incentive trials within the reward block, a finding qualitatively similar to ours. Taken together, these results provide evidence that proactive control is already activated by instructions to perform better, and may be further intensified by incentives.

Error penalty leads to balanced increase in both proactive and reactive control

The analysis of the proactive control index in our study lead to further insights. Whereas all three experimental conditions induced an increase in the proactive index compared to the baseline, direct comparison of the experimental conditions revealed no differences in the accuracy based proactive index and a decrease in the reaction time based proactive index in monetary incentive vs. both social pressure and control conditions. This seemingly contra intuitive finding needs to be understood in relation to overall performance in the experimental conditions, the relationship between proactive and reactive cognitive control, and the nature of the proactive control index itself.

The proactive control index, as computed in this and previous studies (e.g., Chiew & Braver, 2014), provides an estimate of relative reliance on proactive vs. reactive cognitive control, rather than an absolute measure of proactive control. If participants switch their cognitive control strategy from a reactive to a more proactive one, the index increases. If, however, they rely on more reactive cognitive control, the index decreases. Though the proactive index computed in the AX-CPT implies that the two cognitive control mechanisms are antagonistic, DMC theory (Braver, 2012) postulates that proactive and reactive control involve potentially independent mechanisms that can be simultaneously engaged. Engagement of proactive control in the AX-CPT task enables faster and more accurate responses in trials in which the cue stimulus correctly predicts target response, but it also leads to slower responses and higher risk of errors in AY trials, in which the cue leads to incorrect anticipation of a relevant response. To ensure fast responses and low error rates in all conditions, the increase in proactive control needs to be complemented with an increase in reactive control, enabling swift and effective change in response in AY trials. The overall improvement in both reaction times and accuracy under monetary incentive compared to the other two conditions implies that monetary incentive leads to an increase in proactive but also reactive control: this is evident in the reduced ratio of proactive vs. reactive control reflected in the lower value of the proactive control index compared to the other experimental conditions.

Our results do not match the findings by Chiew and Braver (2014), which found a significant increase in the proactive index for error rates (but not for reaction times) in monetary incentive vs. non-incentive trials. This apparent discrepancy can, however, be ascribed to the differences in experimental design. In our study, participants were not only rewarded for fast and accurate responses, but also penalized for incorrect ones. This incentivized them to increase proactive control to enable faster responses, but also stimulated them to increase reactive control to avoid the penalty for increased errors in AY trials. Together this resulted in a smaller proactive control index compared to other experimental conditions with no error penalties. Chiew and Braver (2013, 2014), on the other hand, did not include a penalty for error responses in the incentive condition, allowing participants a more aggressive pursuit of the goal, relying primarily on an increase in proactive control without a concurrent increase in reactive control. Interpretation of our results is further supported by a functional magnetic resonance imaging study using the AX-CPT task in which Braver et al. (2009) found that penalty-based monetary incentives caused a shift from primarily cue-related to probe-related activation in a number of PFC regions-of-interest.

It could be argued that including a penalty in the monetary incentive condition prevents a direct comparison of the effectiveness of monetary incentives and social pressure in their ability to modulate cognitive control. We included a penalty into the monetary incentive condition because the aim of this research is to contribute to practical implications. In organizational environments, the primary goal is not to stimulate proactive control, but to enhance performance, which includes appropriate protection from low-probability errors. Additionally, in the social pressure manipulation, we emphasized accuracy and speed (both mattered for ranking) and as suggested by Dambacher et al. (2011) the same is achieved with a penalty for errors, which also emphasizes accuracy rather than just speed. If we had designed monetary incentives with rewards only, the two conditions would have been less comparable. Our results suggest that only an explicit error penalty elicits concurrent increase in both proactive and reactive control and ensures the best overall performance.

Monitoring as performance enhancer

As our results suggest, the key element in stimulating better performance is a combination of explicit instructions and monitoring, regardless of how monitoring relates to the ultimate monetary rewards or social evaluation. There is an important practical implication of this line of reasoning. For example, measuring performance is a costly venture for most firms, especially since such measurement should be objective to avoid negative social comparison side effects. Without the need for incentivizing or inducing pressures, simply observing working behaviour may come at a lower cost and lower risk of potential dissatisfaction. Such positive effects can be expected especially when monitoring can be organized horizontally (Komaki, 1986; Towry, 2003).

However, when combined with performance non-contingent rewards, the instructions to perform better do not seem to trigger a more proactive mode of cognitive control. Fröber and Dreisbach (2014) compared cognitive strategies elicited by performance-contingent and performance non-contingent rewards. They showed that only the former shifts cognitive control to the proactive mode (faster reaction times and higher error rates in AY trials). In the performance non-contingent reward condition, reaction times did not differ from the baseline condition. In the reward manipulation coupled with a neutral emotional stimulus, participants made significantly fewer errors in AY trials, suggesting a shift toward a less proactive/more reactive mode. However, in the condition combined with a positive emotional stimulus, no effect on the cognitive control strategy was detected. The performance non-contingent reward scheme actually allowed the participants to perform worse and be rewarded for it but, interestingly, their performance did not deteriorate. They maintained the same performance as in the baseline condition, which may be an effect of intrinsic motivation and feedback.

Which type of incentives work best in an applied context depends on current task demands and available context information. If goal-oriented behaviour is to be promoted, incentives that stimulate the proactive control mode are helpful. However, proactive control is not cost-free as evidenced by the increased error rates in the trials that require inhibition of a prepotent response. This might be especially important in an applied context where errors must be avoided at any cost because they have serious (possibly disastrous) consequences. For optimal cognitive performance in such tasks, the reactive mode is a better cognitive strategy as it is oriented to error detecting and conflict monitoring. Dreisbach (2006) and Fröber and Dreisbach (2014) found that a less proactive/more reactive mode was elicited by positive affect. Positive affect was found to positively influence cognitive flexibility (Isen et al., 1992; Ashby et al., 2002; Dreisbach, 2006) and creativity (Amabile et al., 1986), while a rigid imposition of incentives has been found to negatively impact creativity (Stanton, 2000; Bonner & Sprinkle, 2002; Frey & Osterloh, 2002). What further complicates the design of an appropriate management control system is the finding that the influence of positive affect may be easily overridden by performance contingent incentives (Fröber & Dreisbach, 2014).

Limitations and further directions

The size of the observed effect of our monetary and non-monetary incentive conditions also importantly depends on the experimental design. Had we varied the intensity of each condition (i.e., a higher monetary reward, more distressing social incentive), their relative effects could have been different. It would be insightful to test varying intensities of the presently analysed two conditions in future research. As the AX-CPT is a relatively simple task, whereas real-world tasks are more complex, variation in task difficulty could also lead to different relative outcomes. A generalizable finding, however, is that various incentive types are available in organizations to achieve improved cognitive performance and that their ultimate effect on performance depends on their relative intensity. We have shown that not only monetary incentives but also non-monetary incentives (ranking, instructions, monitoring) can be quite effective. These findings provide an important contribution concerning the effectiveness of various mechanisms within an organizational control system.

Other limitations of our study need to be considered when generalizing from our findings. By focusing on the comparison between social and monetary stimuli on cognitive performance, we did not measure social anxiety and reward sensitivity as personality traits. As found by Jimura et al. (2010), the strongest effects of monetary incentives on cognitive control and performance in a high load working memory task are observed in highly reward-sensitive individuals (an increase in both sustained and transient activation of the right DLPFC). If monetary incentive is coupled with trait reward sensitivity, the effect is reinforced.

It is much more difficult to predict the interaction between social pressure and trait social anxiety. A general finding in the literature is that trait anxiety is associated with increased reliance on reactive control, driven primarily by dACC activity (Schmid et al., 2015) and right ventrolateral prefrontal cortex (VLPFC) activity (Fales et al., 2008). As presented by Schmid et al. (2015), highly anxious people are particularly sensitive to socially threatening stimuli, but a low-anxiety group can also be driven to a reactive control mode by a threatening stimulus (Fales et al., 2008). To our knowledge, there is little prior evidence on how healthy individuals react to stimuli similar to the social pressure used in this study. Our participants generally shifted toward the proactive mode. Given the conflicting results in the literature finding both, the positive effect (Latham & Locke, 2006) and the “choking” effect of social pressure on performance, it might be that our participants were not particularly socially anxious. Low-anxiety individuals rely primarily on prefrontal cortex-mediated control processes in cognitive conflict tasks (Schmid et al., 2015). Low anxiety and increased activity in the DLPFC is also associated with approach motivation (Harmon-Jones, 2003).

To rule out that the sample in our study could be systematically skewed in personality traits resulting in participants being more responsive to one or another incentive, and to address some of the concerns that our results might be affected by trait anxiety, or any other personality trait which we did not measure, we investigated whether participants might be differentially affected by the incentive conditions used. The results showed quite the reverse: those who achieved high performance under the monetary incentive condition also performed well under social pressure and in the control condition, and vice versa. This further indicates that monetary incentives and social pressure have similar motivational effects. To be able to generalize the findings to a broader and possibly a more variable population, the moderating effect of personality traits certainly needs to be addressed in future studies. Nevertheless, we believe that the absence of personality trait analysis does not limit the validity of the comparison between stimuli-driven cognitive strategies: the sample is relatively homogenous (in terms of age, which minimizes age-related differences in cognitive control preferences) and the approach examines within-subject effects.

The next step in this line of research is to further validate the behavioural findings using neuroscientific methods. Research in cognitive neuroscience has already identified brain regions and networks implicated in response to monetary incentives or threat stimuli, and has examined their impact on cognitive control strategies (Braver et al., 2007; Fales et al., 2008). Since behavioural results demonstrate that social pressure and instructions shift cognitive control toward the proactive mode, we would expect to find sustained activity of the DLPFC similar to that elicited by monetary incentives, typical of the proactive control mode. In a trial-by-trial analysis, we would anticipate increased transient activity of the dACC and DLPFC in the baseline relative to all three conditions, in particular in trials that require response inhibition. Another relevant direction for future research may also entail testing other formal control mechanisms in order to compile a comprehensive picture of incentive effects on cognitive control. Greater understanding is needed about which control environments in practice represent informational cues handled by reactive and proactive control.

1.5 Conclusion

Our study provided the first direct comparison of the effects of social pressure and monetary incentive on behavioural performance. Surprisingly, whereas the results showed the two incentive conditions to be comparable in their effect, much of the effect seems to be generated by the presence of explicit instructions to improve behaviour and accompanying monitoring of behaviour. The key advantage of monetary incentives, primarily ascribed to explicit error penalties, is ensuring that the increase in performance in most of the trials enabled by increased proactive control was not traded off by increased errors on those occasions that required effective reactive control.

The effect of incentives and other situational factors on cognitive control, effort, and performance will continue to offer a vast opportunity to advance our knowledge. Making use of brain imaging would allow us to identify the brain regions involved in processing pressure/incentives in cognitive control processes, which would provide important insights into the effect of incentives on human cognition. Making incentive systems work is vitally important for the overall functioning of organizations and society. In recent years, research has focused on the dysfunctional effects of these systems (Trotman et al., 2011), which may be a consequence of the way conflicts between incentives and natural (automatic) responses are resolved. Given the current debate in companies and society about the problems of increasing monetary incentives, our findings provide an avenue to start reconsidering the essential role of social pressure and monitoring in organizations, countering prevalent reliance on monetary incentives to enhance performance.

2 THE EFFECT OF SOCIAL INCENTIVES ON COGNITIVE CONTROL AND PERFORMANCE: AN fMRI STUDY[5]

Abstract

Social incentives are used widely by organisations to promote behaviours consistent with organisational goals. Unlike monetary incentives, little is known about how social incentives affect the fundamental executive functions denoted as cognitive control and performance in cognitive tasks. To investigate this issue, 30 financial professionals completed the Eriksen Flanker task (Eriksen & Eriksen, 1974) while undergoing functional magnetic resonance imaging (fMRI) under the baseline and two social incentive conditions – charity donation and public ranking of participants' performance[6]. Behavioural results show the participants responded overall faster with social incentives compared to the baseline while largely maintaining their accuracy in both the congruent and incongruent trials. fMRI analysis of regions of interest (ROI) reveals an overall increase in sustained activity of the dorsolateral prefrontal cortex (DLPFC) and the dorsal anterior cingulate cortex (dACC) and an increase in transient activity of both regions in incongruent trials, implicating simultaneous reliance on proactive and reactive cognitive control strategies. Exploration of NeuroSynth reverse inference maps revealed a general rise in sustained and transient activation in several maps, although only those maps related to cognitive control, attention, conflict and response inhibition show interaction between the incentives and congruency, reflecting no difference in transient responses to the congruent and incongruent trials in the baseline condition and pronounced differences in both incentive conditions. Inspection of the responses across a priori resting state (RS) networks showed increased sustained activation of the incentive conditions compared to the baseline of the visual, cingulo-opercular, fronto-parietal, default, auditory, language and posterior multimodal network and increased transient responses in the task positive cingulo-opercular, dorsal attention, fronto-parietal and posterior multimodal networks. Overall, our results show the effect of social incentives is comparable to that of monetary incentives and that they lead to increased attention, improved motor and attentional control, as well as conflict resolution and inhibition. Both social incentives have comparable effects.

Keywords: social incentives, donation, ranking, cognitive control, Flanker task, fMRI

JEL code: D89, M41

[5] The paper is co-written by Sergeja Slapničar, Anka Slana Ozimič, Grega Repovš (University of Ljubljana), Frank Hartmann (Erasmus University Rotterdam) and Alan Anticevic (Yale University School of Medicine).
[6] Social incentive, i.e. the public ranking of participants' performance, is the same incentive as that in the previous chapter labelled social pressure. Since the Ličen et al. paper (2016) had already been published, we were unable to change the terminology. At the same time, two social incentive are studied in this chapter that require more specific use of terminology than the generic term social pressure.

2.1 Introduction

Incentives are used widely by organisations to motivate employees to enhance their performance. Extant research in cognitive psychology observes enhancements in task performance when incentivised with monetary incentives (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Braver, 2012; Braver & Cohen 2000; Braver, Gray, & Burgess, 2007; Chiew & Braver, 2011; Locke & Braver, 2008; Pochon et al., 2002, Strang & Pollak, 2014). Yet broader research into behavioural economics shows that in several circumstances monetary incentives have limited success in improving cognitive performance of various cognitive tasks (Ariely, Gneezy, Loewenstein, & Mazar, 2009; Baumeister, 1984; Bonner, Hastie, Sprinkle, & Young, 2000; Deci, Koestner, & Ryan, 1999; Ličen, Hartmann, Repovš, & Slapničar, 2016, Oblak, Ličen, & Slapničar, 2017). Organisations often employ non-monetary, social incentives, either in combination with monetary ones or on their own, such as setting challenging goals (not necessarily linked to rewards), making an individual responsible for other employees or for others' economic benefit, observing one's performance, evaluating, ranking and making people's performance transparent etc. (Lerner & Tetlock, 1999). According to Geen (1991), evaluation itself is a powerful motivator of behaviour. Individuals are generally inclined to seek social approval and have an implicit need to avoid criticism or a negative evaluation by others. Locke (1996) maintains that social incentives are frequently used to convince people that the goal is important and to increase their task commitment. Initial task commitment may be facilitated by an authority asking for compliance and providing a rationale for that. Continued commitment, however, calls for extra incentives such as recognition and rewards. Monetary and social incentives are often intertwined in practice and their effects on cognitive control may be hard to disentangle. As explained, monetary incentivising is accompanied by instructions on how to perform better, but instructions or the evaluation of someone's performance may in itself quite effectively impact cognitive control.

The effect of social incentives on cognitive control and performance has received little attention, despite their significant role in organisations. Understanding their effect requires an examination of how they affect fundamental mechanisms of cognition. A set of executive functions that facilitate the execution of cognitive tasks is denoted as cognitive control. Cognitive control enables flexible, goal-directed behaviour via the active maintenance of information, monitoring of the environment, switching between task goals, utilising relevant information that supports task accomplishment and providing resistance to task-irrelevant information (Banich, 2009; Botvinick et al., 2001). It comprises goal setting, attentional and inhibitory control, activation of working memory, reasoning, planning and execution. In short, cognitive control facilitates flexible, goal-directed behaviour and suppresses habitual behaviour if outside the scope of the goal (Braver, 2012; Chiew & Braver, 2011; Cohen, Braver, & O'Reilly, 1996; Miller & Cohen, 2001).

A common finding in the literature on the effect of monetary incentives on cognitive control is that monetary incentives enhance processing in attentional regions in the fronto-parietal cortex (Padmala & Pessoa, 2011) and, more specifically, that they activate proactive, i.e. forward-looking cognitive control strategies (Locke & Braver, 2008; Braver, Paxton, Locke, & Barch, 2009; Chiew & Braver, 2013, 2014; Fröber & Dreisbach, 2014), which leads to improved performance. Yet, it should be noted that performance improvements are only evident in specific conditions in which adjustments of speed or direction of control are efficient (Camerer & Hogarth, 1999; Dambacher, Hübner, & Schlösser, 2011).

To the best of our knowledge, the only study to have directly compared the effects of monetary and non-monetary incentives on cognitive control is our own previous research Ličen et al. (2016). It contrasted the effect of social pressure, here constituted by the fact the participants' results were made public and ranked, with the effect of monetary incentive. Unlike previous studies on the impacts of monetary incentives, the Ličen et al. (2016) study also controlled for the effect of mere instructions to perform better. Surprisingly, we found that instructions by themselves already strongly increased the proactive control mode and enhanced performance compared to the baseline. This effect went unnoticed in other studies that attributed all of the effect simply to monetary incentives. Both incentives further improved performance compared to instructions. Altogether, the results suggest that social incentives may be similarly effective for stimulating cognitive performance as monetary incentives.

This interesting finding led us to further explore the role of social incentives on cognitive control and its underlying neural correlates. In this chapter, we focus on two types of social incentives. The first is *donation to charity* (hereinafter: *donation*). We established this incentive by telling the participants that all proceeds from a successfully accomplished task would be donated to charity rather than earned for personal benefit. Many decisions in work contexts are made on behalf of those for whom the decision-makers take responsibility (Alford, Hibbing, Lohrenz, Harvey, & Montague, 2009). Extensive evidence suggests that people care about other people's interests (Haley & Fessler, 2005; McCabe, Houser, Lee, Smith, & Trouard, 2001; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003, Knoch, Pascual-Leone, Meyer, Treyer, & Fehr, 2006; Tabibnia, Satpute, & Lieberman, 2008). Our variable *donation* combines several incentive mechanisms: it makes individuals accountable for the results, motivates them to earn money and is supposed to evoke positive emotions about donating money (Haidt, 2003). Several analyses of neural activity involved in decisions to perform an activity that benefits others show that such decisions are processed by the mesolimbic reward system in the same way as monetary rewards (Alford et al., 2009; Harbaugh, Mayr, & Burghart, 2007; Moll et al., 2006), suggesting that people derive satisfaction from benefiting others.

Our second incentive is the *ranking of an individual's results* (hereinafter: *ranking*), which we established by telling participants their results would be ranked and publicly shared (as in Ličen et al., 2016). Previous studies reveal that people are concerned about how they perform in front of others and how they are ranked (Camerer & Thaler, 1995; Gneezy, Niederle, & Rustichini, 2003; Rizzo & Zeckhauser, 2005). The mere presence of others and evaluation apprehension count as important drivers of social motivation (Geen, 1991). Anxiety about public performance originates from the evolutionary importance of social standing (Williams, 2007). Earlier studies show that if an individual perceives the pressure to perform well as moderate, the heightened arousal will improve their performance, but if it is too intensive, it will impair it (Bonner & Sprinkle, 2002). Tran and Zeckhauser (2012) demonstrate in a series of lab and field experiments that participants try to achieve a high social ranking even without tangible benefits associated with ranking.

The aim of this study was first to investigate how social incentive mobilises cognitive control and task performance, and whether different types of social incentives (donation vs. ranking) differently affect performance. To probe into cognitive control, we employed a flanker task because it provides both accuracy and reaction-time performance measurements and allows the efficiency of conflict detection and cognitive inhibition of irrelevant stimuli to be investigated. Based on the findings by Ličen et al. (2016), we expected social incentives to reinforce goal commitment and enhance task performance. However, we did not have any a priori prediction of whether the two incentives might vary in their effect.

The second aim of the study was to investigate the neural bases of the incentive effects. Specifically, we were interested in whether social incentives invoke similar neuronal activity as the monetary incentives studied in the literature. Monetary incentives were found to enhance cognitive control by improving the representation, maintenance and use of task goals across a set of cortical and subcortical structures implicated in cognitive control: the dorsolateral prefrontal cortex (DLPFC), the dorsal anterior cingulate (dACC) and the presupplementary cortices, the dorsal premotor cortex, the anterior insula and the intraparietal cortex (Botvinic & Braver, 2015). These regions were reported to shift cognitive control strategy from a less metabolically demanding conflict-monitoring mode (reactive control) to a proactive control mode (Locke & Braver, 2008; Braver, 2012).

We identified two regions most directly implicated in successful performance of the flanker task: DLPFC and dACC. DLPFC is a region most closely associated with active maintenance of goals (Braver et al., 2007), whereas dACC is most associated with conflict monitoring and activates upon the detection of response conflict due to interference (van Veen & Carter, 2002). Upon the detection of interference, dACC signals the need for increased control of the current trial to the DLPFC to resolve it. We thus expected to find increased sustained activity of dACC and DLPFC elicited by social incentives, reflecting higher proactive engagement of the cognitive control system. While analysing the trial-by-trial response, we anticipated a bigger difference in transient responses to congruent and incongruent trials in social incentive conditions compared to the baseline, reflecting increased engagement of these regions in incongruent trials requiring successful conflict detection and resolution.

To further explore the effects of social incentive on brain systems, we successively broadened the analysis; first, to include larger brain systems implicated in attention, conflict detection, cognitive control, and response inhibition, as well as reward and social processing, default mode, speech processing and resting state; second, to include whole-brain functional networks; and, finally, to perform an exploratory whole-brain analysis.

In all analyses, we first focused on identifying differences in performance in the baseline vs. incentive conditions, and then investigated possible differences between the two incentive conditions.

2.2 Materials and methods

2.2.1 Participants and task

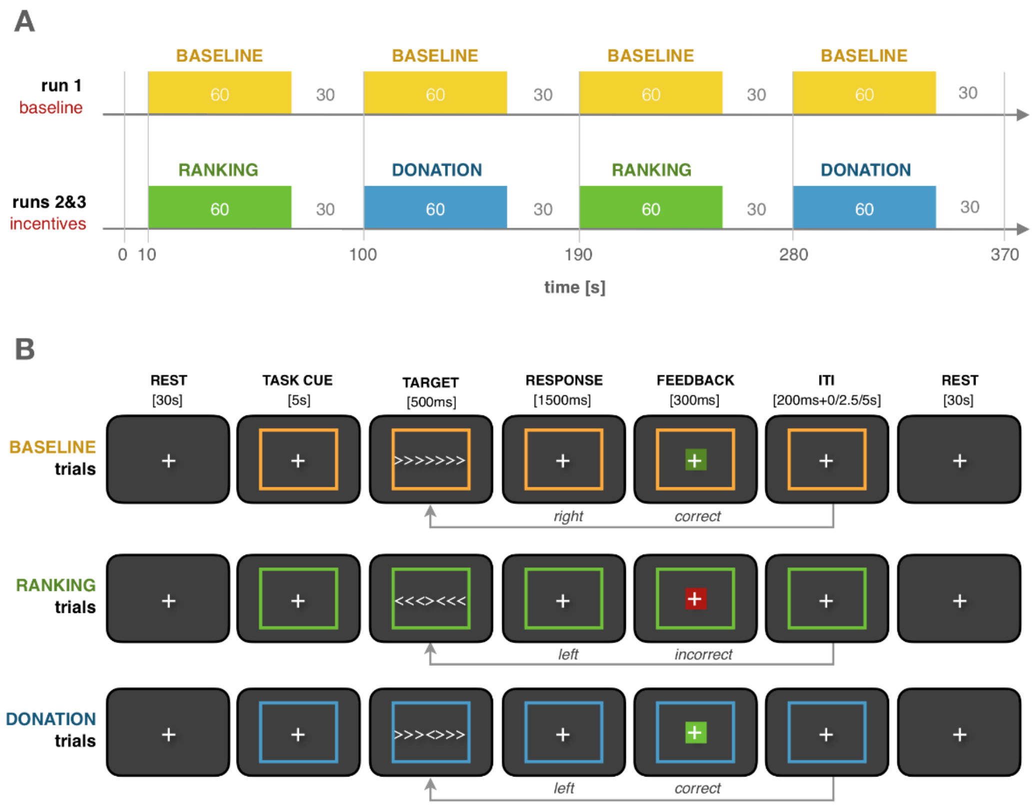
We conducted a functional magnetic resonance imaging (fMRI) study using 31 experienced accounting and finance professionals from Slovenia who hold various functions. One participant (3.2%) was eliminated from the analysis due to technical issues during the scanning session. In the analysis reported below, 30 participants are included (15 males, age M = 37.03, SD = 8.05, range = 24–52 years; work experience M = 12.77, SD = 7.50, range = 1–26 years). The participants had on average 17 years of education, most held a master's degree in business, economics, accounting or finance. We informed the participants their participation was voluntary and they were free to withdraw from the study at any point. All participants gave their written informed consent prior to taking part in the study. The study and the procedures were approved by the Ethics Research Committee of the Faculty of Arts, University of Ljubljana, Slovenia.

We used the Eriksen Flanker task (Eriksen & Eriksen, 1974) developed to measure cognitive inhibition, sustained attention, conflict detection and resolution in the situation of the target response in an incongruent context (Voelsker-Rehage, Niemann, Hübner, Godde, & Winneke, 2016; McMorris, 2016). In the task, seven arrows ("<") were displayed in the middle of a computer screen. They either all pointed in the same direction ("<<<<<<<"; congruent trial) or the middle arrow pointed in the opposite direction (">>><>>>"; incongruent trial). The participants were asked to indicate as quickly and accurately as possible in which direction the middle arrow was pointing by pressing the relevant button (left or right) on the response pad. The accuracy and reaction time of the responses were recorded for each trial.

The task was carried out in three scanning runs each lasting 370 s. A fixation point at the middle of the screen was shown throughout duration of the scanning run. Each scanning run consisted of four blocks of trials. The blocks were 60 s in duration and consisted of 13 trials each. The first block was proceeded by 10 s of rest, and all blocks were followed by 30 s of rest (see Figure 6A). All the blocks were structured in the same manner (see Figure 6B). The onset of the task block was signalled by the appearance of a coloured box within which the stimuli were then presented. The first trial followed 2.5 s or 5 s after the box first appeared. Each trial started with a (500 ms) presentation of the target stimulus followed by a 1.5 s response period that ended with a presentation of feedback (300 ms). Where a correct response was given, a small green box was shown in the centre of the screen, while in the case of an incorrect response or the absence of a response a small red box was displayed. To enable separate modelling of each trial type, the inter-trial interval (ITI) was jittered and lasted 0.2 s, 2.7 s or 5.2 s in a 9:6:4 ratio. After the last ITI of the block, the coloured box disappeared to signal the onset of a rest period. Within each of the four blocks, the four possible trials were presented in a pseudorandom sequence that ensured the number of congruent and incongruent trials with left and right responses balanced.

The Flanker task was programmed in the E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) and ran on a Shuttle J3 5800 computer (Intel Core i7 processor with 2.8 GHz and 2 GB RAM) running Windows Vista Business 2007, Service Pack 2. The stimuli were presented on a 30-inch LCD display (Invivo 000047, 2010, easy patient display, 2560x1600-pixel resolution; 60 HZ refresh rate) that was mounted outside the scanner, 135 cm behind a participant's head. The screen was observed using a mirror placed on an MR head coil directly above a participant's eyes.

Figure 6: Task design



Note: Task design. **A** The progression and duration of task blocks within BOLD runs. The order of ranking and donation task blocks were balanced across participants. **B** The progression and duration of trials within task blocks. An example of target, response and feedback is shown for each incentive type. Each block consisted of 13 trials.

2.2.2 Procedure and manipulation

To familiarise themselves with the task, participants first performed eight practice trials during which their performance was not recorded. The task was then carried out in two parts. In the *baseline* condition (in which the coloured box was presented in yellow), participants performed a single scanning run of the task with 4 blocks of 13 trials. The participants performed the baseline task without any knowledge of the following procedure and incentives.

In the second part, the participants were informed they would perform the same task under two incentives and were instructed to try and improve the speed and accuracy of their responses accordingly. They were told that, whenever a block of trials started with a blue box (*donation* incentive condition), they would have an opportunity to earn EUR 0.5 for charitable purposes for each fast and correct response, but would be penalised with a deduction of EUR 0.5 from the amount collected for each incorrect response. The speed criterion was set so that a participant had to match or exceed the speed of the fastest one-third of responses in the baseline condition, estimated separately for the congruent and incongruent trials. Next, they were told that, whenever a block starts with a green box, their performance across those blocks would be compared with the performance of other participants, ranked and disclosed to the other participants at the end of the study (*ranking* incentive condition).

Participants each performed two scanning runs of four task blocks under the incentive conditions. The incentive condition changed from block to block. Half the participants were randomly selected and started with the ranking incentive condition block and the other half with the donation incentive condition block. Before and after each scan, we checked whether the participants had remembered the colour designations for each incentive condition.

The research was conducted at a research-dedicated MRI recording facility at the Centre of Clinical Physiology, Medical Faculty, the University of Ljubljana, Slovenia. The participants were first given instructions, then they completed the MRI scanning session that lasted approximately 1 h. After participating, they were given a quick debriefing and asked to provide demographic information such as age, gender, years of work experience, and education level completed.

2.2.3 Behavioural Data analysis

To examine the effects of social incentives on cognitive performance, we first considered the behavioural data. The accuracy of responses was analysed using a logistic regression computed within a generalised linear mixed effects framework with the stimulus type (*congruent* vs. *incongruent*) and incentive condition (*baseline* vs. *incentive* and *ranking* vs. *donation*) as fixed effects and participants as random effects using the lme4 package for *R*

(Bates, 2015). The models of interest were compared against the null model using the χ^2 statistic.

Before analysing the reaction times, the reaction times of incorrect trials and any reaction times faster than 200 ms and slower than 2000 ms (0.21%; Schouppe et al., 2015) were removed from the analysis to eliminate automatic button pressing and extreme outliers. In addition, we considered reaction times that deviated by more than two and a half standard deviations from each condition's mean as outliers (1.97%; Lamm, Pine, & Fox, 2013) and ignored them. Participants' mean reaction times in each condition were then analysed with repeated measures analysis of variance (ANOVA) using the ez package for R (Lawrence, 2016), with the stimulus type (*congruent* vs. *incongruent*) and incentive condition (*baseline* vs. *incentive* and *ranking* vs. *donation*) as within-subject factors. Where the assumption of sphericity was violated, indicating that the variance of the differences between all combinations of related groups was not equal, degrees of freedom were adjusted according to the Greenhouse-Geisser correction method (Field, 2009).

To examine the inhibitory control in the three incentive conditions, we computed a cognitive inhibition index (CII). The index was computed for both accuracy and reaction times using the same formula:

$$CII_{ACC} = 1 - \frac{ACC_c - ACC_i}{\frac{ACC_c + ACC_i}{2}} \quad (1)$$

$$CII_{RT} = 1 - \frac{RT_i - RT_c}{\frac{RT_i + RT_c}{2}} \quad (2)$$

The index measures the relative strength of distractor inhibition ability. If inhibition control were perfect, there would be no difference between congruent and incongruent trials, and CII would be 1. The bigger the difference between the congruent and incongruent conditions, the smaller the index, suggesting weaker cognitive inhibition. The index is normalised by the average reaction time and accuracy across the congruent and incongruent conditions with the assumption that whereas the incongruent condition inhibits the speed and accuracy of responses, the congruent condition facilitates them, so the unbiased baseline value can be estimated as the average of the two.

Data for all the behavioural analyses were prepared using in-house scripts written in Python and analysed using R 3.4.3 (R Core Team, 2017). All the figures were created using the ggplot2 library for R (Wickham 2009).

2.2.4 Neuroimaging data acquisition, pre-processing, and analyses

Neuroimaging data were acquired with a Philips Achieva 3.0T TX scanner. One T1-weighted and one T2-weighted high-resolution, whole-brain anatomical scans were acquired (both: 236 sagittal slices, matrix = 336×336, voxel size = 0.7×0.7×0.7 mm; T1: TE = 5.7 ms, TR = 12 ms, flip angle = 8°; T2: TE = 414 ms, TR = 2500 ms, flip angle = 90°). Whole-brain functional volumes (BOLD) were acquired with a T2*-weighted echoplanar imaging sequence (48 axial slices, voxel size = 3×3×3 mm, matrix = 80×80, TR = 2.5 s, TE = 27 ms, flip angle = 90°, SENSE factor 2) in three bold runs (146 frames each). In addition, to support distortion correction of both structural and functional images, two spin-echo images (48 axial slices, voxel size = 3×3×3 mm, matrix = 80×80, TR = 2.5 s, TE = 27 ms, flip angle = 90°, SENSE factor 2) were acquired with opposite frequency readout directions (anterior-to-posterior and posterior-to-anterior).

Images were pre-processed following the Human Connectome Project (HCP) minimal pre-processing pipeline (Glasser et al., 2013). In short, images were slice time corrected, motion corrected, intensity normalised, linearly and nonlinearly coregistered to MNI standard space using the FSL, FLIRT and FNIRT tools. Brain tissue was segmented, subcortical structures were identified, and the cortical surface was reconstructed using FreeSurfer. Functional data were transformed from a 4D volume representation to a cifti, a combined volume-surface "grayordinate" representation in which the signal from the subcortical structures and cerebellum is stored in a volume representation (2×2×2 mm) for each structure separately, and the cortical signal is mapped onto a surface representation (32k vertices) of each hemisphere separately. Further analyses were conducted using in-house software in Matlab 2014a (Mathworks, 2014), Python, and R 3.4.3 (R Core Team 2017). Whole-brain statistical testing was performed using PALM (Permutation Analysis of Linear Models, Winkler, Ridgway, Webster, Smith, & Nichols, 2014).

Prior to performing the ROI and whole-brain analyses, functional data were smoothed within each brain structure separately using a 4 mm gaussian smoothing kernel for both volume and surface data. A mixed state-item GLM model was then fitted to the signal for each grayordinate separately with assumed HRF regressors (Boynton, Engel, Glover, & Heeger, 1996) for the duration of each block for the baseline, ranking and donation incentive conditions separately, and unassumed regressors (separately modelling eight frames after onset of the stimulus) for the block onset, correct and incorrect congruent and incongruent trials, for each of the three incentive conditions (baseline, ranking and donation) separately. The resulting beta coefficients were then submitted to second-level analyses. Specifically, sustained analyses were performed on beta estimates for the baseline, ranking and donation block regressors, for the transient analyses the average of beta estimates for frames 2 and 3 after stimulus presentation (corresponding to the time period 2.5 s to 7.5 s after stimulus presentation), were taken as estimates of the peak transient response to stimuli and used in further analyses. For all ROI-based analyses, beta values were additionally converted to a percent signal change by dividing the beta values of each grayordinate with its mean intensity value across the BOLD image and multiplying the result by 100.

2.2.4.1 Regions-of-interest (ROI) analysis

Targeted ROI analyses focused on the two brain regions most specifically implicated in cognitive control: dACC and DLPFC, the first implicated in conflict detection and the second in more directed conflict resolution. As the two regions' definitions somewhat vary in the literature, NeuroSynth was used to define them. Specifically, "dACC" and "DLPFC" were used as two terms of interest in NeuroSynth. Reverse inference maps (pFgA) were exported from NeuroSynth, mapped on to the surface, spatially smoothed and thresholded to create masks for left and right dACC and left and right DLPFC regions. Mean beta activation and response estimates for all conditions were then exported for each region and subjected to second-level analyses in R. Differences in sustained activation and transient response were tested separately. Specifically, four analyses were conducted for each ROI: 1) repeated measures (dependent sample) *t*-test comparing sustained activation in the baseline condition vs. average sustained activation across the two incentive conditions; 2) repeated measures (dependent sample) *t*-test comparing sustained activation in the two incentive conditions, donation and ranking; 3) repeated measures ANOVA with two factors, incentive (baseline vs. mean incentive) and congruency (congruent vs. incongruent); 4) repeated measures ANOVA with two factors, incentive type (donation vs. ranking) and congruency (congruent vs. incongruent). In both ANOVAs, the interest lay in the main effect of incentive and incentive type and its interaction with congruency. The main effect of congruency was not explored. All resulting p-values were corrected for multiple comparison across the four investigated ROI using FDR.

2.2.4.2 Analysis across functional brain systems

To investigate the effect of incentives on the brain systems of interest, we used NeuroSynth-based meta-analyses to define a set of maps related to the terms of interest. Specifically, by using NeuroSynth we generated reverse inference maps for terms related to cognitive control: Attention, Cognitive control, Conflict, and Response inhibition, relevant for flanker task performance. Moreover, we defined maps for three terms related to social incentives: Default mode, Social (processing of social signals), Reward, and two "negative control" maps: Speech production and Resting state. Each map was mapped onto grayordinates and Z-scores reported by NeuroSynth were normalised to 1. These normalised maps were used to compute a weighted mean activation and response related to each brain system identified. The resulting activation and response estimates were then entered in second-level analyses. The same tests as in the previous case were conducted and the resulting p-values were corrected for multiple comparisons across the nine terms using FDR.

2.2.4.3 Analysis across functional brain networks

To investigate the effects of incentives on distributed whole-brain networks, we used a recently developed cortical and sub-cortical parcellation of grey matter into 12 resting state networks (Spronk et al., 2018): primary visual, secondary visual, somatomotor, cingulo-opercular, dorsal attention, fronto-parietal, default, auditory, language, posterior multimodal, ventral multimodal and orbito-affective networks. We then exported the mean estimates for sustained activation and transient responses across each network and entered them in the second-level analysis the same as in the previous two sections. The resulting p-values were corrected for multiple comparison across the 12 networks using FDR.

2.2.4.4 Whole-brain analysis

Finally, to obtain a more exploratory insight into effects of incentives, we conducted a set of whole-brain analyses. These analyses followed the same tests described in the earlier sections. In addition, using dependent *t*-tests we conducted planned comparisons of the incentive vs. baseline transient responses separately for the congruent and incongruent trials. The statistical significance of the effects was estimated using PALM (Winkler et al., 2014). Specifically, for each contrast of interest p-values were estimated using 500 permutations, the tail approximation acceleration method (Winkler, Ridgway, Douaud, Nichols, & Smith, 2016), threshold-free cluster enhancement (TFCE; Smith & Nichols, 2009), and adjusted using a family-wise error rate (FWER) correction for multiple comparisons. For each analysis, the *p*-value criterion was set to .017 as PALM was run separately for left and right hemisphere surface representation, and volume representation of the subcortical regions and the cerebellum.

2.3 Results

2.3.1 Behavioural results

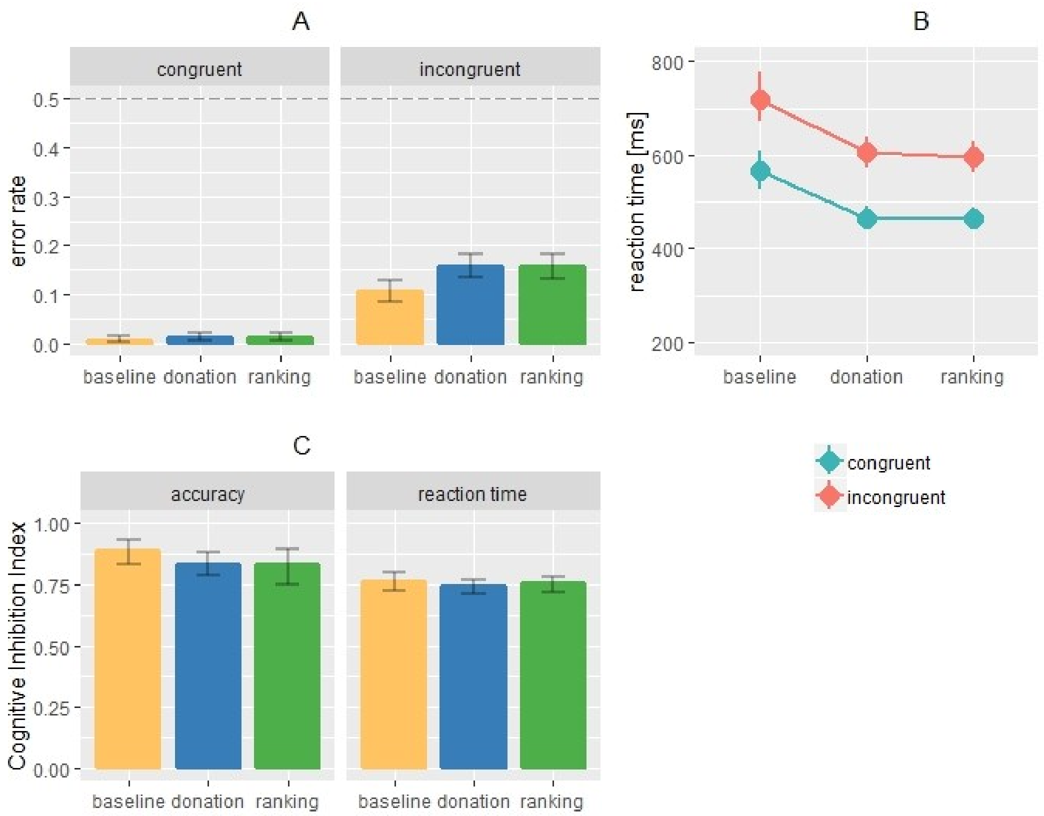
We analysed the effect of incentive on accuracy using a logistic regression with *incentive* (baseline vs. incentive) and *congruency* (congruent vs. incongruent) as fixed effects and participants as the random effect. The effects of interest were estimated by comparing a full model with a model without the effect of interest using χ^2 statistics. The results indicated significant main effects of congruency, $\chi^2(1) = 331.1, p < .001, R^2 = .16$, and incentive, $\chi^2(1) = 15.1, p < .001, R^2 = .01$, but no congruency × incentive interaction, $\chi^2(1) = 0.09$, reflecting the substantively higher error rates in the incongruent condition and the slight increase in error rates in the incentive compared to the baseline conditions (see Figure 7A). Investigation of the effect of *incentive type* (donation vs. ranking) yielded no significant main effect or interaction with congruency (both $\chi^2 < 0.01$).

We analysed the effect of incentive on reaction time using repeated measures ANOVA with within-subject factors *congruency* (congruent vs. incongruent) and *incentive* (baseline vs. incentive). The results indicated significant main effects of congruency, $F(1, 29) = 133.0, p < .001, \varepsilon^2 = .31$, and incentive, $F(1, 29) = 89.3, p < .001, \varepsilon^2 = .20$, but no effect of congruency

× incentive interaction, $F(1, 29) = 3.20$, $p = .084$, reflecting the slower reaction times in response to the incongruent stimuli, and the reduced reaction times in the incentive compared to the baseline conditions (see Figure 7B). ANOVA with the factors *congruency* (congruent vs. incongruent) and *incentive type* (donation vs. ranking) yielded no significant main effect of incentive type, $F(1, 29) < 1$, and no interaction with congruency, $F(1, 29) = 2.12$, $p = .156$.

To investigate the effect of incentive on cognitive control efficiency, we computed dependent *t*-tests comparing accuracy- and reaction-time-based cognitive inhibition indices (CII) between baseline and incentive conditions. No comparison indicated a significant effect of incentive (both $p > .25$). The comparison of CII between incentive types (ranking vs. donation) also revealed no effects (both $p > .16$), indicating that the relative efficiency of cognitive inhibition remained constant across the experimental conditions (see Figure 7C).

Figure 7: The effect of incentive on behavioural performance

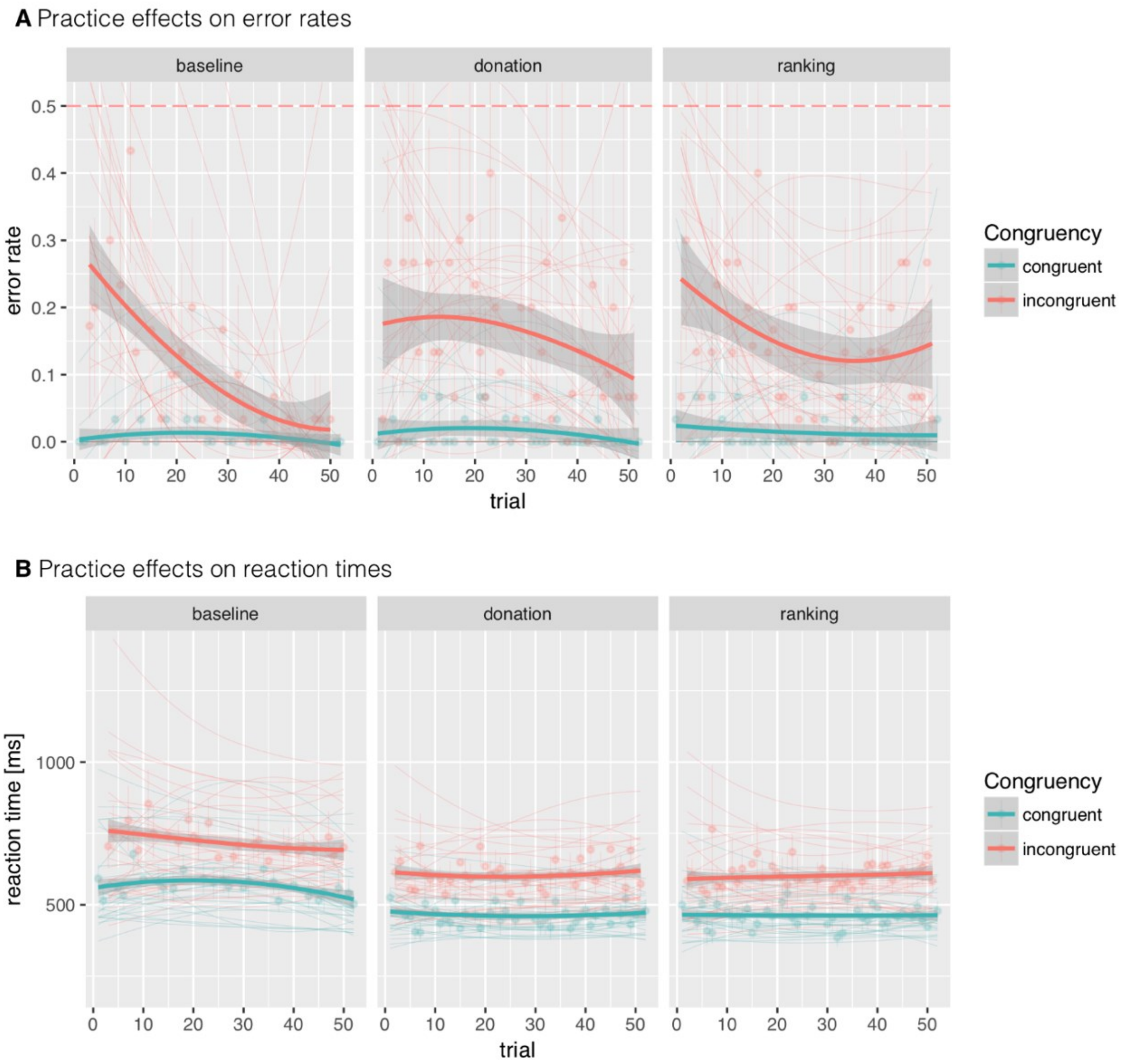


Note: **A** Error rates in congruent and incongruent trials in the baseline and two incentive conditions. Dashed red line denotes chance performance. **B** Reaction times in congruent and incongruent trials in the baseline and two incentive conditions. **C** Cognitive inhibition indices based on accuracy and reaction times in the baseline and two incentive conditions. Error bars show 95% confidence limits based on bootstrap.

Given that incentive conditions always followed baseline, there is a valid concern that the differences between the baseline and incentive conditions reflect the effects of either training or fatigue. To investigate the effects of practice or fatigue on accuracy, we computed a logistic regression on trials in the baseline condition with trial number as a continuous predictor, congruency as a fixed effect and participant as a random factor. The analysis revealed a significant decrease in errors across the baseline trials, $\chi^2(1) = 28.2$, $p < .001$, $R^2 = .01$ (see Figure 8A).

To investigate the effects of practice or fatigue on reaction times, we computed a linear regression on trials in the baseline condition with trial number as a continuous predictor, congruency as a fixed effect and participant as a random factor. The results showed a slight yet statistically significant reduction in reaction times across the baseline trials, $\beta = -1.03$, $t(29.9) = -2.55$, $p = .016$. While significant, the effect of training did not reach the reduction of reaction time seen in the incentive conditions (see Figure 8B).

Figure 8: The effect of practice on behavioural performance



Note: **A** Mean accuracy across participants for each trial (points with bootstrap-based confidence intervals), individual smoothed error rate estimates (thin lines), and smoothed group average error rates (thick line with shaded confidence interval), all separately for congruent and incongruent trials in the baseline and two incentive conditions. **B** Mean reaction times across participants for each trial (points with bootstrap-based confidence intervals), individual smoothed reaction time estimates (thin lines), and smoothed group average reaction times (thick line with shaded confidence interval), all separately for congruent and incongruent trials in the baseline and two incentive conditions.

For more about behavioural performance see Appendix 3, Supplementary Analysis.

2.3.2 Results of the ROI analysis

The ROI analyses results showed a significant increase in sustained activation from the baseline to the incentive conditions in right DLPFC and both left and right dACC, but no significant difference in sustained activation between the two incentive types (see Table 1 and Figure 9B).

Investigation of transient responses revealed significant main effects of incentive (baseline vs. incentive) in left and right DLPFC and right dACC, reflecting an overall increase in transient responses in incentive conditions (see Table 2 and Figure 9B). We also found significant incentive × congruency interactions in all four ROI, reflecting no difference in the transient response to congruent and incongruent stimuli in the baseline but pronounced differences in congruent vs. incongruent responses in both incentive conditions, with stronger responses to incongruent stimuli. We established no significant main effect of incentive type or its interaction with congruency when comparing the two incentive types.

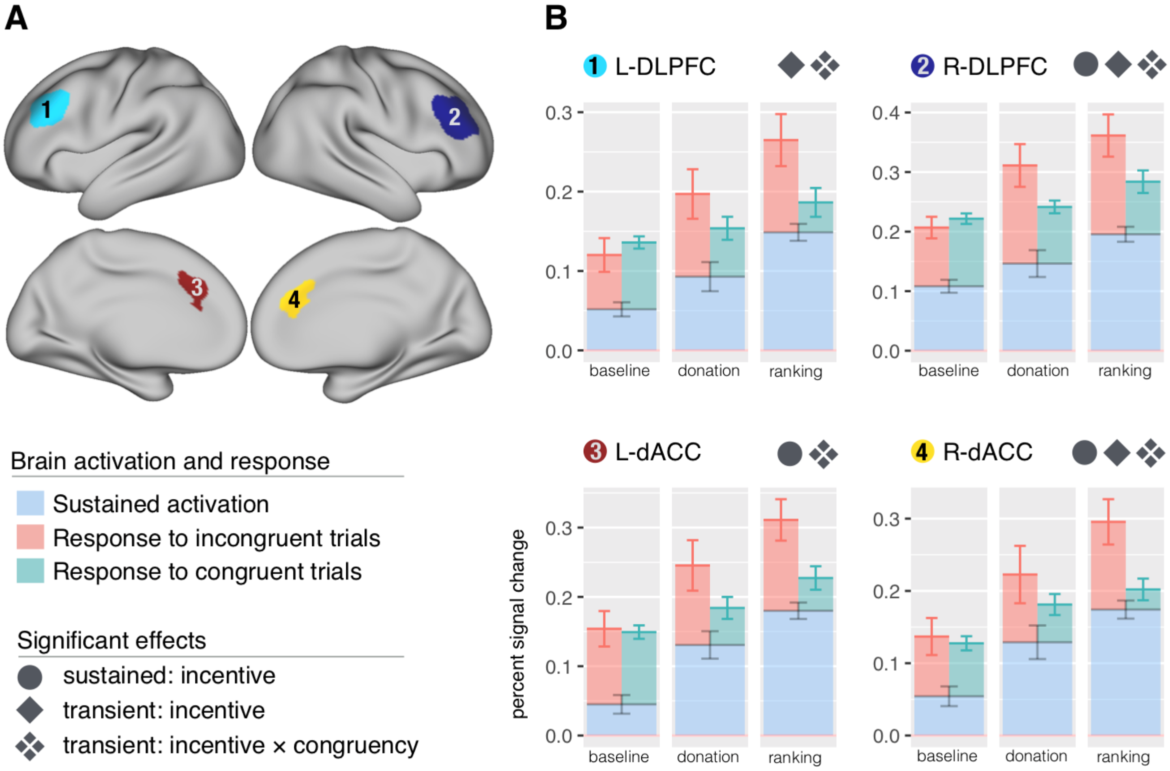
Table 1: A priori ROI t test results for sustained activity: incentive – baseline

ROI	t	dt	d_z	p
L-DLPFC	2.25	29	.411	.067
R-DLPFC	2.53	29	.461	.048
L-dACC	3.34	29	.609	.016
R-dACC	3.14	29	.574	.016

Table 2: A priori ROI ANOVA results on transient activity: incentive – baseline

ROI	Effect	F	df1	df2	η2	p
L-DLPFC	incentive	5.37	1	29	.069	.029
	incentive × congruency	19.60	1	29	.076	< .001
R-DLPFC	incentive	6.99	1	29	.088	< .001
	incentive × congruency	18.48	1	29	.073	< .001
L-dACC	incentive	8.42	1	29	.089	.058
	incentive × congruency	18.53	1	29	.063	< .001
R-dACC	incentive	32.56	1	29	.244	.036
	incentive × congruency	24.02	1	29	.085	< .001

Figure 9: A priori ROI results



Note: Sustained activation and peak transient responses (percent signal change) in four a priori defined regions of interest (ROI). Symbols above each plot denote statistically significant effects ($p < .05$) FDR corrected for multiple comparisons across the four ROI. Error bars show the standard error after removing inter-subject variability. All significant effects relate to comparisons between baseline and incentive, collapsed across incentive types. No comparison within incentive types reached significance. Brain surface maps show NeuroSynth based ROI used to extract brain activation and peak transient responses.

2.3.3 Results of cognitive processes analysed with the use of NeuroSynth maps

The analysis of the NeuroSynth reverse inference maps revealed that all investigated brain systems except the Reward and the Resting state exhibited increased sustained activation in the incentive compared to the baseline condition, indicating an overall increase in engagement across distributed brain systems (see Table 3 and Figure 10). Interestingly, we observed no differences in sustained activation across the investigated brain systems between the two incentive conditions.

Investigation of the transient response revealed a more specific pattern in the results (see Table 4 and Figure 10). Specifically, we observed a modulation in transient response in many of the investigated brain systems, with the exception of the maps related to speech production and social processes. In the Default mode and Resting state networks, we observed an increased transient deactivation in incentive compared to the baseline condition, which seems to some extent to offset the rise in sustained activation. In the Rewards system, we noted an overall increase in the sustained response to both congruent and incongruent trials.

Most interestingly, we observed a significant incentive × congruency interaction, which was specific to the four systems related to executive functions: Attention, Cognitive control, Conflict, and Response inhibition. In all these systems, we detected no differences in the transient response to individual trials in the baseline condition, with a pronounced modulation of response in the incentive condition in which transient responses to congruent stimuli were reduced whereas transient responses to incongruent stimuli were increased. The observed pattern held for both incentive conditions and no significant interaction with the incentive condition was identified.

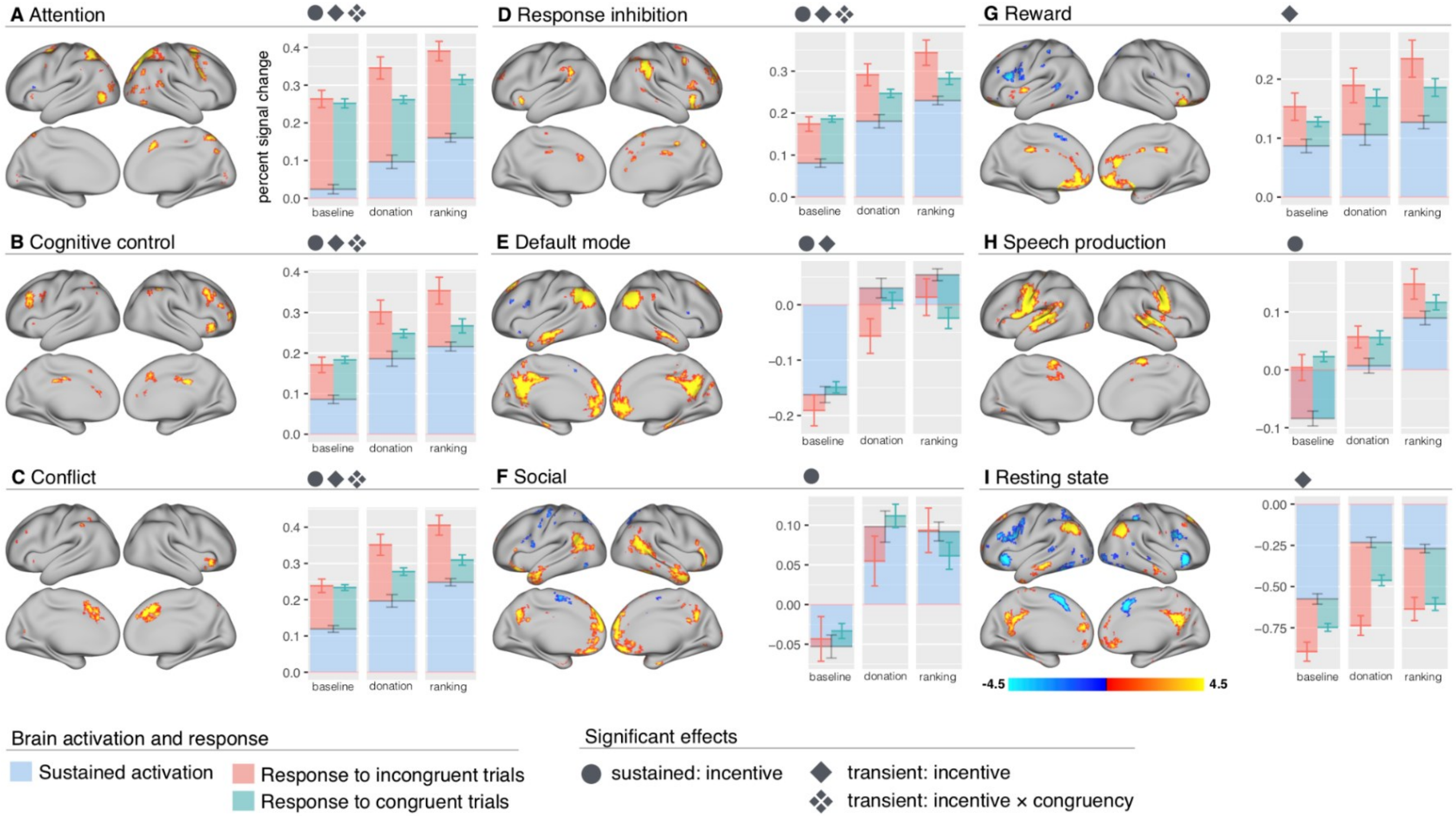
Table 3: A priori NeuroSynth map results of t test on sustained activity: incentive – baseline

NeuroSynth map	**t**	**dt**	**d_z**	**p**
Attention	3.65	29	.666	.007
Cognitive control	4.03	29	.736	.003
Conflict	5.10	29	.931	< .001
Response inhibition	5.24	29	.957	< .001
Default mode	2.97	29	.543	.021
Social	3.11	29	.567	.018
Reward	1.76	29	.321	.283
Speech production	3.53	29	.645	.007
Resting state	< 1	29	.076	1

Table 4: A priori NeuroSynth map results of ANOVAs on transient activity: incentive – baseline

NeuroSynth map	**Effect**	**F**	**df1**	**df2**	**η2**	**p**
Attention	incentive	46.98	1	29	.306	< .001
	incentive × congruency	34.84	1	29	.081	< .001
Cognitive control	incentive	12.33	1	29	.158	.006
	incentive × congruency	32.31	1	29	.113	< .001
Conflict	incentive	26.72	1	29	.260	< .001
	incentive × congruency	55.15	1	29	.164	< .001
Response inhibition	incentive	10.22	1	29	.136	.012
	incentive × congruency	36.57	1	29	.094	< .001
Default mode	incentive	14.89	1	29	.154	.003
	incentive × congruency	< 1	1	29	.001	1
Social	incentive	2.58	1	29	.032	.379
	incentive × congruency	< 1	1	29	.001	1
Reward	incentive	23.11	1	29	.212	< .001
	incentive × congruency	2.74	1	29	.012	.395
Speech production	incentive	< 1	1	29	.001	1
	incentive × congruency	5.00	1	29	.014	.169
Resting state	incentive	61.68	1	29	.378	< .001
	incentive × congruency	3.47	1	29	.017	.308

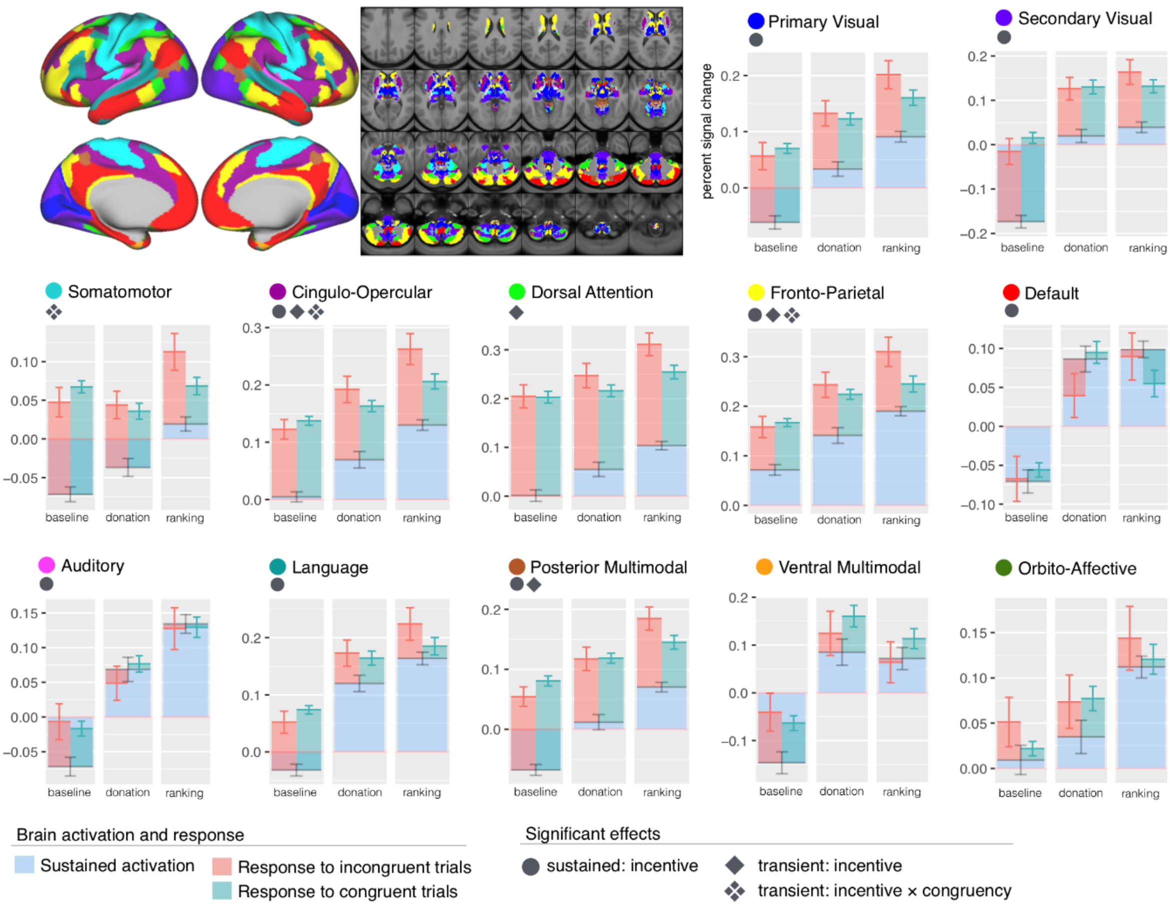
Figure 10: A priori NeuroSynth results (corrected SE)



Note: Sustained activation and peak transient responses (percent signal change) in selected NeuroSynth-based brain systems' maps. Symbols above each plot denote statistically significant effects ($p < .05$), FDR corrected for multiple comparisons across the maps tested. Error bars show the standard error after removing inter-subject variability. All significant effects refer to comparisons between the baseline and incentive, collapsed across incentive types. No comparison within incentive types reached significance. Brain images show NeuroSynth-based maps for each term used to extract brain activation and peak transient responses.

2.3.4 Results of a priori resting state networks analysis

Figure 11: A priori resting state (RS) networks results (corrected SE)



Note: Sustained activation and peak transient responses (percent signal change) in a prior defined resting state (RS) networks (Ji et al., 2018). Symbols above each plot denote statistically significant effects ($p < .05$), FDR corrected for multiple comparisons across the networks. Error bars show the standard error after removing inter-subject variability. All significant effects refer to comparisons between the baseline and incentive, collapsed across incentive types. No comparison within incentive types reached significance. Brain inset shows parcellation into resting state brain networks. Colour circles next to network names correspond with the colour or the related brain parcels.

A similar pattern of results was observed in the analysis of a priori defined resting state (RS) brain networks (see Figure 11, Table 5 and Table 6). Specifically, a number of brain networks, including Primary and Secondary visual, Auditory, Language, Posterior multimodal, Cingulo-Opercular, and Default showed an increase in sustained activation in the incentive compared to the baseline condition that did not differ significantly between the two incentive conditions (see Figure 11 and Table 5). Posterior multimodal and Dorsal attention networks showed a mean decrease in transient response although, together with the increase in sustained activation, the overall response was higher in the incentive compared to the baseline condition. Cingulo-Opercular, Fronto-Parietal and Somatomotor networks were the only ones to exhibit a significant effect of incentive × congruency interaction, reflecting a congruency-specific modulation of the transient response. Namely, whereas no or little difference was observed in the transient response to the congruent and incongruent trials in the baseline condition, in the incentive conditions, the response to the incongruent trials was robustly stronger than to the congruent trials (see Figure 11 and Table 6).

Table 5: A priori RS network results of t test on sustained activity: incentive – baseline

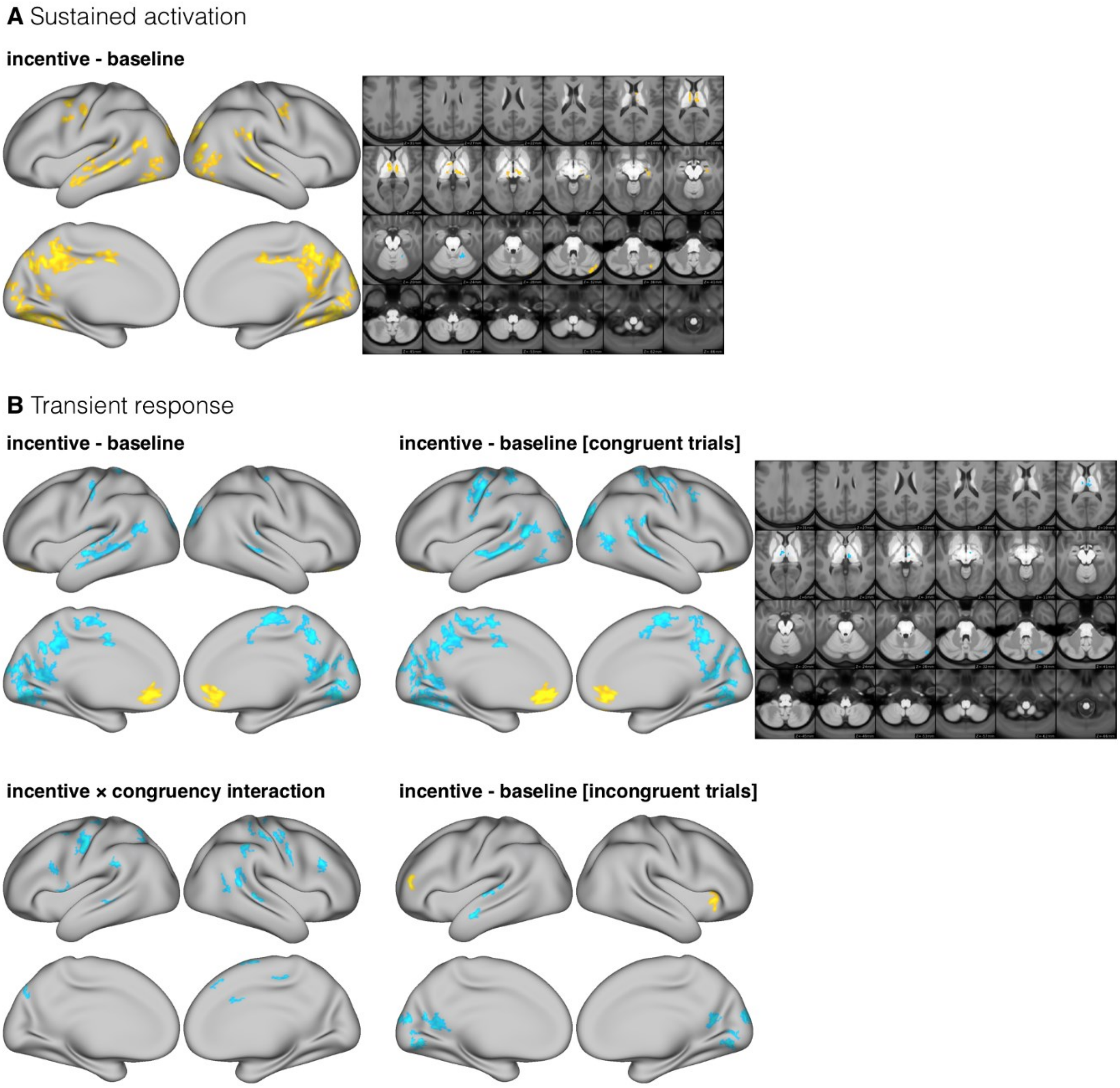
RS network	t	dt	d_z	p
Primary visual	3.38	29	.617	.010
Secondary visual	3.73	29	.681	.010
Somatomotor	1.08	29	.198	.892
Cingulo-Opercular	3.44	29	.628	.010
Dorsal Attention	2.56	29	.467	.065
Fronto-Parietal	3.64	29	.665	.010
Default	3.35	29	.612	.010
Auditory	5.09	29	.929	.001
Language	4.96	29	.906	.001
Posterior Multimodal	3.43	29	.626	.010
Ventral Multimodal	2.52	29	.461	.065
Orbito-Affective	1.52	29	.278	.469

Table 6: A priori RS network results of ANOVAs on transient activity: incentive – baseline

RS	Effect	F	df1	df2	η2	p
Primary Visual	incentive	5.63	1	29	.066	.152
	incentive × congruency	5.46	1	29	.020	.142
Secondary Visual	incentive	2.91	1	29	.031	.460
	incentive × congruency	3.05	1	29	.014	.378
Somatomotor	incentive	< 1	1	29	.008	1
	incentive × congruency	10.51	1	29	.030	.037
Cingulo-Opercular	incentive	19.44	1	29	.200	.002
	incentive × congruency	24.06	1	29	.077	.001
Dorsal Attention	incentive	44.75	1	29	.314	< .001
	incentive × congruency	8.41	1	29	.035	.066
Fronto-Parietal	incentive	14.11	1	29	.154	.010
	incentive × congruency	11.57	1	29	.048	.037
Default	incentive	4.05	1	29	.053	.286
	incentive × congruency	< 1	1	29	< .001	1
Auditory	incentive	8.37	1	29	.100	.053
	incentive × congruency	3.71	1	29	.008	.298
Language	incentive	< 1	1	29	.001	1
	incentive × congruency	7.76	1	29	.028	.069
Posterior Multimodal	incentive	9.54	1	29	.101	.041
	incentive × congruency	6.39	1	29	.027	.107
Ventral Multimodal	incentive	< 1	1	29	.002	1
	incentive × congruency	2.67	1	29	.014	.421
Orbito-Affective	incentive	2.28	1	29	.022	.587
	incentive × congruency	< 1	1	29	< .001	1

2.3.5 Results of whole-brain analysis

Figure 12: Results of whole-brain analysis



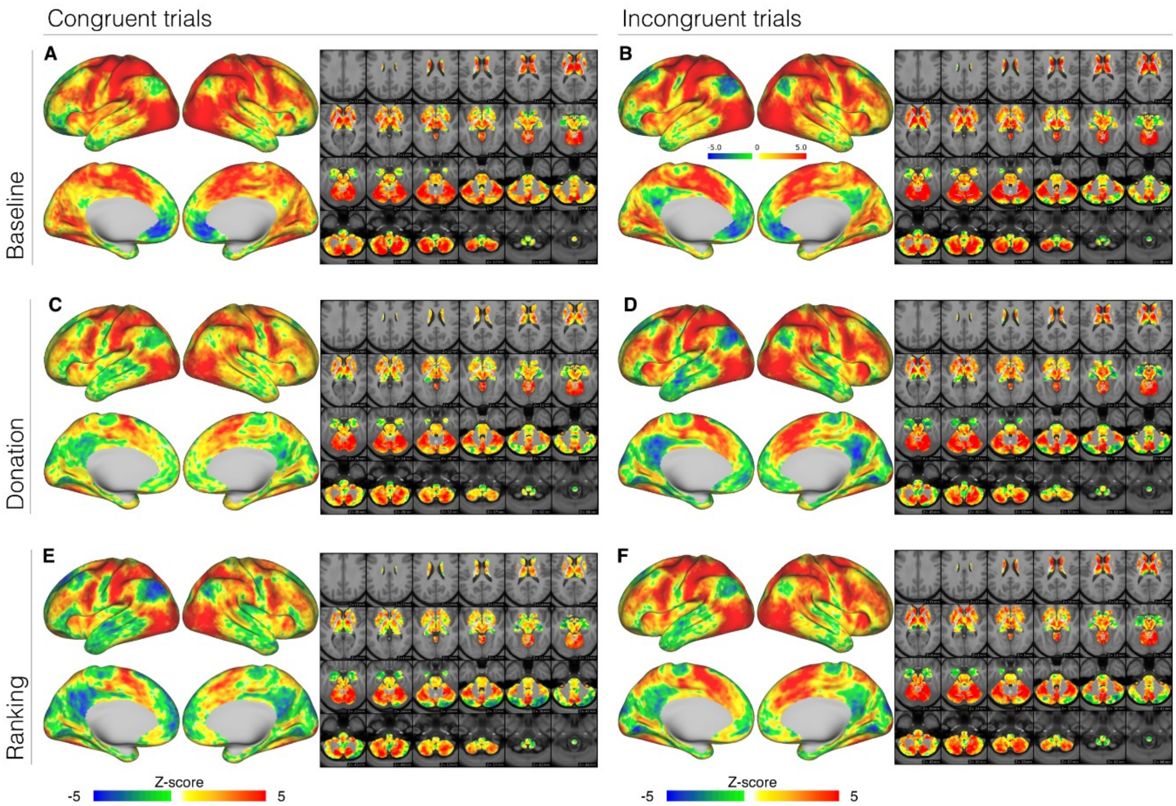
Note: **A** Differences in sustained activation. The image shows differences between the baseline and the mean of incentive conditions (donation and ranking). No differences between the two incentive conditions reached significance after whole-brain correction for multiple comparisons. **B** Effects on the peak transient response. Shown are the main effect of incentive (baseline vs. mean of incentive conditions), incentive (baseline vs. mean of incentive conditions) × congruency interaction, and baseline vs. mean of incentive conditions comparisons for congruent and incongruent trials. No effect within incentive conditions reached significance after whole-brain correction for multiple comparisons. Maps for subcortical areas are not shown if no effects reached significance.

Whole-brain analysis of sustained responses reveals significant increases in activity in several brain regions including secondary visual areas, superior temporal sulcus, primary motor areas, precuneus and posterior cingulate (Figure 12A, see also Appendix 2, Supplementary Figure 5 for untresholded maps). Interestingly, the whole-brain analysis primarily indicates a reduced mean transient response in the incentive compared to the baseline condition (Figure 12B) in many areas that show an increase in sustained activity, indicating an overall shift from a transient response to individual trials to sustained activation throughout the task. Such a decrease in the mean transient response can also be observed in medial supplementary motor areas, thalamic nuclei and the cerebellum.

Remarkably, we also observe a significant difference in the transient response in the medial orbitofrontal cortex, considering whole-brain activation maps in individual conditions (see Figure 13), the observed difference reflects lower transient deactivation of the orbitofrontal cortex in the incentive compared to the baseline condition.

A more detailed comparison of transient responses in the baseline vs. the incentive conditions, conducted separately for the congruent and incongruent trials, reveals a pattern of significant lower transient activation in the incentive compared to the baseline condition as being specific to the congruent trials, including the reduced deactivation of the orbitofrontal cortex. In the incongruent trials, we observe reduced transient activation of the secondary visual and left temporal regions, but also an increased response in the right anterior insula and left anterior middle frontal gyrus.

Figure 13: Results of peak transient responses



Note: Peak transient responses to congruent and incongruent trials during the baseline (**A** and **B**), donation (**C** and **D**), and ranking (**E** and **F**) conditions. Unthresholded maps of Z-scores.

2.4 Discussion

Although organisations are ever more frequently stimulating their employees with various implicit and explicit *social* incentives, the management accounting and the cognitive psychology literature focus almost exclusively on the effects of monetary incentives on cognitive effort and performance. The goal of our study was to understand how social incentives affect cognitive control. We chose to analyse two types of incentives that matter in the setting of performance evaluation in organisations, which we operationalised as *ranking* and *donation*. Although the latter is not employed by organisations literally, we designed it as a combination of working for a target, being measured on performance, and earning money for others, which is a common control situation used in the working context. We were interested in how both incentives affect cognitive control, and whether either incentive might be more effective. The analysis of behavioural and brain responses led us to the following conclusions.

Social incentive improves task performance without affecting conflict resolution

Performance of the Eriksen Flanker task involves a number of cognitive processes from initial perception of the stimuli to response mapping, stimulus-response conflict resolution (in case of incongruent stimuli), and response execution. The observed pattern of reaction times indicates that participants in the incentive condition significantly improved the speed of their processing related to response mapping and/or response execution. However, as shown by the absence of change in the cognitive inhibition index, they were not successful in more efficient resolution of the response conflict. While we observed a slight drop in accuracy in the incentive compared to the baseline condition, the lack of any significant correlation between the two (see Appendix 3, Supplemental Analysis and Supplementary Figure 3C) indicates that the increased speed is not the result of a speed–accuracy trade-off.

The obtained behavioural results display a similar pattern of performance improvement to those observed in studies employing monetary incentives. Prior studies give evidence of the effectiveness of monetary incentives particularly when fast and correct responses are rewarded and errors are not penalised (Chiew and Braver, 2013, 2014, Braem, Verguts, Roggeman, & Notebaert, 2012; Engelmann, Damaraju, Padmala, & Pessoa, 2009; Fröber & Dreisbach 2014; Jimura, Locke, & Braver, 2010; Locke & Braver 2008; Padmala & Pessoa 2011). Yet, in our previous work (Ličen et al., 2016) we asserted that in a real work setting it is more realistic to stimulate not only speed, but also accuracy. We followed this reasoning in the design of the donation condition in this study by penalising incorrect responses. Although we employed a different task (AX-CPT was used in the earlier study), the results we obtained are qualitatively similar to the effects of both social pressure and monetary incentive conditions in the previous study (Ličen et al., 2016).

Brain imaging results indicate an increase in both proactive and reactive cognitive control

Neuroimaging results were congruent and complementary on all four levels of analysis: a priori ROI analysis, a priori brain systems analysis, a priori resting state networks analysis, and exploratory whole-brain analysis. First, we observed a broad increase in sustained activation across multiple brain regions and networks, which we believe indicates an increased level of sustained attention and proactive cognitive control that allowed the participants to substantially increase their processing speed as evident in the significantly reduced reaction time.

Second, we observed a modulation of the transient responses to individual trials in the incentive compared to the baseline condition. The specific form of modulation varied across brain regions, systems and networks. Of most direct interest is the observed effect of the interaction between incentive and congruency on transient responses. Whereas no differences in transient responses were observed in the baseline condition, in the incentive conditions we observed robustly stronger responses in the incongruent compared to the congruent responses. Importantly, this modulation was only seen in regions, systems and networks related to cognitive control. The observed results are congruent with more efficient reactive cognitive control that is employed to ensure maintenance of a high level of accuracy despite a significant rise in reaction times.

Interestingly, the results of both the a priori-based as well as whole-brain analyses indicate that the increased sustained activation in the incentive compared to the baseline condition is often coupled with a decrease in the transient response to congruent stimuli, suggesting a decrease in reactive control to congruent stimuli due to increased proactive control and better identification of the conflict or rather the lack of it. While showing a tendency for an increase in the incentive vs. the baseline condition, in the a priori cognitive control regions, the transient response to incongruent stimuli mostly retains the response level in other brain systems and networks. In the whole-brain analysis, only the right anterior insula and left anterior medium gyrus, regions closely related to the control of attention and inhibition of distractors, show a significant increase in the transient response in incongruent trials.

Similar increases in sustained activity in DLPFC and dACC to monetary incentives were reported in previous studies (e.g. Braver et al., 2007). Yet those studies did not observe increased transient activation in these two regions of interest. One possible explanation for the difference is that in our, and not in previous, studies errors were penalised, which incentivised subjects to increase their reactive control.

Overall, in our opinion the observed results show increased engagement of the proactive control mode, complemented with increased engagement of the reactive control mode in incongruent trials. As proposed by Braver (2012), the two mechanisms are not necessarily antagonistic, but can reinforce each other in circumstances in which speed is stimulated, but conflicts also need to be resolved. Ličen et al. (2016) also found the simultaneous engagement of proactive and reactive control modes was invoked by the monetary incentive combined with a penalty for errors. Interestingly, while in our study we observed the described effect not only in the donation condition where errors were penalised, but also in the ranking condition where errors were not explicitly penalised.

No differences observed between the two incentive conditions

Although a slight tendency towards stronger effects in the ranking compared to the donation incentive condition can be observed in the neuroimaging results, the behavioural results are for all practical purposes indistinguishable between the two incentive conditions, and no significant statistical difference was observed in the neuroimaging results. Such results were not expected because seemed that both ranking and donation had similar effects on task performance.

A possible explanation for the equivalence of the two incentive conditions is that they were indeed perceived to be equally important. One explanation might be the social presence effect according to which the mere social presence and observation of one's results enhances the drive to perform (Zajonc, 1965). Another possibility is that the similarity between the two incentives outweighed the differences. Namely, donation can also be understood as means for measuring the participants' performance, and neither donation nor ranking resulted in a personal monetary benefit. Both incentives may have facilitated the adoption of improved task performance as their personal goal, and evidently had the intended effect. As maintained by Locke and Latham (1990), the internal adoption of personal goals counts as the primary and general determinant of effort.

While during the task performance we checked the participants' understanding of the cue (the colour of the bounding square) indicating the incentive condition several times, we cannot completely rule out the possibility the participants did not qualitatively distinguish the two incentives. Whereas the participants understood the meaning of the cues, they might not have paid attention to which incentive was relevant for each particular task block.

Brain systems and networks engaged in task performance

Whereas the focus of the study was to assess the impact of social incentive on cognitive control, the analysis of its impact on the investigated brain systems and network provides additional information and insights into the effect of the incentive.

Investigation of the Reward system, comprising the midbrain, the ventral striatum, and the medial orbitofrontal cortex (Rohe, Weber, & Fliessbach, 2012) revealed high sustained activation that was already present in the baseline and remained basically unchanged in the incentive conditions, suggesting that the brain system involved in reward processing (i.e. reward anticipation, computation of reward prediction errors and processing of reward receipts) is activated and sustainably maintained throughout task performance irrespective of the incentive. Interestingly, the transient response to both the congruent and incongruent trials significantly increased in the incentive compared to the baseline condition, indicating increased responsiveness under incentive.

Less anticipated but not entirely unexpected is the lack of deactivation of the Default Mode Network (DMN) system as identified using NeuroSynth and actual activation when defined using resting state connectivity in the incentive conditions coupled with more pronounced transient deactivations. Activation in DMN regions is typically associated with self-awareness and with errors in performance by externally stimulated tasks (Dixon, Fox, & Christoff, 2014; Spreng, 2012; Spreng et al., 2014). Spreng (2012) proposes that the DMN is not task-negative *per se*, but is often engaged during goal-directed cognition if required so by the task. It is associated with internally focused cognitive process, among others, with social cognition. As shown by studies on autobiographical planning, with simulated problem-solving, evaluating one's creative work, social working memory and others the DMN can be simultaneously engaged with task positive networks. Dixon et al. (2014) suggest that the DMN competes with externally directed cognition only if both types of cognition involve higher levels of intentionality due to capacity limitations. The two networks can be concurrently engaged with minimal interference if one involves spontaneous processing, as may be the case with self-awareness during this experiment.

Activation of the default mode network may also be explained by the recent finding by Spronk et al. (2018) that the orbitofrontal cortex is shared by three networks (fronto-parietal, DMN and orbito-affective network), suggesting that task representations in the lateral prefrontal cortex interact with action-outcome and stimulus-reward associations in the orbitofrontal cortex (OFC) (Kahnt, Heinzle, Park, & Haynes, 2011), which is then reflected as increased activation of the DMN.

The Social map as identified by NeuroSynth comprises brain areas mostly related to social perception. Important regions in this map are the superior temporal sulcus (Lahnakoski et al., 2012), superior anterior temporal cortex (Zahn et al., 2007), dorso-medial prefrontal cortex, posterior cingulate/precuneus, bilateral temporal poles, bilateral temporoparietal junction and amygdala (Frewen et al., 2011). In our study, we observed a significant increase in sustained activity in the incentive compared to the baseline condition, whereas transient activity seems to vary across individuals and overall does not show a significant response. This pattern could be ascribed to engagement in social processing due to the nature of the incentive, which however does not relate to specific responses in individual trials.

Whereas Speech production was initially included as a negative control, the results still show a significant change in sustained activity, from robust deactivation in the baseline to activation in the ranking condition. The observed change could be the result of enhanced motor control, response inhibition and processing of social information rather than speech production per se, as the latter was not required by the task. The Speech production map also includes the primary motor cortex (Brown, Laird, Thelen, Turkeltaub, & Liotti, 2009), supplementary motor cortex (SMA) (Alario, Chainay, Lehericy, & Cohen, 2006) and preSMA (Seghier, Bagdasaryan, Jung, & Price, 2014), where the latter two are also implicated in executive control of motor input, response inhibition (Cieslik, Mueller, Eickhoff, Langner, Eickhoffa, 2015) and choice-related activity (Schouppe et al., 2015), also relevant for performance of the Flanker task, which might explain some of the observed sustained activation in the ranking condition.

2.5 Conclusion

The findings of our study not only contribute academic evidence on the role of motivation in cognitive control, but also hold practical implications for the workplace. An increasing amount of research in psychology and behavioural economics gives evidence of the boundaries of monetary incentives in motivating individuals in highly difficult cognitive tasks, judgmental or creative tasks (Ariely et al. 2009; Bonner et al., 2000; Deci et al., 1999; Oblak et al., 2017). However, the importance of non-monetary, social incentives in various forms has been given more merit in psychology (i.e. Gees, 1991; Lerner & Tetlock, 1999; Locke, 1996; Ličen et al., 2016; Wright, Tunstall, Williams, & Goodwin, 1995) than in behavioural economics or management accounting literature, which may explain why social incentives are still seen as a complementary control mechanism rather than incentives in their own right. The objective of our research was to add to neuroscientific evidence concerning the effects of social incentives on the exertion of cognitive control and extend the previous behavioural results reported in Ličen et al. (2016). Our findings indicate that social incentives can affect executive processes to a similar extent as monetary rewards. While not providing direct personal benefits, the benefits related to social incentives are more indirect and longer term, such as social standing (Williams, 2007) due to a high ranking or helping others, the quality of the relationship with one's superiors (if respecting their instructions) or benefits derived from mere satisfaction of having helped others (Alford et al., 2009). Since innovative, creative, highly difficult cognitive tasks, as well as tasks that require sound judgement in risk-taking in which the link between the reward and effort is not straightforward and predictable, are becoming increasingly more relevant for the success of modern organisations, the use of social incentives may become ever more valuable for encouraging employees to undertake them.

Several possible directions for future research remain open. The inclusion of monetary and social incentives in the same experiment would enable their direct comparison. A comparison of positive and negative social incentives on cognitive control and performance as well as other formal control mechanisms would also further our understanding of the efficacy of the elements of management control in and optimal design of control environments.

3 CAN ACCOUNATBILITY MITIGATE MANAGERIAL MYOPIA?

Abstract

In this chapter, we examine the impact of accountability on managerial myopia by measuring the managers' tolerance to delay and risk-taking. To analyse this question, we use a within-subjects experiment with delay discounting and probability discounting choice tasks on 147 students. We operationalise accountability as a justification pressure, which is the expectation of decision-makers that they will be called on to justify their behaviour to their supervisors. The findings support our hypotheses about the mitigating effect of accountability on myopic behaviour. We find that accountability decreases the excessive discounting of risky and delayed outcomes and contributes to the use of more consistent discount rates. We advance the management accounting literature by showing that managerial myopia is not just a rational response to short-term oriented and too frequent performance evaluations but a cognitive constraint to tolerate delay and risk. The study provides original evidence that justification pressure can reduce individuals' biases regarding too conservative and inconsistent evaluations of future outcomes.

Keywords: accountability, justification pressure, managerial myopia, delay and probability discounting, time preference, indifference point, risk aversion, impulsivity

JEL code: D87, M41, M48

3.1 Introduction

Managers regularly make decisions in which they have to weigh between current costs and future benefits to an organisation. For instance, they decide on investment projects and estimate how the current investment's cash outflows will be paid back by future cash inflows. They engage in a cost cutting strategy to increase future margins. They weigh between expensive marketing campaigns that are expected to yield positive returns in the future and spending less for marketing to boost short-term profits. A common denominator of such decisions is a trade-off that managers face between present and future outcomes. Making such trade-offs is difficult because they essentially require a comparison of immediate, relatively certain, decision outcomes with future, relatively uncertain ones. In practice, managers often show behaviour incongruent with long-term organisational goals (Graham, Harvey, & Rajgopal, 2005; Lant, Milliken, & Batra, 1992; Miller, 2002; Mizik, 2010; Mizik & Jacobs, 2007). Acting with the desire to increase present earnings and the stock price at the cost of long-term firm value is called *managerial myopia* (Bebchuk & Stole, 1993; Bhojraj & Libby 2005; Chowdhury, 2011; Edmans, 2009; Levinthal & March, 1993; Merchant, 1990; Narayanan, 1985; Stein, 1988, 1989; Thakor, 1990; Van der Stede, 2000).

Myopia is a term that stems from optometry that signifies people's inability to see at a distance. In other words, it means being short-sighted. In management accounting, myopia denotes managers' propensity to optimise the present at the expense of the future. Short-sightedness is a well-known example of dysfunctional managerial decision-making. The management accounting and behavioural economic research have provided pervasive evidence about the characteristics of performance evaluation systems that may aggravate myopic behaviour (Bhojraj & Libby, 2005; Hermalin & Weisbach, 2012; Gigler, Kanodia, Sapra, & Venugopalan, 2014; Edmans, Heinle, & Huang, 2016; Kraft, Vashistha, & Venkatachalam, 2018; Bernatzi & Thaler, 1995; Graham, Harvey, & Rajgopal, 2005; Thaler, Tversky, Kahneman, & Scheartz, 1997). Frequent performance evaluations, overemphasis on financials, and aggressive performance-based incentives are such examples. Myopia, however, can also be a cognitive constraint that stems from the human evaluation of the distant future (Ardila, Rosselli, & Strumwasser, 1991; Bickel, Yi, Landes, Hill, & Baxter, 2011; Chi & Fan, 1997; Simon et al., 2002; Tversky & Kahneman, 1974).

Individuals' evaluation of future outcomes is reflected in their intertemporal and risky choices. The recent literature suggests that the two decision processes are closely related (Baucells & Heukamp, 2012; Frederick, Loewenstein, & O'Donoghue, 2002; Luckman, Donkin, & Newell, 2017). Several personality traits such as self-control, impulsivity, and risk inclination play a decisive role in both (e.g., Jones, Fearnley, Panagiotopoulos, & Kemp, 2015; Kirby, Petry, & Bickel, 1999; Petry, 2001; Reynolds, 2004; Reynolds, Karraker, Horn, & Richards, 2003; Reynolds, Ortengeren, Richads, & de Wit, 2006; Reynolds, Richards, Horn, & Karraker, 2004; Steward et al., 2017; Xue, Sonuga-Barkle, & Liu, 2015). In this study, we examine to what extent accountability can mitigate persistent psychological patterns that encourage myopic behaviour. We analyse whether accountability has the power to reduce excessive intolerance to delay and risk and the inconsistent use of discount rates that lead to suboptimal investment decisions.

To address our research question, we conduct a within-subject experiment in which we measure myopia by using delay discounting and probability discounting choice tasks. We hypothesise that accountability reduces excessive delay and risk discount rates and prevents inconsistent use of discount rates which lead to preference reversals. Accountability is operationalised as justification pressure (Lerner & Tetlock, 1999), which is the expectation by decision-makers that they will be called on to justify their behaviour to superiors. We observe delay and risk tolerance in a series of choices between an immediate outcome and outcomes at different time delays and between a certain outcome and outcomes at different probabilities under no accountability and accountability conditions. A point at which a participant becomes indifferent between the immediate or the delay outcome and the certain or the risky outcome is called the *indifference point* (Vanderveldt, Oliveira, & Green, 2016). Based on the indifference point we estimate a curve of delay and probability discounting (Mazur, 1987; Rachlin, Raineri, & Cross 1991, respectively). We also investigate whether accountability reduces the use of inconsistent discount rates by deferring both the immediate and the delayed outcomes for one year. We also decrease the probability of the certain and the risky outcomes by 50 percentage points that makes all options considerably riskier. The experiment was tested on 147 students.

Our findings show that the participants use the hyperbolic rather than the exponential discounting function that indicates a sharply falling discount rate with time distance and increased uncertainty. The justification pressure elicits higher indifference points and less steep delay and probability discounting, which indicates that the participants by having to justify their choices decreased their excessive risk and delay aversion. The shape of the discounting curves and the significant interactions among delay, risk, and accountability show that accountability leads participants to use more consistent discount rates in the distant future and at higher risk levels. Our findings show that some performance evaluation mechanisms exacerbate myopic behaviour and that justification pressure reduces excessive subjective discount rates for time delay and risk that makes it more consistent in priming the participants to think harder about their choices.

Understanding behavioural causes and the effectiveness of remedies for managerial myopia is timely and relevant as there is considerable pressure from financial regulators and firms' owners to better align managers' decisions with the long-term interests of the firm. Our study is an original analysis of the effect of justification pressure on individuals' excessive delay and risk aversion, which are two biases that contribute to managerial myopic behaviour. The finding that accountability can reduce excessive risk and delay aversions and the use of inconsistent discount rates is novel and original. It contributes to the scarce body of knowledge about the effectiveness of management accounting mechanisms to undo behavioural biases (Oblak et al., 2017; Vieider, 2009). The study's findings could fruitfully contribute to the design of more effective and congruent performance evaluations that would be of relevance not only to management accounting academics but also to practitioners.

The remainder of the chapter is structured as follows: Section 3.2 provides theoretical background and develops the hypotheses. Section 3.3 focuses on the research method and the design of the experiment. Section 3.4 presents the results of the analysis. In section 3.5, we discuss the findings, outline some limitations of the study, and conclude with implications.

3.2 Theoretical background and hypotheses development

Managerial myopia is a phenomenon so common that it has received extensive coverage in management accounting, economic, and psychologic studies. Chowdhury (2011), Merchant (1990), and Miller (2002) describe it as the tendency of managers to invest in fast yielding projects by redirecting resources from long-term value maximising projects. Lant et al. (1992) stress that a narrow view of temporal choices restricts the awareness of future opportunities and the evaluation of the strategic alternatives. Narayanan (1985) denotes such behaviour as irrational. It can lead to a restricted interpretation of information and limited awareness of the competitive environment (Nadkarni & Barr, 2008). Myopia creates biases in strategic decision-making (Levinthal & March, 1993) and causes dysfunctional organisational and market behaviours that can ultimately result in breakdowns of companies and economic systems (Dallas, 2012). According to Edmans (2009), managerial myopia is a first-order problem in modern firms.

The management accounting literature proposes that the main reason for myopic behaviour is the maximisation of managers' personal interests as a reaction to a performance evaluation system's incomplete design (Merchant, 1990; Narayanan, 1985; Stein, 1989). In other words, if a performance evaluation system is short-term oriented, then it encourages myopia. As such, managerial myopia could be viewed as a *rational* response to the dysfunctional performance evaluation. On the other side, myopia might be irrational human behavioural predisposition. Management accounting studies consider human *cognitive constraints* as the acceptance of distant future outcomes to a very limited extent.

Performance evaluation systems typically assume that people adhere to some rational decision rules. Outcome choices are relatively simple when the available options differ only in one dimension: individuals tend to prefer larger to smaller rewards, to receive them sooner rather than later, to exert less rather than more effort, and to receive them with a greater degree of certainty. Decision-making is substantially more difficult because the options vary for more than one dimension. When the evaluation of future outcomes is involved, performance evaluation systems are based on the premise that decision-makers will correctly estimate the probabilities and timing of future outcomes and that they will have all the needed information about the future. In the normative theory, rational decision rules are consistent with expected utility predictions and exponential discounting functions.

Behavioural research has provided robust evidence that people strongly prefer the soonest outcomes to shortly delayed ones, but they do not really perceive the difference for the same delay in the distant future (Dasgupta & Maskin, 2005; Farmer & Geanakoplos, 2009; Green & Myerson, 2004; Green, Myerson & McFadden, 1997). The lack of perception indicates the use of a falling discounting rate rather than a constant one, and a hyperbolic or quasi-hyperbolic discounting function rather than an exponential one (Green & Myerson, 2004; Mazur, 1987). Although the preference for the soonest outcomes was first ascribed to the impulsivity of people (McClure, Cohen, Laibson, & Loewenstein, 2004), Glimcher, Kable, and Louie (2007) find that people adhere to an "as soon as possible" rule rather than simply being impulsive.

When evaluating risky and uncertain outcomes, individuals prefer smaller and more certain gains over larger and risky ones. In choices that are framed as gains people have a strong risk aversion, but they reverse their preference when it comes to choices framed as losses (Kahneman & Tversky, 1979). For such comparisons, individuals use probability discounting. The probability discounting curve is initially very steep, which reflects the higher utility of smaller certain outcomes over larger risky outcomes despite their equal or higher expected value. However, when comparing outcomes with low probabilities individuals' sensitivity to the same difference in risk decreases. This is reflected in a shallower discounting curve. Many authors propose that probability discounting has a similar hyperbolic function to temporal discounting (Green, Myerson, & Ostaszewski, 1999; Rachlin et al., 1991). In fact, recent studies show that risk and time processing are closely related cognitive processes (Baucells & Heukamp, 2012; Halevy, 2008; Luckman, Donkin, & Newell, 2017; Walther, 2010). As explained by Fehr-Duda and Epper (2012), uncertainty is closely attached to future events and only immediate consequences can be viewed as certain. Probability discounting is time dependent and time discounting is risk dependant. (Lopez-Guzman, Konova, Louie, & Glimcher, 2018).

The use of inconsistent discounting rates in discounting process often leads to individuals reversing their preferences at different risk and delay levels. Decision-makers are said to display dynamically inconsistent choices, which the normative theory considers irrational (Ainslie, 1974; Ainslie & Herrnstein, 1981; Rachlin & Green, 1972). For example, although individuals generally prefer a smaller, immediate reward over a larger reward in the future, this preference will shift to the larger reward when the same time delay is added to both alternatives. Similarly, the tendency to prefer a smaller, certain reward over a larger riskier reward will reverse if the probability of obtaining the reward will decrease by the same percentage points for both alternatives.

To explain the steep discounting of risk and delay in the near future and the preference reversals, researchers have proposed various explanations. Several authors show that impulsive preference reversals are indicative of a disproportionate valuation of rewards (Ainslie, 1992; Bénabou & Pycia, 2002; Peters & Büchel, 2009; Shefrin & Thaler, 1988). People ascribe subjective weights to probabilities in dependence of reward attractiveness

(Damasio, 1994). The neuroscientific research on risky and temporal decision-making indicates that risk and uncertainty are associated with fear and anxiety, which are two very strong emotions that hinder rational responses (Loewenstein, Weber, Hsee, & Welch, 2001). Some researchers find that the excessively aversive response to uncertainty arises due to the domination of the affective system over a more rational evaluation of options performed by the cognitive decision system in the brain (Camerer, Loewenstein; & Prelec, 2005; De Martino, Kumran, Seymour, & Dolan, 2006; Gonzalez, Dana, Koshino, & Just, 2005; Loewenstein, Rick, & Cohen, 2008). In other words, the authors show that individuals do not exert enough cognitive effort to make more rational decisions and that they could be nudged into better decisions (Thaler & Sunstein, 2008).

How accountability affects delay and risk aversions is an interesting question. Assuming that the excessive aversion to future outcomes and the preference reversals arise from emotional reactions rather than reasoning. The question is whether accountability can make individuals think more or whether it can compel them to engage in more "cognitive effort" that would lead them to de-bias their decisions about long-term outcomes. The management literature describes accountability as a system in which individuals report to a recognised authority and are held responsible for their actions (Edwards & Hulme, 1996; Fox & Brown, 1998). Accountability usually means that if people fail to provide a justification, they will experience negative consequences (Lerner & Tetlock, 1999). According to Tetlock (1985), a potential evaluation by others is one of the most powerful factors that influences human decision-making. People's natural tendency is to conform to the expectations of those that they are accountable to, albeit without an explicit monetary incentive, has been documented by a large body of research (Cialdini et al., 1976; Klimoski & Inks, 1990; Quinn & Schlenker, 2002; Tetlock, 1983; Tetlock, Skitka, & Boettger, 1989). Lerner and Tetlock (1999) find that if the decision-makers know the view of a superior to whom they report, they usually conform to it. They adopt positions to gain the favour of those to whom they are accountable to and avoid the cognitive effort of analysing various alternatives and trade-offs. However, such attitude shifting takes place only when participants are not personally involved in the decisions. Accountability to a supervisor whose views are unknown generally results in more cognitive effort. Studies have termed this phenomenon pre-emptive self-criticism (Lerner & Tetlock, 1999; Tetlock, 1983; Tetlock & Kim, 1987). In anticipating possible criticisms of others, it makes individuals consider more options in more depth.

The studies that investigate the effect of accountability or public evaluation on risk aversion report inconsistent findings, possibly because of the variation in the experimental manipulations. The research has shown that public scrutiny accentuates pre-existing risk attitudes, thus making risk averters more risk averse and risk-seekers more risk seeking (Baltussen, van den Assem, & van Dolder, 2010). Curley, Yates, and Abrams (1986) find that the fear of a negative evaluation increases ambiguity aversion. Trautmann, Vieider, and Wakker (2008) report that by eliminating such fear, the ambiguity aversion disappears. Vieider (2009) and Pahkle, Strasser, and Vieider (2015), on the other hand, find that accountability reduces loss aversion. They interpret accountability as the subjects recognising the bias and reducing it. The reasons that studies report contrasting findings may be the different decisions they analyse, distinctive manipulation of accountability (from mere observation, to the evaluation of others and the justification pressure), and most importantly different participants' expectation of what the normatively correct answers would be. To the best of our knowledge no study exists about the effect of accountability on excessive delay aversion, the second determinant of managerial myopia.

We argue that accountability helps decision-makers understand the expectations of the supervisors and makes them anticipate possible criticism for irrational choices and can become an effective social incentive. Social incentives have a positive influence on cognitive control, which is the human ability to regulate thoughts and actions in the pursuit of behavioural goals (Braver, 2012). As demonstrated by Ličen et al. (2016) individuals that are incentivised with social pressure or a social incentive enhance their cognitive control which leads to improved attentional control, conflict resolution, and better inhibition of erroneous responses. This is precisely what is required for suppressing intrinsic excessive risk and delay aversions in evaluations of distant future prospects. Controlling such behaviour requires conflict resolution and the inhibition of prepotent responses, that is, the responses that come to mind quickly and intuitively. Individuals who are asked to justify their choices are expected to improve cognitive control over the decision process and moderate their risk and delay aversions. Thus, we hypothesise the following:

H1: Accountability reduces excessive delay aversion.

H2: Accountability reduces excessive risk aversion.

H3: Accountability reduces the use of inconsistent discount rates.

3.3 Research method

3.3.1 Participants

We conducted a laboratory experiment that used 150 students majoring in accounting, management, and finance in the Faculty of Economics at the University of Ljubljana, Slovenia. Three participants (2.0%) were eliminated from the analysis due to technical issues with the computer during the experiment. In the analysis reported below, 147 participants were included (53 males, age $M = 22.59$, $SD = 2.92$, range = 20–37 years) with an average 3.3 years of work experience ($SD = 3.03$, range = 0–18 years). Participants were invited to take part in the study and were compensated with course credits in return. They were also informed at the beginning of the experimental task that some of the participants would be randomly chosen to receive the actual outcome based on one of the choices made during the experiment. The rewarded choice and the probability of obtaining it would also be randomly selected by a computer. In case of the intertemporal choice, the reward would be paid out in the preferred time. Even though not every participant was compensated, the potential reward of up to EUR 40 was high enough to motivate them to make choices as if any of them could be actually earned. In total 18 students were selected based on the random draw and paid the total amount of EUR 482 or on average EUR 26.8 per participant. Before the start of the experiment, all participants were informed that their participation was voluntary and that they were free to withdraw from the study at any point without any consequences. They also gave written informed consent prior to the participation in the study.

3.3.2 Task

Most of the studies that investigate delay discounting involve a series of choices between a smaller reward available sooner and a larger reward available later. Similarly, probability discounting studies contain a series of choices between a smaller certain reward and a larger riskier reward. To measure individuals' delay and risk inclination, we used a choice task with a discount titration (e.g., Green, Myerson, Holt, Slevin, & Estle, 2004; Mazur, 1984,1985, 1988; Mazur & Coe, 1987; Mazur, Synderman, & Coe, 1985). The titration procedure has been frequently used to determine *the indifference points* (Vanderveldt et al., 2016) and reflects the procedure where the reward or delay or probability is incrementally adjusted until the subject is indifferent between the two options presented.

For illustration, in the first series of choices the participants had to choose between the immediate and the delayed reward being provided at a fixed point in time in the future (after one, three, and six months and one year). The initial amount of the immediate reward started at EUR 40 and was systematically titrated by EUR 2 in each trial. The delayed reward remained the same in all trials (EUR 40), that is, in the first trial the participants had to choose between EUR 40 now versus EUR 40 after one month, in the second trial between EUR 38 now versus EUR 40 after two months, and so on, for all time delays). At a certain point the participant chose the delayed outcome and the amount was defined as the participant's indifference point. By that point the participant completed the first series of trials. In the next series of choices, immediate rewards were postponed for one year. The participants had to choose between the reward being given in one year and an even more delayed reward being given in one year and one month, one year and three months, one year and six months, and two years. Again, the reward that was more delayed remained the same for all trials (EUR 40), whereas the reward that was fixed at one year from the decision time gradually decreased by EUR 2 in each trial (i.e., in the first trial the participants had to decide between EUR 40 in one year versus EUR 40 in one year and one month, in the second trial between EUR 38 in one year versus EUR 40 and so on, for all time delays) (see Table 7).

Table 7: Design of experimental task

	Intertemporal choice			*Delay*	Δ Delay
Delay discounting task	EUR **X** now	vs.	EUR 40 in	1 month 3 months 6 months 1 year	1 month 3 months 6 months 1 year
	EUR **X** in 1 year	vs.	EUR 40 in	1 year and 1 month 1 year and 3 months 1 year and 6 months 2 years	1 month 3 months 6 months 1 year
	Probabilistic choice			***Probability***	**Δ Probability**
Probability discounting task	EUR **X** with 100%	vs.	EUR 40 with	95% 90% 80% 60%	5 p.p. 10 p.p. 20 p.p. 40 p.p.
	EUR **X** with 50%	vs.	EUR 40 with	45% 40% 30% 10%	5 p.p. 10 p.p. 20 p.p. 40 p.p.

Note. p.p. = percentage point.

A similar procedure was applied for the probability discounting task. In each trial the participants were asked to choose between EUR 40 available with different probabilities and a more certain reward. In the third set of choices the participants had to choose between a certain reward (with 100% probability) and a riskier reward with different probabilities (95%, 90%, 80%, and 60%). The riskier reward remained the same for all trials (EUR 40), whereas the certain reward decreased from EUR 40 by EUR 2 in each trial (i.e., in the first trial the participants had to choose between EUR 40 with 100% versus EUR 40 with 95%, in the second trial between EUR 38 with 100% versus EUR 40 with 95%, and so on until the indifference point was reached). In the fourth set of choices the participants had to choose between a less risky reward being given with 50% probability and a riskier reward being given with a substantially lower probability (45%, 40%, 30%, and 10%). The difference in probabilities between more and less certain rewards was the same as in the third set of choices (5%, 10%, 20%, and 40%), but overall the whole set of choices was presented at lower probability levels. In the first trial the participants had to choose between EUR 40 with a 50% probability versus EUR 40 with 45% probability, in the second trial between EUR 38 with 50% probability versus EUR 40 with 45% probability, and so on (see Table 7).

The delay and probability discounting task were programmed in the E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) running on Windows 7 OS. The instructions and choices were presented on a 19-inch LCD display. We analysed the data in R (R core team, 2016).

3.3.3 Procedure and manipulation

We manipulated the no accountability condition by telling the participants that their responses would not to be publicly disclosed. By contrast, in the accountability condition, the participants were informed that their responses would be publicly revealed and were instructed to write down an explicit justification of their choice to the supervisor of the experiment for each task. Because the design of the experiment was within-subject, the participants first performed the task with no accountability condition and then with the accountability condition. As the task was about preferences, the learning effect did not apply. Before the participants in the accountability condition could make their choice, their required returns from the no accountability condition appeared on the screen to make them aware of them. The research was conducted in computer rooms in the Faculty of Economics at the University of Ljubljana in May 2017. The experiment lasted approximately one hour and included the questionnaire that measured the demographic variables, such as age, gender, and years of work experiences.

3.3.4 Data analysis

The indifference points were derived from the choices in all the delay and risk trials. From the indifference points we were able to determine a subjective discount factor *k* based on the Equation 3 (Mazur, 1987) and Equation 4 (Rachlin et al., 1991):

$$V = \frac{A}{(1 + k\,D)} \tag{3}$$

$$V = \frac{A}{(1 + k\,\theta)}, \quad \theta = \frac{1-p}{p} \tag{4}$$

where V is the subjective (discounted) value (i.e. indifference point) of the delayed or risky amount A, D is delay in months (1, 3, 6, and 12 months), θ is the odds of not receiving the risky reward, and p is the probability of receiving it[7]. The best-fitting discount factor k for each individual is estimated based on Equations 3 and 4 that are solved for k. The discount factor k describes an individual's myopic tendency. A lower indifference point results in a higher discount factor k and reflects steeper delay or probability discounting (i.e., greater discounting of future or riskier options) and stronger delay or risk aversion.

The discount factors k are fitted to the hyperbolic function as in Equations 3 and 4. The quality of the fits is evaluated with the determination coefficients R^2. In addition, the

[7] For the first set of the probability discounting choices, p (probability) equals .95, .90, .80, and .60, which corresponds to the values of θ obtained in Equation 4 as .053, .111, .25, and .667, respectively. For the second set of the probabilistic task, A is received with 50% probability and p (probability) equals to .45, .40, .30, and .10. To properly adjust the formula in this case, θ is calculated as (.5-p)/p instead of (1-p)/p, which corresponds to the values of θ as .111, .25, .667, and 4, respectively.

discount factors are analysed for each task separately using repeated measures analysis of variance (ANOVA) with the delay (*1* vs. *3* vs. *6* vs. *12 months*) or with probability (*5%* vs. *10%* vs. *20%* vs. *40%*) and the accountability condition (*no accountability* vs. *accountability*) as within-subject factors. In cases where the assumption of sphericity is violated, which indicates that the variance of the differences between all combinations of related groups is not equal, the degrees of freedom are adjusted according to the Greenhouse-Geisser correction method (Field, 2009).

3.4 Results

3.4.1 The impact of accountability on the delay aversion

The descriptive statistics for the delay discounting task are presented in Table 8. The results show the mean indifference points depending on the delay and the accountability conditions that are based on which discount factor *k* was calculated. The results of the paired t test confirm that the participants' average indifferent point is substantially higher (see Table 8 and Figure 14) and that the discount factor is significantly lower (see Table 9 and Figure 15) in the no accountability condition compared to the accountability condition for all the delays.

Table 9 presents the discount rates that were used to discount the delayed outcomes in the first set of trials (choices between an immediate and a delayed outcome) and in the second set of trials (choices between a one-year delayed outcome and an outcome delayed for one year plus the same interval as in the previous trials: 1, 3, 6, and 12 months). The discount rates are calculated on a monthly basis to be comparable. The discount factors are excessively high that indicates an acute delay aversion, for example, the participants on average required a return of 273% for a one-month delay, which decreased with accountability pressure to a required return of 122%. We observe that the discount rates are sharply falling[8].

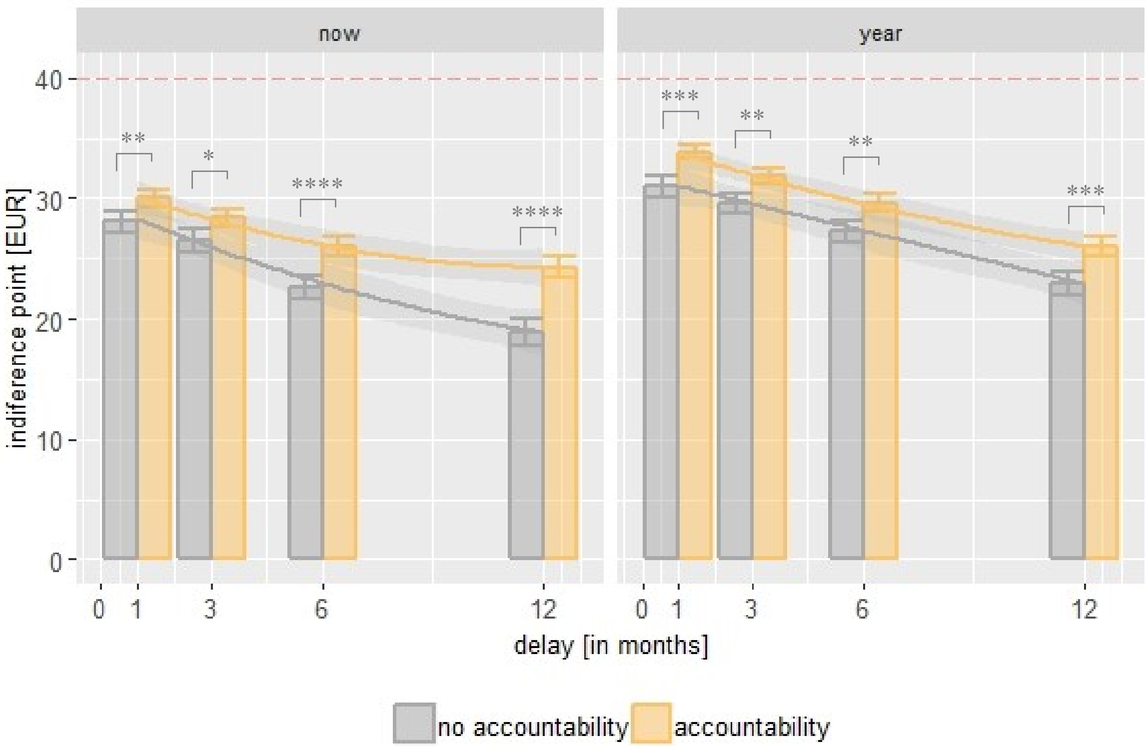
[8] These high discount rates are partly induced by the concrete experimental design rather than just an outrageous delay aversion of our participants. They are therefore not to be taken at face values. For example, the participants had to decide between an outcome of EUR 40 delayed for one month and the lowest value at which they would accept to be paid out immediately. If they indicated that the lowest value is EUR 38, we calculate the indifference point as EUR 39 and the discount rate of 2.564% on a monthly level and of 35.5% on an annual level. If, on the other hand, individuals were not willing to accept a delayed outcome at any value, they indicated that with zero, which resulted in an indifference point of one (for the sake of calculation) and a discount rate on an annual basis of 4000%. The distribution of such discount rates resulted in the resulting extremely high mean values.

Table 8: Descriptive statistics for the delay discounting task and the results of the paired t test for indifference point

INDIFFERENCE POINT		No accountability			Accountability			t test	
Task	**Delay**	***M***	***SD***	***t test***	***M***	***SD***	***t test***	***t***	***P***
now vs.	1 month	28.07	11.24	*t* = -3.40	30.05	8.68	*t* = -7.06	-2.74	**.007**
year vs. year and	1 month	30.99	10.58	***p* = .001**	33.86	7.34	***p* < .001**	-3.98	**.000**
now vs.	3 months	26.50	11.48	*t* = -3.88	28.41	9.39	*t* = -6.08	-2.48	**.014**
year vs. year and	3 months	29.61	10.29	***p* < .001**	31.80	7.73	***p* < .001**	-3.20	**.002**
now vs.	6 months	22.65	12.01	*t* = -6.12	26.01	10.32	*t* = -5.48	-4.64	**.000**
year vs. year and	6 months	27.28	10.75	***p* < .001**	29.66	8.19	***p* < .001**	-3.06	**.003**
now vs.	1 year	18.88	12.89	*t* = -5.16	24.27	10.87	*t* = -2.44	-7.24	**.000**
year vs. year and	1 year	22.92	12.39	***p* < .001**	25.99	10.01	***p* = .016**	-3.68	**.000**

Note. Significant differences appear in bold. The paired t test testing differences in accountability is presented in the last column comparing the indifference points in the no accountability versus the accountability condition. The results of the paired t test testing the differences in discounting at various time intervals (now vs year) are presented within the table comparing rows with the same delay difference.

Figure 14: Indifference points in delay discounting tasks



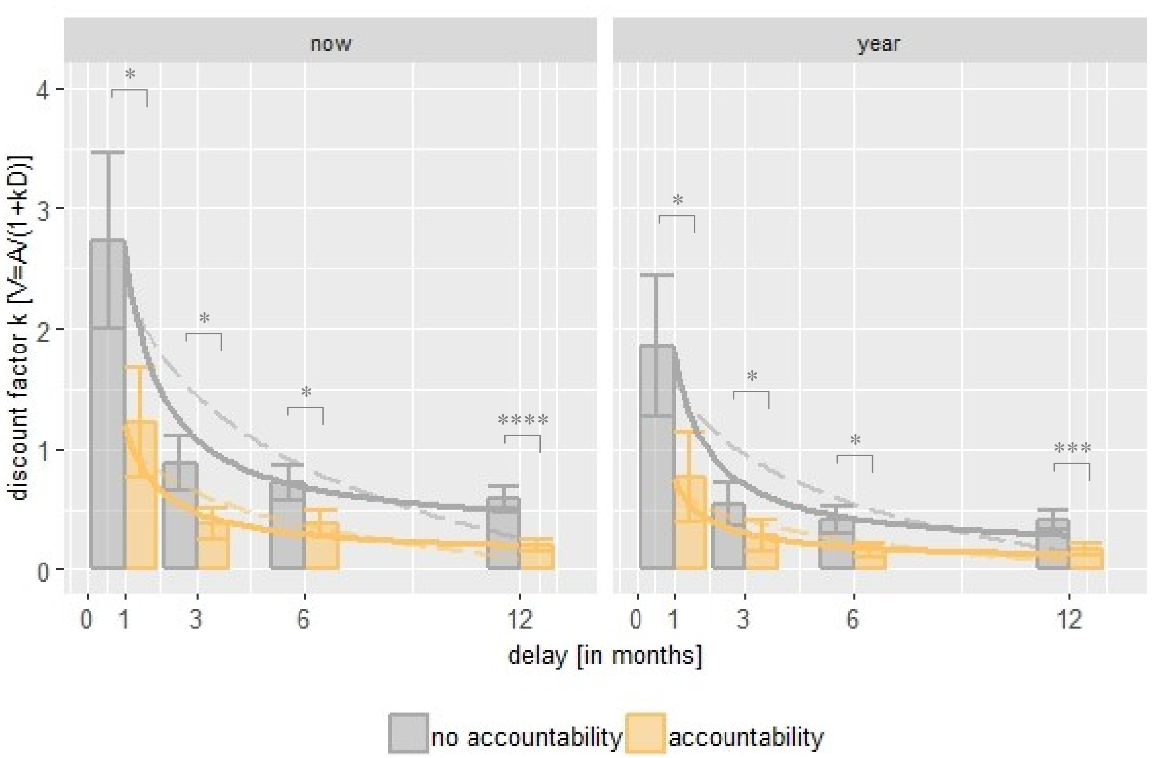
Note. "Now" relates to the pay-out of the earlier reward, whereas "Year" indicates a one-year delay of the earlier reward. The delayed rewards are paid out at indicated times after the earlier reward, measured in months. * $p < .05$; ** $p < .01$; *** $p < .001$; **** $p < .0001$; *ns* = not significant. A lower indifference point means a higher discount factor k and reflects steeper delay discounting and stronger delay aversion.

Table 9: Descriptive statistics for the delay discounting task and the results of the paired t test for the discount factors

DISCOUNT FACTOR		**No accountability**			**Accountability**			**t test**	
Task	**Delay**	***M***	***SD***	***t test***	***M***	***SD***	***t test***	***t***	***p***
now vs.	1 month	2.74	8.82	*t* = 1.46	1.22	5.50	*t* = 1.73	2.62	**.010**
year vs. year and	1 month	1.86	7.13	*p* = .146	0.76	4.53	*p* = .086	2.36	**.020**
now vs.	3 months	0.89	2.75	*t* = 1.80	0.38	1.51	*t* = 5.17	2.70	**.008**
year vs. year and	3 months	0.54	2.12	*p* = .073	0.28	1.51	***p* < .001**	2.01	**.046**
now vs.	6 months	0.72	1.76	*t* = 2.66	0.38	1.27	*t* = 2.61	2.52	**.013**
year vs. year and	6 months	0.42	1.37	***p* = .009**	0.16	0.75	***p* = .010**	2.23	**.027**
now vs.	1 year	0.60	1.10	*t* = 2.07	0.19	0.58	*t* = 0.47	4.86	**.000**
year vs. year and	1 year	0.42	0.97	***p* = .040**	0.17	0.58	*p* = .642	3.71	**.000**

Note. Significant differences appear in bold. The paired t test testing differences in accountability is presented in the last column comparing the discount factors in the no accountability versus the accountability condition. The results of the paired t test testing the differences in discounting at various time intervals (now vs year) are presented within the table comparing rows with the same delay difference.

Figure 15: Discount factor in delay discounting tasks



Note. "Now" relates to the pay-out of the earlier reward, whereas "Year" indicates a one-year delay of the earlier reward. The delayed rewards are paid out at indicated times after the earlier reward. * $p < .05$; ** $p < .01$; *** $p < .001$; **** $p < .0001$; *ns* = not significant. A higher discount factor k reflects steeper delay discounting and stronger delay aversion. The solid curve represents hyperbola-like discounting function (Equation 3). The dashed curve represents the exponential-like discounting function (Samuelson, 1937).

The analysis of ANOVA on the *discount factor k* for the delay discounting task in which choices between the immediate and the delayed rewards were made shows a significant main effect for the delay, $F(1, 146) = 9.00$, $p = .003$, that reflects the decrease in the discount factor with the increasing time delay. We also see a significant main effect of accountability condition, $F(1, 146) = 11.2$, $p = .001$, that shows lower discounting rates under the accountability pressure (or lower delay aversion), and marginally significant delay × condition interaction, $F(1, 146) = 3.45$, $p < .065$, that shows more consistent discounting rates with the increasing delay under accountability (see Figure 15). Similarly, in the second set of trials in which the delay of one year was added to both options the results also show a significant main effect for the delay, $F(1, 146) = 5.33$, $p = .022$, that shows a decline in a discount factor with increasing delay; a significant main effect of accountability condition, $F(1, 146) = 7.59$, $p = .007$, that reflects a higher discounting under no accountability; and a marginally significant delay × condition interaction, $F(1, 146) = 2.85$, $p = .093$, due to a decreased decline in the evaluation of future rewards with an increasing delay under the no accountability and accountability conditions (see Figure 15).

We estimated which discounting function better fits the actual discounting rates. A χ^2 test of goodness-of-fit showed a better fit to the hyperbolic function than to the exponential function of discounting for the no accountability and the accountability conditions, respectively for first series of choices, $\chi^2(0) = 4.86$, $p < .001$, $R^2 = .001$, $\chi^2(0) = 1.98$, $p < .001$, $R^2 = .001$, and also for the second series of choices, $\chi^2(0) = 4.33$, $p < .001$, $R^2 = .001$, $\chi^2(0) = 1.27$, $p < .001$, $R^2 < .001$ (see Figure 15).

Overall, the results confirm hypothesis H1 and show that imposing accountability as a mere justification pressure has a significant impact on the subjective evaluation of future rewards that reduces the excessive delay aversion that leads to a more reasonable required returns for accepting future outcomes. Although the results are marginally significant, the accountability reflects the use of more constant discount rates at various times, which partially confirms hypothesis H3.

3.4.2 The impact of accountability on the risk aversion

Table 10: Descriptive statistics for the probability discounting task and the results of paired t test for indifference point

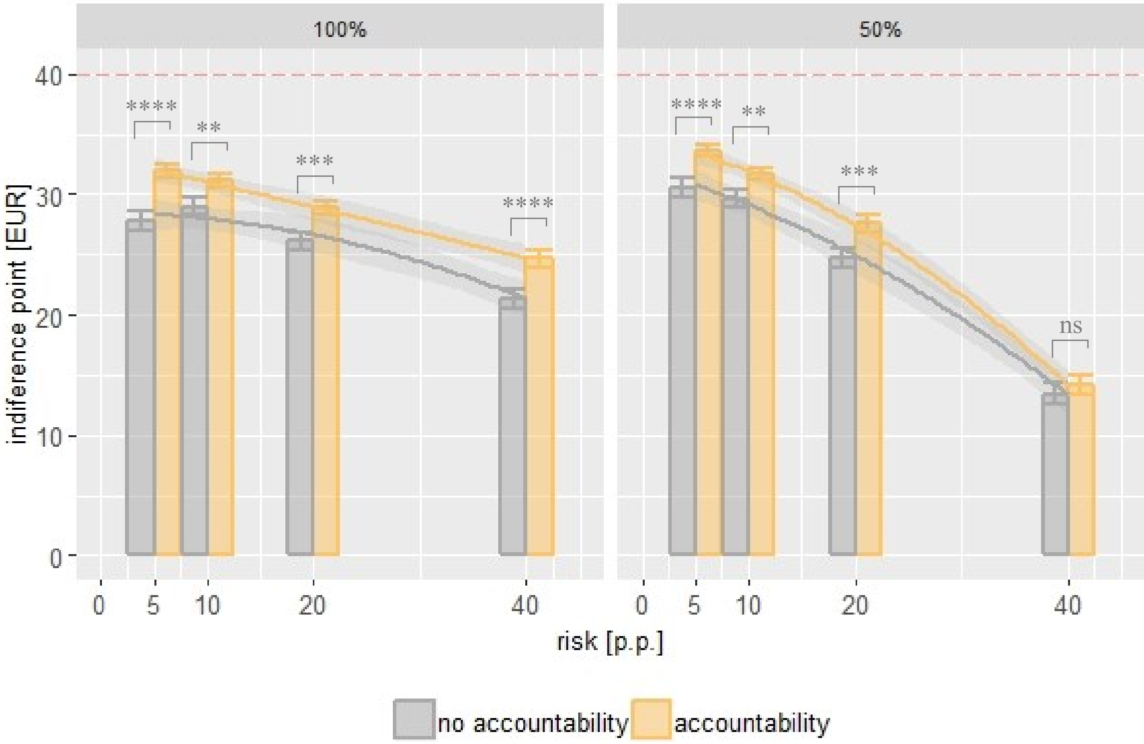
INDIFFERENCE POINT		**no accountability**				**accountability**				**t test**	
task	**Δ risk**	***M***	***SD***	***lambda***	***t test***	***M***	***SD***	***lambda***	***t test***	**t**	**p**
100% vs. 95%	5 p.p.	27.73	9.76	1.37	t = -3.15	31.95	7.19	1.19	t = -3.10	-5.73	**.000**
50% vs. 45%	5 p.p.	30.58	9.91	1.18	***p* = .002**	33.65	5.36	1.07	***p* = .002**	-3.07	**.003**
100% vs. 90%	10 p.p.	28.97	9.17	1.24	t = -0.65	31.17	6.80	1.15	t = -0.98	-3.89	**.000**
50% vs. 40%	10 p.p.	29.63	9.26	1.08	p = .515	31.71	6.06	1.01	p = .328	-4.51	**.000**
100% vs. 80%	20 p.p.	26.13	9.35	1.22	t = 1.47	28.86	7.57	1.11	t = 1.78	-4.27	**.000**
50% vs. 30%	20 p.p.	24.71	9.72	0.97	p = .144	27.61	8.71	0.87	p = .078	-2.90	**.004**
100% vs. 60%	40 p.p.	21.37	9.75	1.12	t = 8.91	24.70	8.70	0.97	t = 13.79	-3.43	**.001**
50% vs. 10%	40 p.p.	13.38	10.72	0.60	***p* < .001**	14.18	9.66	0.56	***p* < .001**	-0.86	.391

Note. p.p. = percentage point. Significant differences appear in bold. The paired t test of differences in the accountability conditions is presented in the last column comparing indifference point in the no accountability versus the accountability condition. The results of the paired t test of differences in tasks' probability levels (100% vs 50%) are presented within the table comparing rows with the same risk difference.

Table 10 presents the descriptive statistics for the probability discounting task. The results show mean indifference points that depend on the probability and the accountability conditions based on which lambda was calculated[9]. Lambda is defined as a multiplier of a certain reward that decision-makers require to accept a risky reward (Kahneman & Tversky, 1979). The results of the paired t test show a significant increase in the indifferent points (or a decrease in risk aversion) in the accountability versus the no accountability condition for all risk levels except in the choice between the reward with 50% probability and the one with 10% probability (see Table 10 and Figure 16). The calculated lambdas show a very high-risk aversion when the choice involves a certain option: the participants on average required 1.37 times more for only a 5-percentage point difference in the probability of the reward. The lambdas decrease when both options are probable. Under the accountability pressure, the lambdas become lower, which reflects reduced risk aversion for choices with a certain option. However, when both options are only probable, the lambdas around one indicate that the participants were more or less indifferent to the options with different probabilities. The lambdas under one indicate the participants' insensitivity to different low probabilities which led them to reverse their preferences. Such behaviour is irrational in the opposite direction (it indicates risk seeking rather than risk aversion). Risk seeking might have occurred because the participants were unable to quickly calculate the expected values of a gamble and to decide on the best possible option.

[9] Lambda as defined by Tversky and Kahneman (1979) is calculated as (Ap/V) where where V is the indifference point of the risky amount A of EUR 40, and p is the probability of receipt (.95, .90, .80, and .60) for certain option. For the probabilistic, option lambda is calculated as (Ap/V*0.5) with p values equal to .45, .40, .30, and .10.

Figure 16: Indifference points in probability discounting tasks



Note. "100%" relates to the probability of the certain reward, whereas "50%" relates to the probability of a more probable option. The probability of less probable options is decreased by the percentage points indicated on the x-axis. * *p* < .05; ** *p* < .01; *** *p* < .001; **** *p* < .0001; *ns* = not significant. A lower indifference point means a higher discount factor k and reflects steeper probability discounting and stronger risk aversion.

Table 11 presents the descriptive statistics for the discount factor obtained in the probability discounting task that are calculated based on the indifference point by using Equation 4. The results of the paired t test confirm that the participants' average discount factor is significantly higher (see Table 11 and Figure 17) for all the delays in the no accountability condition compared to the accountability condition.

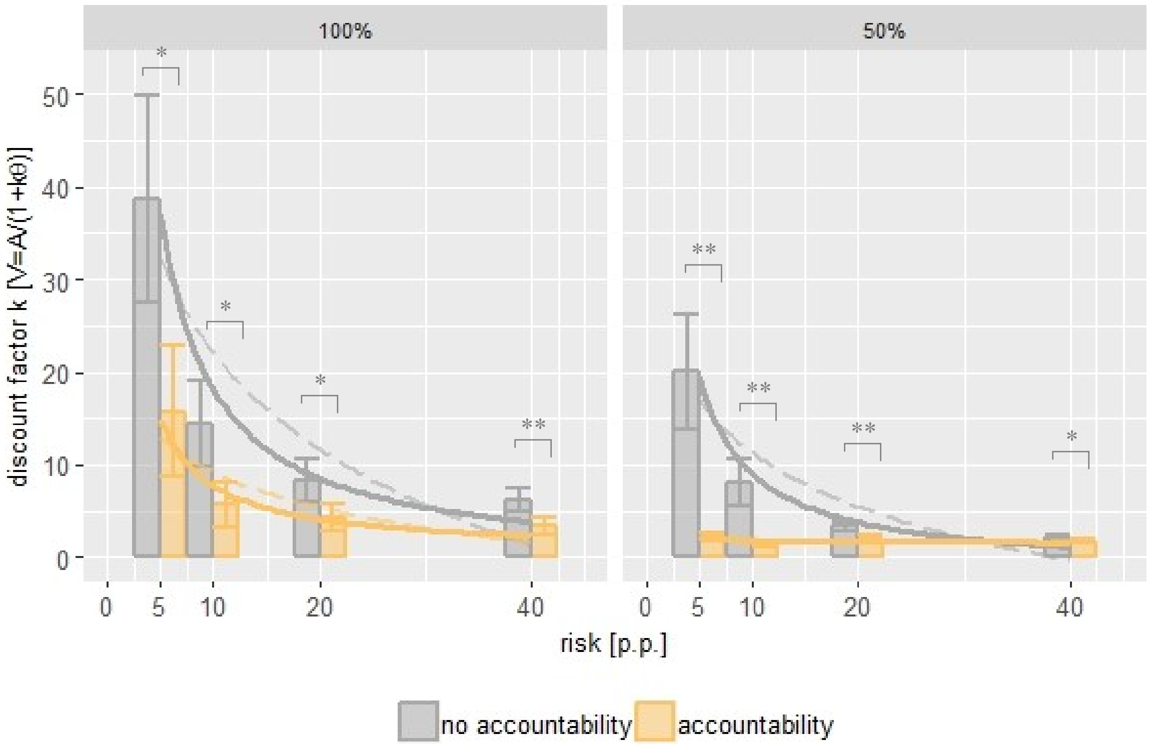
Although the participants used significantly higher discount factors to compare certain and risky options than to compare only risky options, the differences are significant only for choices that differed 20 and 40 percentage points in the no accountability condition and 40 percentage points in the accountability condition (Table 11).

Table 11: Descriptive statistics for the probability discounting task and the results of paired t test for discount factor

DISCOUNT FACTOR k		**no accountability**			**accountability**			**t test**	
task	**Δ risk**	***M***	***SD***	***t test***	***M***	***SD***	***t test***	**t**	**p**
100% vs. 95%	5 p.p.	38.59	135.64	*t* = 1.69	15.70	85.73	*t* = 1.93	2.15	**.033**
50% vs. 45%	5 p.p.	20.01	74.47	*p* = .093	2.25	4.21	*p* = .056	2.91	**.004**
100% vs. 90%	10 p.p.	14.39	57.14	*t* = 1.17	5.74	29.26	*t* = 1.83	2.11	**.037**
50% vs. 40%	10 p.p.	8.02	30.74	*p* = .243	1.38	1.98	*p* = .070	2.66	**.009**
100% vs. 80%	20 p.p.	8.28	28.29	*t* = 2.08	4.25	18.41	*t* = 1.47	2.40	**.018**
50% vs. 30%	20 p.p.	3.35	7.20	***p* = .039**	1.97	5.45	*p* = .144	2.66	**.009**
100% vs. 60%	40 p.p.	6.18	15.72	*t* = 3.37	3.45	11.44	*t* = 2.05	2.95	**.004**
50% vs. 10%	40 p.p.	2.14	3.35	***p* < .001**	1.70	2.99	***p* = .042**	2.27	**.025**

Note. p.p. = percentage point. Significant differences appear in bold. The paired t test of differences in the accountability conditions is presented in the last column that compares the discount rates in the no accountability versus the accountability condition. The results of the paired t test of differences in tasks' probability levels (100% vs 50%) are presented within the table by comparing rows with the same risk difference.

Figure 17: Discount factor in probability discounting tasks



Note. "100%" relates to the probability of the certain reward, whereas "50%" relates to the probability of a more probable option. The probability of less probable options decreases by the percentage points indicated on the x-axis. * $p < .05$; ** $p < .01$; *** $p < .001$; **** $p < .0001$; *ns* = not significant. A higher discount factor k reflects steeper probability discounting and stronger risk aversion. The solid curve represents the hyperbola-like discounting function (Equation 4). The dashed curve represents the exponential-like discounting function.

The analysis of the ANOVA on the *discount factor k* for the probability discounting task in which choices between certain and risky rewards are made, shows a significant main effect of the risk, $F(1, 146) = 9.35$, $p = .003$, that indicates a decrease in the discount factor with increasing risk, a significant main effect of the accountability condition, $F(1, 146) = 6.84$, $p = .010$, that reflects a lower discount factor under accountability (reduced risk aversion), and a significant risk × condition interaction, $F(1, 146) = 3.92$, $p = .050$, that shows a shallower discounting with increased risk under accountability (see Figure 17).

In the second set of trials of the probability discounting task, the participants needed to decide between the EUR 40 with a 50% probability and options that were riskier by the same percentage points in probability as in the first set of trials. The results also show a significant main effect of risk, $F(1, 146) = 8.74$, $p = .004$, that shows a steep decline in the discount factor with increasing risk, and a significant main effect of the accountability condition, $F(1, 146) = 9.14$, $p = .003$, that indicates the participants are less risk averse under accountability as they have lower discount factor. The results also show a significant risk × condition interaction, $F(1, 146) = 7.80$, $p = .006$, that indicates a strong decrease in discounting with increasing risk (see Figure 17). While the probability discounting of more certain options becomes shallower if the participants are exposed to accountability, when confronted with two more risky options, the discount function becomes constant.

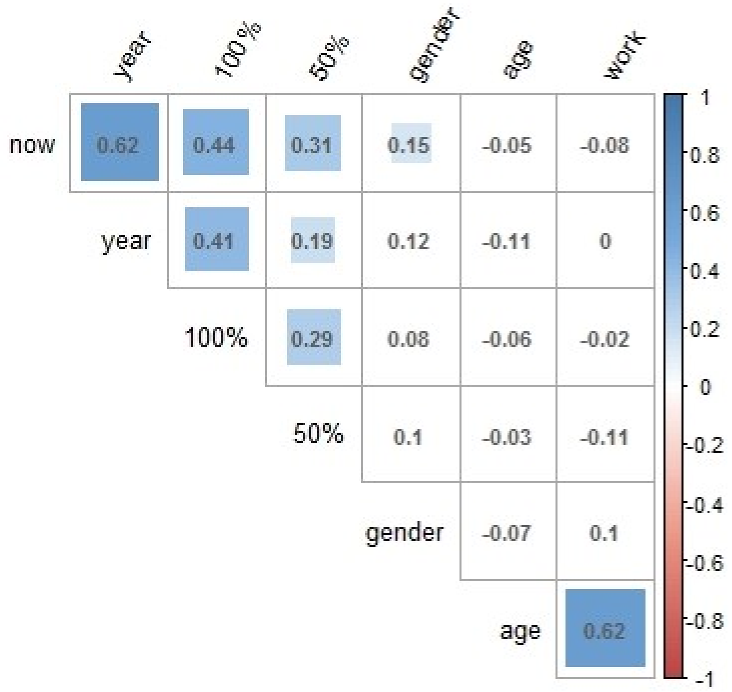
The results of the χ^2 test of goodness-of-fit show a better fit of probability discounting factors *k* to the hyperbolic model of discounting than to the exponential one for the no accountability and the accountability conditions respectively for first series of choices, $\chi^2(0) = 4.08$, $p < .001$, $R^2 < .001$, $\chi^2(0) = 1.84$, $p < .001$, $R^2 < .001$, and also for the second series of choices respectively, $\chi^2(0) = 3.42$, $p < .001$, $R^2 = .001$, $\chi^2(0) = 1.06$, $p < .001$, $R^2 < .001$ (see Figure 17).

Overall, being accountable reduces risk aversion, which confirms hypothesis H2. The findings also indicate that accountability contributes to more constant discount rates and to risky decision-making, which confirms H3.

3.4.3 Correlation analysis of delay and probability discounting

We are also interested in whether temporal and probabilistic discounting are correlated. The results of the correlation analysis show that average discounting factors *k* calculated in the delay discounting tasks (*now* and *year*) and the probability discounting tasks (*100%* and *50%*) are strongly and positively correlated. This correlation indicates that participants who were *a priori* delay averse were also risk averse (see Figure 18). The correlation shows that myopia can justifiably be analysed with both decision processes.

Figure 18: Correlation of discount factor k



Note. "Now" relates to the pay-out of the earlier reward, whereas "Year" indicates a one-year delay in the earlier reward. "100%" relates to the probability of the certain reward, whereas "50%" relates to the probability of a more probable option. Positive significant correlations are coloured in blue with the correlation coefficient given in the squares. For example, the figure is interpreted as discount factor k in delay discounting task "Now" (measuring delay aversion) is highly and positively correlated with discount factor *k* from probability discounting task "100%" (measuring risk aversion), $r = .44$, $p < .001$.

3.5 Discussion and conclusion

One of the challenges of management accounting is to motivate managers to take decisions in the long-term interest of the firm. In this study, we focus on the question of how to mitigate myopic tendencies with accountability through the operationalisation as the pressure to justify the decisions. Such pressure belongs to the class of social incentives that is frequently used by organisations in their management control systems either on a standalone basis or in combination with monetary incentives. In the desire to be favourably evaluated by their supervisors, justification pressure should activate more rational thought processes in the participants and divert them from quick intuitive responses (Vieider, 2009). Given that about half of the experimental studies demonstrate no effectiveness for monetary incentives in improving performance in judgemental and reasoning tasks (Bonner et al., 2000), our study advances the literature by exploring the roles of various social incentives. Social incentives can improve cognitive control by regulating thought processes in line with the behavioural goals of judgement and reasoning (Ličen et al., 2016). We also propose that accountability improves cognitive control which increases attention, enhances conflict resolution and inhibits the prepotent responses that could arise from intuitive answers (Ličen et al., 2016).

As argued by Lerner and Tetlock (1999), different kinds of accountability motivate distinctive cognitive coping strategies. In our study, justification pressure is designed so that it makes the participants aware of the actual discount rates they will use in the no accountability condition. Our findings indicate that because of the complexity in discounting, the participants think of choices in terms of absolute values and indifference points rather than comparing the options by more relative measures, that is, discount rates or required returns. When choosing between an immediate and delayed outcome or a certain and risky outcome, the discount rates are actually not obvious to the decision-makers and are too difficult to be logically calculated. As a result, they decide intuitively. The discount rates in our experiment are so high that they can undoubtedly be deemed as excessive and irrational. Although our manipulation of the justification pressure does not contain any explicit expectation of a supervisor, it makes the participants understand that their personal discount rates are beyond reasonable ones. Justification pressure is effective at decreasing their required returns for delayed and risky outcomes, probably to appear more rational to the supervisor. In accordance with the literature, we find that the participants use the hyperbolic discounting function for both temporal and probabilistic discounting. Typical of hyperbolic discounting, it displays disproportionately high discount rates in the near future and little sensitivity between various delayed outcomes in the distant future or risky outcomes with low probabilities. We find that accountability not only decreases the discount rates but contributes to the use of more constant discount rates at various time and risk intervals.

Our findings are concordant with the findings of Vieider's (2009) study that accountability triggers more intensive thought processes and reduces loss aversion. They, however, are in contrast to the findings of Baltussen et al. (2010) who find that public scrutiny accentuates risk aversion. The discrepancy lies in the manipulation of accountability: Baltussen and his co-authors test whether decisions in public scrutiny (i.e., mimicking a TV show with a real audience) decreases risk aversion and find the contrary. Such manipulation is substantially different to ours as ours does not contain a socially threatening stimulus of public embarrassment that can hinder not only individuals in economic decisions but also, for example, athletes in sport (Hickman & Metz, 2015).

The implication of our findings for practising accountants and supervising managers is to bring in more accountability, justification pressure, and other social incentives that have a positive influence on cognitive control and reasoning and to de-emphasise short-term maximisation of bonuses. The importance of playing down short-term targets and bonuses has long been stressed in the management accounting literature (Salter, 2013; Thanassoulis, 2012); however, there is limited evidence in the literature on whether changes in practice have taken place on a large scale.

We find the following limitations to our findings, which are inherent to the experimental method. The experiment shows that the use of very high discount rates are not realistic in real life. As already explained in the results section, such discount rates are a product of the experimental design and are dependent on the amounts in the concrete choices. The experiment was designed based on several prior studies that aimed to infer the discounting function (Green, Myerson, Holt, Slevin, & Estle, 2004; Mazur, Synderman, & Coe, 1985; Richards, Mitchell, De Wit, & Seiden, 1997). We set up the choices so that they would be realistic and relevant to our participants and the pay-out feasible (i.e., within our budget). If we had changed the amounts, we could have obtained less excessive discount rates. In general, experimental results are not to be taken at face value as all conditions and decisions are manipulated. What is important is the sign and the strength of the relation between the independent and the dependent variables. The effect of accountability is robust as it is persistent throughout all risk and temporal choices. A limitation could also be that the participants perceived choices as hypothetical since not all choices were paid out and only 18 participants received a reward by being randomly selected on one of their choices. However, Madden, Begitka, Raiff, and Kastern (2003) report similar discount rates regardless of whether rewards and delays are real or hypothetical. Vieider (2009), for example, does not use any monetary rewards at all. Another concern may be the order of the conditions: the participants first took decisions under no accountability and then under accountability. We argue that the learning effect is not an issue in these types of tasks as they are about preferences and not about performance. Besides, accountability manipulation required information about the discount rates used in the no accountability condition.

Overall, the study's contributions are in highlighting the cognitive constraints in temporal and risky decisions, which are the two most crucial underlying processes in evaluating long-term outcomes. We theorise and provide original evidence on to what extent accountability can reduce such constraints. The understanding of when and why managers engage in myopic behaviour not only because of their self-interest but because of their innate risk aversion and cognitive limitations is of vital importance to management accountants. Being able to implement the appropriate characteristics of the accountability system to control managers' propensity to optimise the present, at the expense of the future, is critical for the success of organisations.

CONCLUSION

More than ever, organisations today stimulate their employees with various implicit and explicit *social* incentives. However, the management accounting and the cognitive psychology literatures almost exclusively focus on the effects of monetary incentives on cognitive effort and performance. The goal of this paper is to gain an understanding of how accountability structures affect managerial cognition, decision-making, and myopic tendencies. We analyse several types of incentives that matter in the context of the accountability systems in organisations, which we operationalise as *social pressure/ranking, authority instructions*, *justification pressure,* and *donation*. We are interested in the question of how those social incentives stimulate cognitive control, affect the neural activity in decision-makers, and ultimately mitigate managerial excessive delay and risk aversions that we denote as managerial myopia.

In the first chapter, we investigate how social pressure influences cognitive control modes and cognitive performance compared to a monetary incentive beyond simple instructions to perform better. We use a within-subjects experimental design in which 47 students performed the AX-CPT task, which enables the measurement of goal representation, maintenance, and information updates, and the underlying modes of cognitive control. The results show that instructing participants to improve their performance on its own leads to a significant shift from a reactive to a proactive control mode and that both social pressure and a monetary incentive further enhance performance. Our study provides the first direct comparison of the effects of social pressure and a monetary incentive on behavioural performance. Surprisingly, whereas the results show the two incentive conditions to be comparable in their effect, much of the effect seems to be generated by the presence of explicit instructions to improve behaviour and the accompanying monitoring of behaviour.

We also study the neural bases of the social incentive effect. The main objective of the second chapter is to provide neuroscientific evidence on the effects of social incentives on the exertion of cognitive control. We focus on the question of whether two social incentives — charity donation and public ranking of participants' performance — invoke a similar neuronal activity to the monetary incentives studied in the literature. During functional magnetic resonance imaging, 30 financial professionals performed the Eriksen Flanker task (Eriksen and Eriksen, 1974) in which one of the vigilance and detection tasks requires subjects to notice and respond to a stimulus or pattern of stimuli that mobilises selective attention and inhibitory control. Overall, the results show that the effect of social incentives is comparable to monetary incentives and that they lead to improved cognitive performance, increased attention, improved motor and attentional control as well as conflict resolution and inhibition. Both social incentives have comparable effects. Making use of brain imaging allowed us to identify the brain regions involved in processing social incentives in cognitive control processes, which provides important insights into the effect of incentives on human cognition.

We then examine the impact of accountability on managerial myopia that is measured as managerial tolerance to delay and risk-taking. In the third chapter, we focus on the question of how to mitigate myopic tendencies with justification pressure as another social incentive. The main objective is to provide an answer to whether accountability has the power to reduce excessive intolerance to delay and risk and the inconsistent use of discount rates that lead to suboptimal investment decisions. We conducted a within-subject experiment on 147 subjects in which we measured myopia by using delay discounting and probability discounting choice tasks. Our findings show that in contrast to some performance evaluation mechanisms that exacerbate myopic behaviour, justification pressure reduces excessive subjective discount rates for time delay and risk that makes it more consistent in priming the participants to think harder about their choices. We advance the management accounting literature by suggesting that managerial myopia is not just a rational response to short-term oriented and too frequent performance evaluations, but a cognitive constraint to tolerate delay and risk. The study provides original evidence that justification pressure can reduce individuals' biases regarding too conservative and inconsistent evaluations of future outcomes. The study's findings could fruitfully contribute to the design of more effective and congruent performance evaluations and could be of relevance not only to management accounting academics but also to practitioners.

Making incentive systems work is vitally important for the overall functioning of organisations and society. Given the current debate in companies and society about the problems of increasing monetary incentives, our findings provide an avenue to start reconsidering the essential role of social incentives and monitoring in organisations that counters the prevalent reliance on monetary incentives to enhance performance. Our findings indicate that social incentives can affect executive processes to a similar extent as monetary rewards. Though not providing direct personal benefits the benefits related to social incentives are more indirect and long-term. In tasks that are becoming increasingly relevant for success in contemporary organisations (innovative, creative, highly difficult cognitive tasks and tasks that require sound judgement in risk-taking) and in which the link between the reward and effort is not straightforward and predictable, the use of social incentives may be even more important in encouraging employees to undertake such tasks.

In our experiments, we used simple cognitive tasks which are not directly performed by practicing accountants and supervising managers. However, the use of such tasks is an advantage rather than a disadvantage because they allow us to follow the effect of incentives very specifically and ensure a possibility of the detailed probing of alterations which could simply not be detected in the case of performing a more complex task.

Overall, the results show that accountability in the form of various social incentives improves cognitive performance, induces proactive control, and increases attention and inhibition and, thus, due to enhanced cognitive control successfully mitigates managerial myopia. Future research could complement our research by directly testing individuals' delay and risk tolerance in relation to cognitive control in order to build a comprehensive picture of the drivers of myopic behaviour. A step further could be a move from behavioural to brain activity research by directly observing the neural activity of a decision-maker confronted with intertemporal and probabilistic choices while exposed to accountability pressure.

The findings of this contribute to the small body of knowledge about the effectiveness of management accounting mechanisms to undo behavioural biases. We believe that they are relevant also for the practice. The implication of our findings for practising accountants and supervising managers is to bring in more accountability, justification pressure, and other social incentives that have positive influences on cognitive control and reasoning and to de-emphasise short-term oriented monetary incentives. Social incentives change the way of cognitive processing. They activate proactive cognitive control, which enables more attentive performance with regards to the essential aspects of the task and faster recognition of critical or even conflicting information. In the process, however, the proactive cognitive control is more demanding and consumable in energy and, thus, cannot be maintained indefinitely. The findings of the doctoral dissertation, therefore, do not offer a one-time recipe but rather a part of the puzzle which has to be considered in the integrated planning of work and the design of reward systems.

All in all, this doctoral dissertation was not a journey to a known destination, but an exploration of an unknown territory. It advances theories from psychology and neuroscience that are quite new to the management accounting literature. The doctoral dissertation contributes to a scarce body of knowledge that investigates social incentives rather than monetary ones. We explored our research questions with experimental and neuroscientific methods that are novel in the field of management accounting. At the same time, we tried to bring management accounting to other disciplines of research by providing a context to those disciplines. We have intentionally moved away from complex tasks, usually studied in accounting, and have broken up complex decision-making into more simple and tangible cognitive processes to be able to gain further insights into the effects of social incentives. Some questions have been answered in the present doctoral dissertation, but more have been opened. We believe that our findings and related literature offer vast potential for future research and life time commitments of several more researchers.

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APPENDICES

Appendix 1: Summary in Slovenian language / Daljši povzetek disertacije v slovenskem jeziku

VPLIV UVEDBE ODGOVORNOSTI NA KRATKOVIDNOST V ODLOČANJU MANAGERJEV

Managerji so vpeti v proces sprejemanja različnih odločitev, ki vplivajo ne samo na sedanjost podjetja, temveč tudi na stroške, prihodke in dobiček podjetja v prihodnosti. Managerji so na primer vpeti v proces odločanja o investicijskih projektih in ocenjujejo, kako se bodo začetni denarni odlivi zaradi investiranja poplačali s prihodnjimi pričakovanimi denarnimi tokovi. Managerji sodelujejo tudi v procesu kontrole stroškov in potencialnem zniževanju le-teh z namenom dosega višje marže in višjega dobička v prihodnosti. Managerji so vključeni tudi v odločitev, ali se bo izvedlo drago oglasno kampanjo v pričakovanju pozitivnih učinkov v prihodnosti in s tem optimizacijo vrednosti podjetja. Temeljna značilnost takšnih managerskih odločitev je kompromis med naložbo v sedanjosti in pričakovanimi donosi v prihodnosti. Sprejetje takšnega kompromisa je zahtevno, kajti v bistvu je potrebno pretehtati in oceniti takojšne in skoraj gotove izide odločitve s prihodnjimi in sorazmerno negotovimi izidi.

V praksi je žal vidno, da managerji niso uspešni v oceni in sprejetju najbolj optimalne odločitve in se obnašajo v nasprotju s cilji organizacije (Graham, Harvey, & Rajgopal, 2005; Lant, Milliken, & Batra, 1992; Miller, 2002; Mizik, 2010; Mizik & Jacobs, 2007). Primer takšnega vedenja so managerji, ki ne investirajo v projekte, katerih donosi v prihodnosti so videti bolj tvegani. Managerji znižujejo stroške poslovanja z namenom dosega višje marže in posledično višjega dobička. Hkrati pa zanemarjajo negativne učinke takšne sprejete odločitve na kakovost proizvodov in posledično prihodke v prihodnosti. Managerji se bodo prav tako raje izognili izvedbi drage oglaševalne kampanje, da bi zaščitili trenutni dobiček, pri čemer pa pozabljajo na izgubo prihodkov v prihodnosti zaradi tržne neizpostavljenosti. Managerji napihujejo sedanje dobičke in vrednost podjetja na račun dolgoročne stabilnosti in koristi podjetja, kar se imenuje *kratkovidnost v odločanju managerjev* (angl. *managerial myopia*) (Bebchuk & Stole, 1993; Bhojraj & Libby 2005; Chowdhury, 2011; Edmans, 2009; Levinthal & March, 1993; Merchant, 1990; Narayanan, 1985; Stein, 1988, 1989; Thakor, 1990; Van der Stede, 2000).

Termin kratkovidnost izvira iz optometrike in označuje nesposobnost videnja v daljavo. Z drugimi besedami: osredotočenost na kratko časovno obdobje. V poslovodnem računovodstvu kratkovidnost označuje naklonjenost managerjev, da optimizirajo sedanjost na račun prihodnosti. Kratkovidnost managerjev je zelo dobro poznan fenomen in primer disfunkcionalnega odločanja managerjev. Kljub temu pa je pojav kratkovidnosti pri odločanju managerjev precej slabo raziskan in razumljen.

Raziskave s področja poslovodnega računovodstva in vedenjske ekonomije so ponudile razširjene dokaze o karakteristikah sistema za ocenjevanje uspešnosti, ki pojav kratkovidnosti povečujejo, namesto da bi ga zmanjševale (Bernatzi and Thaler, 1995; Bhojraj & Libby, 2005; Edmans, Heinle, & Huang, 2016; Gigler, Kanodia, Sapra, & Venugopalan, 2014; Graham, Harvey, & Rajgopal, 2005; Hermalin & Weisbach, 2012; Kraft, Vashistha, & Venkatachalam, 2018; Thaler, Tversky, Kahneman & Scheartz, 1997). Pogosto ocenjevanje uspešnosti, prevelik poudarek finančnim spodbudam in agresivnim spodbudam na podlagi delovne uspešnosti so tovrstni primeri. Na drugi strani je kratkovidnost lahko tudi kognitivna omejitev, ki izvira iz človeškega ocenjevanja daljne prihodnosti (Ardila, Rosselli, & Strumwasser, 1991; Bickel, Yi, Landes, Hill, & Baxter, 2011; Chi & Fan, 1997; Simon et al., 2002; Tversky & Kahneman, 1974).

Trenutno razumevanje kratkovidnosti kaže na to, da gre za obliko vedenjske pristranskosti, ki uporablja pretirane diskotne stopnje za časovni odlog in daje prevelik poudarek tveganju. V primeru izbire med dvema projektoma, ki prinašata dobiček v različnih časovnih obdobjih, so posamezniki (ne samo managerji) nagnjeni k temu, da izberejo opcijo, ki omogoča hitrejšo realizacijo dobička, čeprav je ekonomska vrednost projekta nižja. To imenujemo vedenje nenaklonjeno časovnemu odlogu. Odločevalci imajo prav tako raje manjše gotove izide kot pa ekonomsko bolj privlačne, ampak bolj tvegane izide, kar je znano kot nenaklonjenost tveganju. Oba učinka opisujeta fenomen kratkovidnosti, vendar ne nudita razlage, zakaj takšno vedenje.

Temeljni vzroki nastanka kratkovidnosti v odločanju je moč poiskati v vlogi impulzivnosti, strahu, povezanim z negotovostjo, vpletenostjo čustev v odločanje, uporabo intuicije za razpoznavo vzorcev, uporabo hevristike pri kompleksnih odločitvah, ki vključujejo čas, in omejene kognitivne sposobnosti, ki so potrebne za polno in objektivno evalvacijo prihodnjih izidov. V tradicionalni ekonomiji so vsi ti faktorji označeni kot »iracionalno odločanje«, ki odstopa od odločanja na način maksimiranja dobička. Ker temeljni vzroki kratkovidnosti niso uniformni, je za boljše razumevanje potrebna preučitev človeške kognicije.

Nevroekonomija vse bolj priznava, da je racionalno odločanje bolj izjema kot pravilo in da so čustva pogosto vmešana v skoraj vsako odločitev (Forgas, 1995). Po Loewensteinu, Lernerju, Davidsonu, Goldsmithu in Schererju (2003) so človeške odločitve v veliki meri bolj intuitivne kot analitične in na njih močno vplivajo čustva in kognitivni procesi, ki so dosti bolj kompleksni kot dovoljuje predpostavka racionalnosti. Kahneman (2011) v svoji teoriji dvojnega procesa predpostavlja, da misli nastajajo na dva različna načina. Avtor argumentira, da sta razmišljanje in sklepanje osnova teh dveh sistemov – sistem 1 je hiter, instinktiven, čustven in podzavesten; sistem 2 je počasnejši, bolj preudaren, logičen in zavesten. Čeprav normativna teorija predpostavlja racionalno odločanje, ljudje po Kahnemanu (2011) veliko svojih odločitev sprejmejo v skladu s sistemom 1 in jih samo določeni dogodki prisilijo, da se začasno preusmerijo v sistem 2. Ni enostavne rešitve, ki bi nadzorovala ta preklop. Še več, racionalnost vedno ni najboljša. Dobre managerske odločitve niso samo rezultat hladne kognicije in aktivacije sistema 2, ampak so bolj izidi kompleksne mešanice racionalnih in afektivnih reakcij.

Nevroekonomija je običajno preučevala odločanje v sistemih 1 in 2 kot aktivacijo tako imenovanih čustvenih možganov, tj. limbičnega sistema nasproti aktivaciji prefrontalnega korteksa. Toda to temelji na zastareli koncepciji nevroznanosti iz sredine dvajsetega stoletja o tem, kako delujejo možgani. Sodobni pristopi se osredotočajo na kognitivni nadzor. Kognitivni nadzor predstavlja izvršilne funkcije, ki omogočajo fleksibilno in v cilj usmerjeno obnašanje v smeri vzdrževanja informacij, nadziranja okolja ter preklapljanja med cilji nalog, izkoriščanjem relevantnih informacij, ki podpirajo izvršitev naloge, in odpora proti informacijam, ki za nalogo niso relevantne (Banich, 2009; Botvinick et al., 2001). To je povezano s številnimi procesi, kot so zastavljanje ciljev, pozorni in zaviralni nadzor, aktivacija delovnega spomina, sklepanje, reševanje problemov in načrtovanje ter izvedba. Kognitivni nadzor olajša fleksibilno regulacijo misli in dejanja sledenja vedenjskim ciljem ter zatira vedenje na podlagi navade, če to ni v okviru cilja (Braver, 2012; Chiew & Braver, 2011; Cohen, Braver, & O'Reilly, 1996; Miller & Cohen, 2001). Kognitivni nadzor izvaja mreža funkcionalno povezanih možganskih predelov. Tako smo v disertaciji osredinjeni na *kognitivni nadzor*, temeljni mehanizem kognicije.

Razumevanje, kako se lahko kratkovidnost prepreči, zahteva boljše poznavanje načina, kako lahko postanejo managerji *odgovorni* (angl. *accountable*) za rezultate svojih odločitev, tako da se izboljša kakovost njihovega odločanja s okrepitvijo kognitivnega nadzora.

Odgovornost ali pričakovanja odločevalcev, da bodo poklicani, da upravičijo svoje vedenje drugim (Lerner in Tetlock, 1999), je kostitutivni element vsake oblike človeške organizacije. Potencialna evaluacija s strani drugih je eden najmočnejših dejavnikov, ki vplivajo na človeško odločanje (Tetlock, 1985). Človeška naravna tendenca je obnašati se v skladu s pričakovanji tistih, katerim so odgovorni. Sistemi odgovornosti na področju poslovodnega računovodstva pomenijo hierarhično strukturirano poročanje nadrejenim, s čimer se izvaja nadzor nad odločitvami in vedenjem podrejenega (Edwards & Hulme, 1996; Fox & Brown, 1998). Podjetja in javna uprava izoblikujejo sisteme odgovornosti z namenom, da bi usklajevala vedenje posameznikov s skupnimi cilji organizacije. Takšni sistemi običajno vključujejo sisteme načrtovanja želenih rezultatov, merjenja in ocenjevanja uspešnosti in nagrajevanje za določene rezultate. Po splošnem prepričanju posameznik zaradi uvedbe odgovornosti dobro premisli, izboljša t.i. *kognitvni napor* (angl. *cognitive effort*) (Simonson & Nye, 1992), kar vodi do boljših odločitev (Vieider, 2009, Parker, Carvalho, & Rohwedder, 2013; Pahkle, Strasser, & Vieider, 2015) in k izboljšanju vedenja (Latham & Locke, 2006; Samuel, 2006). Kakorkoli, v praksi se prav tako pogosto pojavljajo tudi nasprotni učinki (npr. Curley, Yates, & Abrams, 1986; Trautmann, Vieider, & Wakker, 2008; Baltussen, van den Assem, & van Dolder, 2010; Weigold & Schlenker, 1991, Collins & Collins, 2002; Sen, 2008). Neučinkovitost sistemov odgovornosti predstavlja praktičen izziv in kaže, da so učinki uvedbe odgovornosti tudi teoretično slabo razumljeni.

Tovrstno pomanjkanje razumevanja posledic različnih sistemov odgovornosti je v popolnem nasprotju s težnjo po izvajanju različnih mehanizmov, kjerkoli se zdi, da so potrebni za nadzor nad človeškim vedenjem. Da bi popolnoma razumeli in pravilno ter učinkovito izvajali in vpeljali sistem odgovornosti, je potrebno raziskati vpliv uvedbe odgovornosti na bistvene izvršilne funkcije, označene kot kognitivni nadzor.

Čeprav so mehanizmi odgovornosti lahko oblikovani na različne načine, v osnovi temeljijo na uporabi pozitivnih in negativnih spodbud, ki so pogosto v svojem bistvu denarne ali družbene. Medtem ko so bile denarne spodbude temeljito raziskane na področju poslovodnega računovodstva in kognitivne psihologije, je bilo le malo pozornosti namenjeno učinku družbenih spodbud glede na njihovo pomembno vlogo v okviru sistemov odgovornosti v organizacijah. Glede na vedno večje zneske denarja, ki so porabljene za spodbudo managerjem, nas še posebej zanima učinek družbenih spodbud na kognitivni nadzor in izboljšanje uspešnosti managerjev. Ker so managerji naklonjeni, da optimizirajo sedanjo vrednost podjetja na račun dolgoročne stabilnosti in vrednosti, je še posebej pomembno uvesti učinkovit sistem odgovornosti, ki bo takšna kratkoročna nagnjenja managerjev ustrezno ublažil ali celo preprečil.

Namen pričujoče disertacije je torej razumeti, kako lahko uvedba odgovornosti vpliva na kognicijo managerjev, sprejemanje odločitev in tendence kratkovidnosti. Poleg denarne spodbude v prvem poglavju smo se odločili za proučevanje več vrst družbenih spodbud, kot so navodila nadzornika, zahteva po utemeljevanju, rangiranje oziroma družbeni pritisk in donacija v smislu delati dobro za druge in ne za lastno korist.

Po sledeh nedavnih ugotovitev raziskav s področja ekonomije, poslovodnega računovodstva, socialne in kognitivne psihologije ter nevroznanosti je cilj doktorske raziskave ugotoviti, kako uvedba odgovornosti vpliva na kognitivni nadzor, nevronske aktivnosti pri odločanju in ali z uvedbo odgovornosti lahko ublažimo kratkovidnost managerjev v odločanju.

Disertacija obsega tri raziskovalne projekte o denarnih in družbenih spodbudah, da bi bolje razumeli njihove primerljive in razločevalne učinke na kognitivni nadzor ter časovno in verjetnostno diskontiranje kot neposredno merilo kratkovidnega vedenja. V doktorski disertaciji smo za proučitev raziskovalnih vprašanj uporabili eksperimentalne in nevroznanstvene metode, ki so nove na področju vedenjske ekonomije. Hipoteze smo preverili v dveh laboratorijskih eksperimentih na študentih ter z eksperimentom na izkušenih strokovnjakih s področja financ in računovodstva z uporabo funkcijskega slikanja možganov v magnetni resonanci (fMR). Zastavljen raziskovalni problem smo analizirali v treh različnih, a hkrati povezanih raziskavah.

V prvem poglavju doktorske disertacije primerjamo učinke dveh pomembnih organizacijskih mehanizmov nadzora — *družbeni pritisk* (angl. *social pressure*) ter *denarno spodbudo* (angl. *monetary incentive*) — na način kognitivnega nadzora. Kognitivni nadzor je sposobnost nadzora notranjih stanj, kognitivnih procesov ter vedenja, ki omogoča načrtovati, upreti se lastnim impulzom, prilagajati in spreminjati trenutno vedenje z namenom dosega relativno oddaljenih ciljev (Braver, 2012; Chiew & Braver, 2011; Cohen, Braver, & O'Reilly, 1996; Miller & Cohen, 2001). Teoretična podlaga za preučevanje kognitivnega nadzora in vpliva uvedbe odgovornosti na kognitivni nadzor izhaja iz *teorije dvojnega mehanizma nadzora* (angl. *Dual Mechanism of Control Theory*), katere avtor je Braver s sodelavci (2007). Teorija predpostavlja, da nadzor kognitivnih procesov deluje preko dveh različnih načinov, tj. proaktivnega in reaktivnega načina. Proaktivni način nadzora je usmerjen v prihodnost in pomaga pripraviti kognitivni sistem na prihajajoče dogodke s predvidevanjem na podlagi konteksta oziroma preteklih dogodkov. Nasprotno pa je reaktivni način nadzora retrospektiven, odziven na prisotnost izraženih ali nujnih dogodkov. Reaktivni način nadzora se aktivira preko reaktivacije že shranjenih podatkov in le če je to potrebno.

Prejšnje raziskave kažejo, da lahko denarne spodbude prispevajo k ciljno usmerjenemu vedenju z aktivacijo proaktivnega nadzora (Braver et al., 2009; Chiew & Braver, 2013, 2014; Dambacher et al., 2011; Fröber & Dreisbach, 2014; Locke & Braver, 2008; Padmala & Pessoa, 2011). Nasprotno pa obstaja dosti manj dokazov, kako družbeni pritisk vpliva na kognitivni nadzor in uspešnost nalog. Poleg tega ti dve vrsti spodbud nista bili neposredno primerjani znotraj ene raziskave. Za njihov specifični učinek smo jih primerjali z učinki drugega mehanizma odgovornosti — *navodili nadzornika* (angl. *authority instructions*). Da različni vidiki odgovornosti spodbudijo aktivacijo značilnih kognitivnih strategij spoprijemanja s situacijo, postaja vse bolj priznano (Lerner & Tetlock, 1999; Vieider, 2011), čeprav razlogi za to niso najbolj razumljeni. Obstoječe raziskave kažejo, da denarne spodbude pripeljejo do aktivacije proaktivnega načina kognitivnega nadzora (Braver et al., 2009; Chiew & Braver, 2013, 2014; Engelmann et al., 2009; Fröber & Dreisbach, 2014; Jimura et al., 2010; Locke & Braver, 2008; Padmala & Pessoa, 2011). Pri proaktivnem načinu nadzora je vključena uporaba predvidenih kontekstualnih namigov za maksimiranje nagrade. Družbeni pritisk lahko deluje preko podobnih kognitivnih mehanizmov kot denarna spodbuda. Mi postavljamo hipotezo, da uvedba katerekoli vrste odgovornosti vodi do povečanega kognitivnega napora in posledično aktivacije proaktivnega načina kognitivnega nadzora.

Da bi lahko raziskali vpliv preučevanih spodbud na način kognitivnega nadzora in uspešnost reševanja kognitivne naloge, smo izvedli laboratorijski eksperiment na 47 udeležencih. Udeleženci so bili dodiplomski in podiplomski študenti Ekonomske fakultete Univerze v Ljubljani s področja računovodstva in financ. V eksperimentu so udeleženci reševali AX-CPT nalogo (Cohen & Servan-Schreiber, 1992; Servan-Schreiber et al., 1996; Braver et al., 2001) pod družbenim pritiskom, denarno spodbudo in stanjem nadzora (samo z navodili). AX-CPT je naloga vzdrževane pozornosti, ki omogoča določitev načina kognitivnega nadzora. Ta kognitivna naloga meri zastopanost cilja, vzdrževanje in posodobitev informacij ter je bila pogosto uporabljena v raziskavah, ki so preučevale način kognitivnega (Barch et al., 1997; Braver et al., 2001, 2005; Braver and Bongiolatti, 2002; McDonald and Carter, 2003; Paxton et al., 2006, 2008; Locke and Braver, 2008).

Naloga AX-CPT zahteva od udeleženca, da pozorno spremlja prikazane črke A, B, X in Y na zaslonu in pritisne črko "n" takoj, kadar črki A sledi črka X (torej paru A-X), in črko "m", kadar črki A sledi črka Y ali kadar črki B sledi X ali Y (torej pri parih A-Y, B-Y in B-X). V primeru uporabe proaktivnega načina kognitivnega nadzora, ki je obrnjen v prihodnost, je subjekt osredotočen predvsem na prvo črko, na podlagi katere sklepa vnaprej, kaj bo potrebno pritisniti. Če bo zagledal B, ve, da mora pritisniti "m" ne glede na to, ali se X ali Y prikaže v nadaljevanju. V nasprotnem primeru, ko je prva črka A, pa bo v veliki verjetnosti za A sledila črka X (v 70 % primerov). Do napake v odgovoru bo prišlo torej v primeru, ko se bo za A prikazal Y. Število napak pri parih A-Y je indikator za aktivacijo proaktivnega načina kognitivnega nadzora. Nasprotno, reaktivni kognitivni nadzor deluje po principu »just in time«, kar pomeni, da bo posameznik udeleženec osredotočen predvsem na drugo prikazano črko, to je X oziroma Y. Če bo zagledal Y, ve, da mora pritisniti "m" ne glede na to, ali se je pred Y prikazal A ali B. V nasprotnem primeru, ko se prikaže črka X, pa se mora posameznik spomniti, katera črka se je prikazala pred X. Če je bila to črka A, mora pritisniti "n", sicer pa črko "m". V 70 % je pred X črka A, zaradi česar bo ob uporabi reaktivnega načina kognitivnega nadzora prišlo do največ napak v primeru, ko se bo pred X pokazal B. Število napak pri parih B-X je torej indikator za merjenje aktivacije reaktivnega načina kognitivnega nadzora.

Udeleženci v raziskavi so najprej rešili 30 poskusov v osnovnem pogoju brez spodbude (baseline), med izvedbo katere smo beležili število in reakcijske čase pravilnih odgovorov. V drugem delu reševanja naloge smo udeležencem naročili, da izboljšajo hitrost svojih odgovorov, ter jih seznanili, da bo reševanje potekalo v treh pogojih – pod denarno spodbudo, družbenim pritiskom in navodili nadzornika (kontrolni pogoj). V drugem delu so isto nalogo rešili v treh različnih pogojih spodbud, pri čemer so v vsakem rešili štiri bloke po 30 poskusov. Skupno so tako rešili 390 poskusov.

Denarno spodbudo smo opredelili kot pridobivanje denarnih sredstev z nadpovprečno uspešnostjo izvedbe kognitivnih nalog, pri čemer smo napačne odgovore denarno kaznovali. Družbeni pritisk po doseganju rezultatov smo definirali v obliki javne objave rezultatov in primerjave le-teh z ostalimi udeleženci. Navodila nadzornika so bila opredeljena zgolj kot navodila »delaj bolje« brez drugih dodatnih spodbud. Zaradi nasprotujočih si dokazov glede družbenega pritiska na kognitivno uspešnost nismo imeli močnih apriornih napovedi, povezanih z njegovim učinkom na strategijo kognitivnega nadzora in uspešnost.

Naši rezultati kažejo, da že samo podajanje navodil »delaj bolje« vodi do izboljšanje uspešnosti reševanja naloge ter pomembnega premika od reaktivnega do proaktivnega nadzora. Družbeni pritisk in denarna spodbuda nadalje izboljšata uspešnost nad učinkom samih navodil.

Naša raziskava je omogočila prvo neposredno primerjavo učinkov družbenega pritiska in denarne spodbude na vedenjsko uspešnost. Presenetljivo je, da medtem ko so rezultati pokazali, da sta prej omenjeni spodbudi primerljivi v njunih učinkih, pa se zdi, da je učinek v večji meri povzročen že s samo prisotnostjo natančnih navodil, da se izboljša vedenje in s spremljajočim opazovanjem vedenja.

Prispevek naše raziskave je predvsem v obsežnosti učinka različnih vrst odgovornosti na kognitivni nadzor s primerjavo vseh treh vrst spodbud v istem eksperimentu. Struktura raziskave in njena izvedba uspešno združuje dve disciplini – poslovodno računovodstvo in kognitivno psihologijo. Boljše razumevanje učinkov različnih oblik spodbud in pritiskov na kognitivni nadzor nadgrajuje in pomembno prispeva k nadgradnji teorije poslovodnega računovodstva in teorije dvojnega mehanizma nadzora. Nadalje, rezultati raziskave pomembno prispevajo k razumevanju in oblikovanju učinkovitih oblik shem nagrajevanja in sistemov odgovornosti, ki so namenjene kot vodilo za vedenje managerjev.

V drugem poglavju raziskujemo nevronske osnove učinka družbenih spodbud. Glavni cilj je predstaviti nevroznanstvene dokaze o učinkih družbenih spodbud na uporabo kognitivnega nadzora. Osredotočimo se na vprašanje, ali obe družbeni spodbudi — *dobrodelna donacija* (angl. *donation*) in javno razvrščanje udeležencev po uspešnosti (angl. *ranking*) — sprožita podobne nevronske aktivnosti kot denarne spodbude, ki so bile raziskane v obstoječi literaturi. Izvedli smo eksperiment s pomočjo funkcijskega slikanja možganov v magnetni resonanci (fMR). V eksperimentu smo preučevali možgansko aktivnost med izvajanjem kognitivne naloge selektivne pozornosti, t.i. Eriksen Flanker nalogo (Eriksen and Eriksen, 1974) pod različnimi pogoji vpeljane odgovornosti. Naloga Flanker omogoča merjenje kognitivnega napora, načina kognitivnega nadzora in sposobnost inhibicije pred motečimi dražljaji.

Naloga Flanker zahteva od udeleženca, da pozorno spremlja prikazane puščice na zaslonu. V okviru na sredini zaslona se je prikazovalo sedem puščic (“<”), ki so bodisi vse kazale v isto smer (npr. “<<<<<<<", skladni pogoj), bodisi je srednja puščica kazala v drugo smer (“>>><>>>”, neskladni pogoj). Naloga udeležencev je bila s pritiskom na gumb odgovoriti, v katero smer kaže srednja puščica (levo ali desno). Nalogo smo izvedli v dveh delih. V prvem delu je naloga obsegala štiri bloke po 13 poskusov, med izvedbo katere smo beležili število in reakcijske čase pravilnih odgovorov. V drugem delu smo udeležencem naročili, da izboljšajo hitrost svojih odgovorov, ter jih seznanili, da bo reševanje potekalo ob dveh pogojih. V enem od pogojev bodo njihovi rezultati šteli k povprečju, ki bo javno objavljeno in predstavljeno drugim udeležencem, v drugem pogoju pa bodo za vsak pravilen odgovor, ki bo hitrejši od 2/3 poskusov v prvem delu, prislužili 50 centov za dobrodelne namene, za vsak nepravilen ali nepodan odgovor pa se bo 50 centov odštelo od darovanega zneska. Drugi del naloge smo izvedli v dveh meritvah. Vsaka meritev je vključevala 4 bloke poskusov enake časovne strukture kot prvi del. Pogoja izvedbe sta se med bloki menjavala; aktivni pogoj je označevala barva okvira, znotraj katerega so bili prikazani dražljaji.

Eksperiment je potekal v magnetni resonanci Centra za klinično fiziologijo Medicinske fakultete Univerze v Ljubljani. V raziskavi je sodelovalo 30 udeležencev iz poslovnega sveta, ki zasedajo različne funkcije, kot so računovodja, kontrolor in predsednik uprave. Strukturno in funkcijsko slikanje možganov smo izvedli med izvajanjem kognitivne naloge selektivne pozornosti (Flanker naloga; Eriksen and Eriksen, 1974). V fMR eksperimentu smo preučevani družbeni spodbudi podobno definirali kot v prvem delu raziskave doktorske disertacije. Družbeno spodbudo dobrodelna donacija smo definirali kot pridobivanje denarnih sredstev za humanitarne namene z nadpovprečno uspešnostjo izvedbe kognitivne naloge. Javno razvrščanje udeležencev po uspešnosti (oziroma družbeni pritisk) pa smo definirali v obliki javne objave rezultatov in primerjave le-teh z ostalimi udeleženci. Tako smo ugotavljali, kako različne oblike družbenih spodbud aktivirajo živčne sisteme v prefrontalnem režnju in kako je ta aktivacija povezana z izvrševanjem kognitivnih nalog.

Vedenjski rezultati kažejo, da so se udeleženci na splošno odzvali hitreje na družbene spodbude v primerjavi z izhodiščem, medtem ko so v glavnem ohranili natančnost pri skladnih in neskladnih dražljajih. fMR analiza vnaprej definiranih predelov interesa (ROI) je razkrila splošno povečanje ohranjene aktivnosti v dorzolateralni prefrontalni skorji (DLPFC) in dorzalno anteriorni cingularni skorji (dACC) in povečanje prehodne aktivnosti v obeh predelih pri neskladnih dražljajih, ki implicirajo simultano zanašanje na proaktivne in reaktivne načine kognitivnega nadzora. Na splošno naši rezultati kažejo, da je učinek družbenih spodbud primerljiv z denarnimi spodbudami in da vodijo do povečane pozornosti, izboljšanega motoričnega nadzora in nadzora pozornosti ter reševanja konfliktov in inhibicije. Obe družbeni spodbudi imata primerljive učinke. Ugotovitve naše raziskave ne prispevajo samo k akademskim dokazom o vlogi motivacije na kognitivni nadzor, ampak imajo tudi praktične implikacije na delovnem mestu. Povečan obseg raziskav v psihologiji in vedenjski ekonomiji nudi dokaze o omejitvah denarnih spodbud pri motivaciji posameznikov pri visoko zahtevnih kognitivnih nalogah, nalogah presojanja in kreativnih nalogah (Ariely et al. 2009; Bonner et al., 2000; Deci et al., 1999; Oblak et al., 2017).

Pomembnost nedenarnih, t.i. družbenih spodbud, v različnih oblikah ima večjo vrednost v psihologiji (npr. Gees, 1991; Lerner & Tetlock, 1999; Locke, 1996; Ličen et al., 2016; Wright et al., 1995) kot v literaturi na področju vedenjske ekonomije in poslovodnega računovodstva. Razlog za to gre iskati v tem, da so družbene spodbude še vedno gledane kot komplementarni mehanizem nadzora (npr. denarnim spodbudam) in ne kot samostojne spodbude. Cilj naše raziskave v drugem poglavju doktorske raziskave je bil prispevati nevroznanstvene dokaze o učinkih družbenih spodbud na uporabo kognitivnega nadzora in razširiti prejšnje vedenjske rezultate, predstavljene v prvem delu disertacije (Ličen et al., 2016).

V tretjem poglavju disertacije se osredotočamo na vprašanje kako zmanjšati tendenco kratkovidnosti z uvedbo odgovornosti, opredeljeno kot *zahteva po utemeljevanju* (angl. *justification pressure*). Takšen pritisk prav tako spada v razred družbenih spodbud, pogosto uporabljen v organizacijah, ali kot samostojna spodbuda ali v kombinaciji z denarnimi spodbudami. V tej raziskavi smo želeli razumeti, v kakšnem obsegu lahko uvedba odgovornosti v obliki zahteve po utemeljitvi odločitve zmanjša kratkovidnost managerjev v odločanju. Analizirali smo, ali odgovornost zmanjša pretirano nenaklonjenost do časovnega odloga in tveganja ter nedosledno uporabo diskontnih stopenj. Takšno vedenje managerjev namreč vodi do suboptimalnih investicijskih odločitev. Da bi obravnavali naše raziskovalno vprašanje, smo izvedli eksperiment na 147 subjektih, kjer smo merili kratkovidnost z uporabo naloge časovnega in verjetnostnega diskontiranja. Predpostavljali smo, da odgovornost zmanjša pretirane diskontne stopnje za časovni odlog in sprejemanje tveganja ter prepreči nedosledno uporabo diskontnih stopenj, ki vodijo do preobrata izbire.

V nalogi časovnega diskontiranja so udeleženci izbirali med takojšnjo, a manjšo nagrado ter večjo nagrado, izplačano kasneje v času (1-, 3-, 6-, ali 12-mesečni odlog). V nalogi verjetnostnega diskontiranja pa so udeleženci izbirali med gotovo, a manjšo nagrado ter večjo nagrado, vendar tudi z večjim tveganjem (5, 10, 20 ali 40 odstotnih točk).

Opazovali smo, pri kateri vrednosti so bili udeleženci indiferentni med takojšnim izidom in tistim z daljšim odlogom izplačila. Enako smo merili indiferentnost med zagotovim izidom in bolj tvegano izbiro. Na podlagi izbir smo za vsakega posameznika določili njegovo indiferenčno točko (angl. *indifference point*) (Vanderveldt, Oliveira, & Green, 2016). To je točka, na kateri udeleženec postane neopredeljen med takojšnjim izidom in izidom z zamikom ali gotovim izidom v primerjavi z bolj tveganim oziroma sta mu obe izbiri enakovredni. Na podlagi točke indiferenčnosti smo izračunali diskontni faktor in ocenili krivuljo časovnega in verjetnostnega diskontiranja (Mazur, 1978, in Rachlin, Raineri, & Cross, 1991). Prav tako smo raziskali, ali odgovornost zmanjša uporabo nedoslednih diskontnih stopenj z odložitvijo obeh, torej takojšnjega izida in izida z zamikom za obdobje enega leta ter zmanjšanjem verjetnosti določenih in tveganih izidov s 50 odstotnimi točkami in s tem povzroči, da so vse možnosti precej tvegane. Eksperiment smo izvedli na 147 študentih.

Na podlagi rezultatov ugotavljamo, da so udeleženci uporabili bolj hiperbolično kot eksponentno funkcijo diskontiranja, kar kaže na oster padec diskontne stopnje s časovno oddaljenostjo in z naraščajočo negotovostjo. Uvedba zahteve po utemeljitvi odločitev je vodila do višje točke indiferenčnosti in manj strmi zamik ter verjetnost diskontiranja, kar nakazuje, da so udeleženci z utemeljitvijo svojih izbir zmanjšali pretirano sprejemanje tveganja in nenaklonjenost do časovnega odloga. Oblika diskontne krivulje in pomembnih interakcij med zamikom/tveganjem in odgovornostjo je razkrila, da je odgovornost vodila udeležence k uporabi bolj doslednih diskontnih stopenj v daljni prihodnosti in pri višjih stopnjah tveganja. Naše ugotovitve kažejo, da je nasprotno nekaterim mehanizmom ocenjevanja uspešnosti, ki poslabšajo kratkovidno vedenje, pritisk, da se utemeljijo sprejete odločitve, zmanjšal pretirane subjektivne diskontne stopnje za časovni zamik in tveganje, zaradi česar so postale bolj dosledne s tem, da so udeleženci dobro premislili o njihovih izbirah.

Razumevanje vedenjskih vzrokov in učinkovitosti ukrepov za zmanjšanje kratkovidnosti managerjev je časovno in relevantno, saj obstaja precejšnji pritisk s strani finančnih regulatorjev in lastnikov podjetij za boljšo uskladitev vedenja managerjev z dolgoročnimi interesi podjetja. Naša raziskava je izvirna analiza učinka zahteve po utemeljivi na pretirano nenaklonjenost časovnega odloga in sprejemanja tveganja, dva vidika kratkovidnost v odločanju managerjev. Ugotovitev, da odgovornost lahko zmanjša pretirano nenaklonjenost sprejemanja časovnega odloga in tveganja ter vodi do bolj dosledne uporabe diskontnih stopenj, je velik prispevek k dotedanjim raziskavam s področja ekonomije in psihologije. Prispeva k skromnemu obsegu znanja o učinkovitosti mehanizmov poslovodnega računovodstva za odpravo vedenjskih pristranskosti (Oblak et al., 2017; Vieider, 2009). Ugotovitve raziskave bi lahko uspešno prispevale k oblikovanju bolj učinkovitega načina ocenjevanja uspešnosti in bi lahko bile relevantne ne samo za poslovodno računovodstvo raziskovalcev, ampak tudi za strokovnjake v praksi.

Uvedba učinkovitega sistema odgovornosti, ki bi uspešno zmanjšala kratkoročno naravnane odločitve managerjev, je ključnega pomena za vse organizacije. Glede na vedno večje zneske denarja, ki so porabljeni za spodbudo managerjem, nas še posebej zanima učinek družbenih spodbud. Naše ugotovitve nakazujejo, da družbene spodbude lahko vplivajo na izvršilne procese v podobnem obsegu kot denarne nagrade. Čeprav ne nudijo neposredne osebne koristi, so koristi povezane s družbenimi spodbudami bolj posredne in dolgotrajne, kot je recimo družbeni status (Williams, 2007) zaradi visoke razvrstitve ali pomoči drugim, kvalitete odnosa z nadrejenim (če se spoštujejo njegova navodila) ali koristi, ki izhajajo iz čistega zadovoljstva, da pomagaš drugim (Alford et al., 2009). Kot inovativne, kreativne, visoko zahtevne kognitivne naloge in naloge, ki zahtevajo tehtno presojo pri tveganju, kjer povezava med nagrado in učinkom ni enostavna in predvidljiva, postajajo vse bolj relevantne za uspeh v sodobnih organizacijah; uporaba družbenih spodbud postaja vse bolj pomembna za spodbudo zaposlenim.

Rezultati vseh treh raziskav na splošno kažejo, da odgovornost kot družbena spodbuda izboljša kognitivno učinkovitost, aktivira proaktivni nadzor, poveča pozornost in inhibicijo in s tem uspešno blaži kratkovidnost managerjev. Ugotovitve disertacije prispevajo k majhnemu obsegu znanja o učinkovitosti sistemov odgovornosti namenjenih za usmerjanje managerskega vedenja pri odpravljanju vedenskih pristranskosti kot je kratkovidnost v odločanju. Uporabnost naših ugotovitev za prakso je v vzpostavitvi večje odgovornosti, uvedbi zahteve po utemeljitvi in drugih družbenih spodbudah, ki imajo pozitiven vpliv na kognitivni nadzor in razmišljanje, ter odvzeti poudarek kratkoročno usmerjenim denarnim spodbudam.

Družbene spodbude spremenijo način kognitivnega procesiranja. Aktivirajo proaktivni kognitivni nadzor, ki omogoča bolj skrbno izvedbo ob upoštevanju ključnih vidikov naloge in hitrejše prepoznavanje odločilnih ali celo nasprotujočih si informacij. Toda pri izvajanju je proaktivni kognitivni nadzor bolj zahteven in zahteva več energije ter ga zato ni mogoče vzdrževati v nedogled. Izsledki doktorske disertacije zato ne nudijo enkratnega recepta, ampak so bolj del sestavljanke, ki jo je treba upoštevati pri celostnem načrtovanju dela in načrtovanju sistemov nagrajevanja.

Vsekakor ta doktorska disertacija ni bila potovanje na znano destinacijo, temveč raziskovanje neznanega področja. Predstavlja in gradi na teorijah iz psihologije in nevroznanosti, ki so v literaturi poslovodnega računovodstva dokaj nove. Doktorska disertacija prispeva k skromni bazi znanja, ki preiskuje družbene spodbude poleg denarnih spodbud. Za proučitev naših raziskovalnih vprašanj smo uporabili eksperimentalne in nevroznanstvene metode, ki so nove na področju poslovodnega računovodstva in vedenjske ekonomije. Hkrati smo poizkusili poslovodno računovodstvo približati drugim disciplinam z zagotavljanjem konteksta. Namerno smo se odmaknili od kompleksnih nalog, ki jih v računovodstvu običajno raziskujejo, in razdelali kompleksno sprejemanje odločitev v bolj enostavne in oprijemljive kognitivne procese. Tako smo dobili bolj podroben vpogled v učinke družbenih spodbud. Na nekatera vprašanja smo v pričujoči doktorski disertaciji odgovorili, ampak še več jih ostaja odprtih. Verjamemo, da naši izsledki in zadevna literatura ponujajo velik potencial za prihodnje raziskave in doživljenjsko delo več raziskovalcev.

Appendix 2: Supplementary Material (Paper 1)

2.1 Supplementary Analysis

2.1.1 Practice effect across experimental conditions

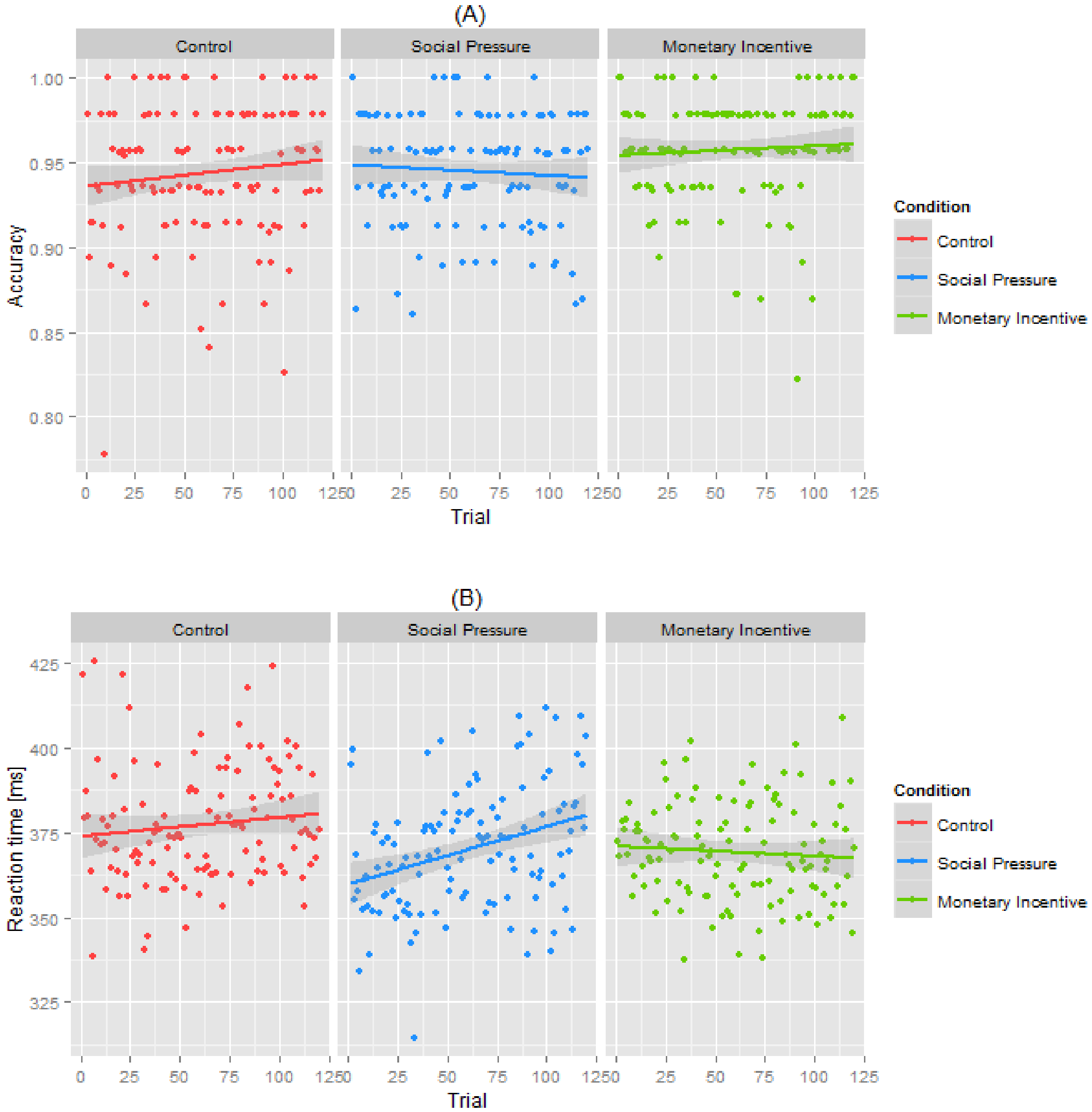
Due to the within-subject block design of the study there is a potential concern that differences between blocks reflect practice effects rather than experimental manipulation. To address this concern, we conducted a logistic regression of accuracy and a linear regression analysis of reaction times on a trial number in the experimental conditions. As the trials were manipulated within-subjects, the subjects were treated as a random factor and intercepts were modelled for each subject separately. Statistical significance was estimated using likelihood ratio χ^2 tests.

Results of a *logistic regression* of accuracy of responses (0 for an incorrect and 1 for a correct response) on a trial number did not reveal a significant effect of trials number in any condition (control condition, $\beta < 0.002$, $\chi^2(1) = 2.09$, $R^2 < .001$, $p = .148$, social pressure condition, $\beta = -0.001$, $\chi^2(1) = 0.40$, $R^2 < .001$, $p = .530$, monetary incentive condition, $\beta = 0.001$, $\chi^2(1) = 0.45$, $R^2 < .001$, $p = .501$; see Supplementary Figure 1A), suggesting that the accuracy did not improve with progression of the task. Results of a *linear regression* of reaction times on trial number also failed to show a significant effect in the control condition, $\beta = -0.06$, $\chi^2(1) = 1.66$, $R^2 = .18$, $p = .198$, and the monetary incentive condition, $\beta = 0.03$, $\chi^2(1) = 0.65$, $R^2 = .19$, $p = .422$, it did reveal a significant negative effect in the social pressure condition, $\beta = -0.17$, $\chi^2(1) = 16.87$, $R^2 = .17$, $p < .001$ (see Supplementary Figure 1B). Overall, results show no significant practice related improvements either on accuracy or reaction times in any of the experimental conditions, but rather a small effect of fatigue reflected in reaction times in the social pressure condition.

2.2 Supplementary Figures

2.2.1 Practice effect across experimental conditions

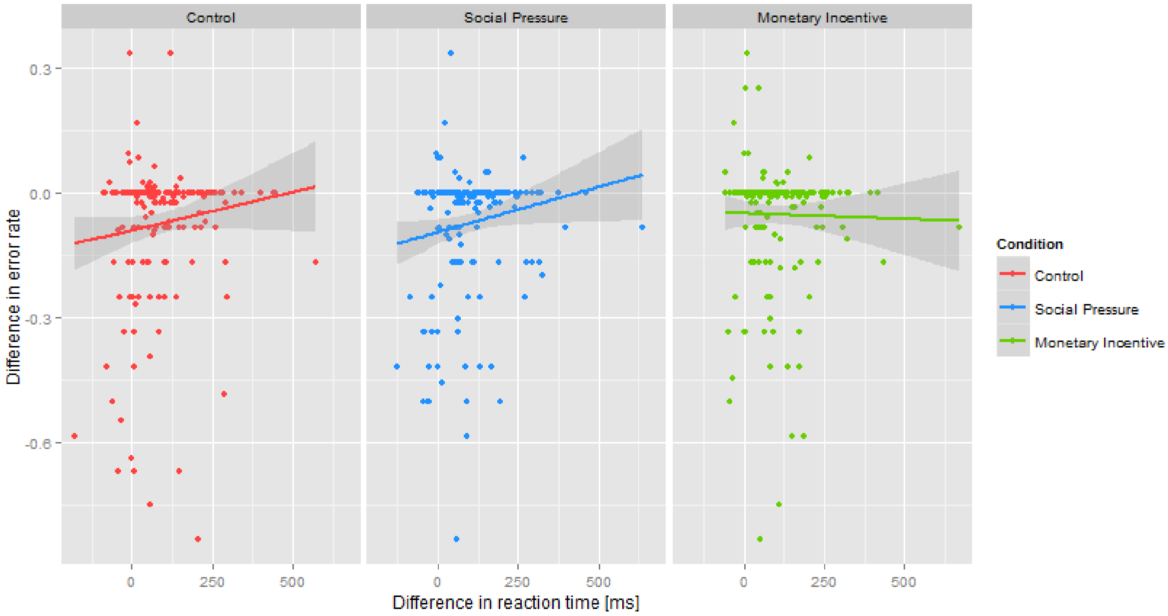
Supplementary Figure 1: Logistic regression of accuracy (A) and linear regression of reaction times (B) on trial number for each of the experimental conditions



Note: A logistic regression of accuracy (**A**) and linear regression of reaction times of correct responses (**B**) collapsed over the trial type for all trials are shown in aggregated form for all the subjects in all the experimental conditions.

2.2.2 Speed-accuracy trade-off effect

Supplementary Figure 2: Speed-accuracy trade-off effect depending on condition



Note: Changes in the error rates are plotted against changes in the mean reaction times of correct responses collapsed over the trial type for each of the incentive conditions. Differences in the error rates and reaction times are presented in milliseconds saved in a baseline vs. incentive condition. Positive values indicate an improvement in reaction times (shorter reaction time) and accuracy (lower error rate) under an incentive condition. A linear regression and its confidence interval are shown for each experimental condition.

Appendix 3: Supplementary Material (Paper 2)

3.1 Supplementary Analysis

3.1.1 Global incentive effect

For both social incentives, the participants were asked to improve the speed of their responses. The cut-off for correct and sufficiently fast responses was the upper one-third correct responses in the baseline. For congruent trials, there were 70.7% of such responses in the donation condition and 71.0% in the ranking condition while for the incongruent trials there were 61.9% of such responses in the donation condition and 63.7% in the ranking condition versus the expected rate of 33.3% had the speed remained at the baseline level.

3.1.2 Practice effect

As the baseline condition was always presented first, one potential concern is whether the successful incentive manipulation presented above may actually reflect practice-related changes in performance. Therefore, we conducted a logistic regression on error rates and a linear regression analysis on reaction times separately for the congruent and incongruent trials in all experimental conditions to test for the presence of performance improvement with the task progression reflecting a practice effect. As the trials were manipulated within-subjects, the subjects were treated as a random factor and intercepts were modelled for each subject separately. Statistical significance was estimated using likelihood ratio χ^2 tests.

Results of a logistic regression of the accuracy of responses (0 for an incorrect and 1 for a correct response) on the trial number only revealed a significant positive effect in the baseline condition, β = .05, $\chi^2(1)$ = 43.92, R^2 = .07, p < .001, suggesting that accuracy improved with progression of the task at the beginning of the baseline condition (see Supplementary Figure 3A). However, the practice effect was not observed later in any of the social incentive conditions (ranking condition, β < .001, $\chi^2(1)$ = .01, R^2 < .001, p = .910, donation condition, β = -.007, $\chi^2(1)$ = 1.11, R^2 = .001, p = .291; see Supplementary Figure 3B) since performance accuracy worsened in both social incentive conditions.

Similarly, results of a *linear regression of reaction times on trial number* also revealed a significant negative effect in the baseline condition, β = -.784, $\chi^2(1)$ = 9.44, R^2 = .416, p = .002, suggesting that the speed improved with progression of the task in the baseline condition (see Supplementary Figure 3A). However, the practice effect was not observed later under social incentives (ranking condition, β = .313, $\chi^2(1)$ = 1.95, R^2 = .323, p = .163, donation condition, β = .057, $\chi^2(1)$ = .07, R^2 = .313, p = .795; see Supplementary Figure 3B) since reaction time in both the ranking and donation condition was on average 17% faster than performance speed in the baseline condition. Overall, the results show no significant practice-related improvements on either accuracy or reaction times in any of the social incentive conditions.

3.1.3 Speed-accuracy trade-off effect

To exclude the possibility the observed changes in performance were due to a speed–accuracy trade-off rather than an actual performance improvement, we conducted a *correlation analysis between the change in accuracy rates and the change in reaction times in the baseline vs. the social incentive conditions*. This was a particular concern since we had observed higher speeds but also lower accuracy rates with the social incentives. The results show a non-significant correlation between changes in accuracy rates and speed for the congruent and incongruent trials, respectively, in the donation, $r = .18$, $p = .337$, $r = -.24$, $p = .203$, and in the ranking condition, $r = -.12$, $p = .521$, $r = -.27$, $p = .154$ (see Supplementary Figure 3C). The effect of the trade-off accounts for as little as 5.76% of the variance. We can therefore dismiss the concern that the subjects achieved a faster reaction time on account of slightly higher error rates.

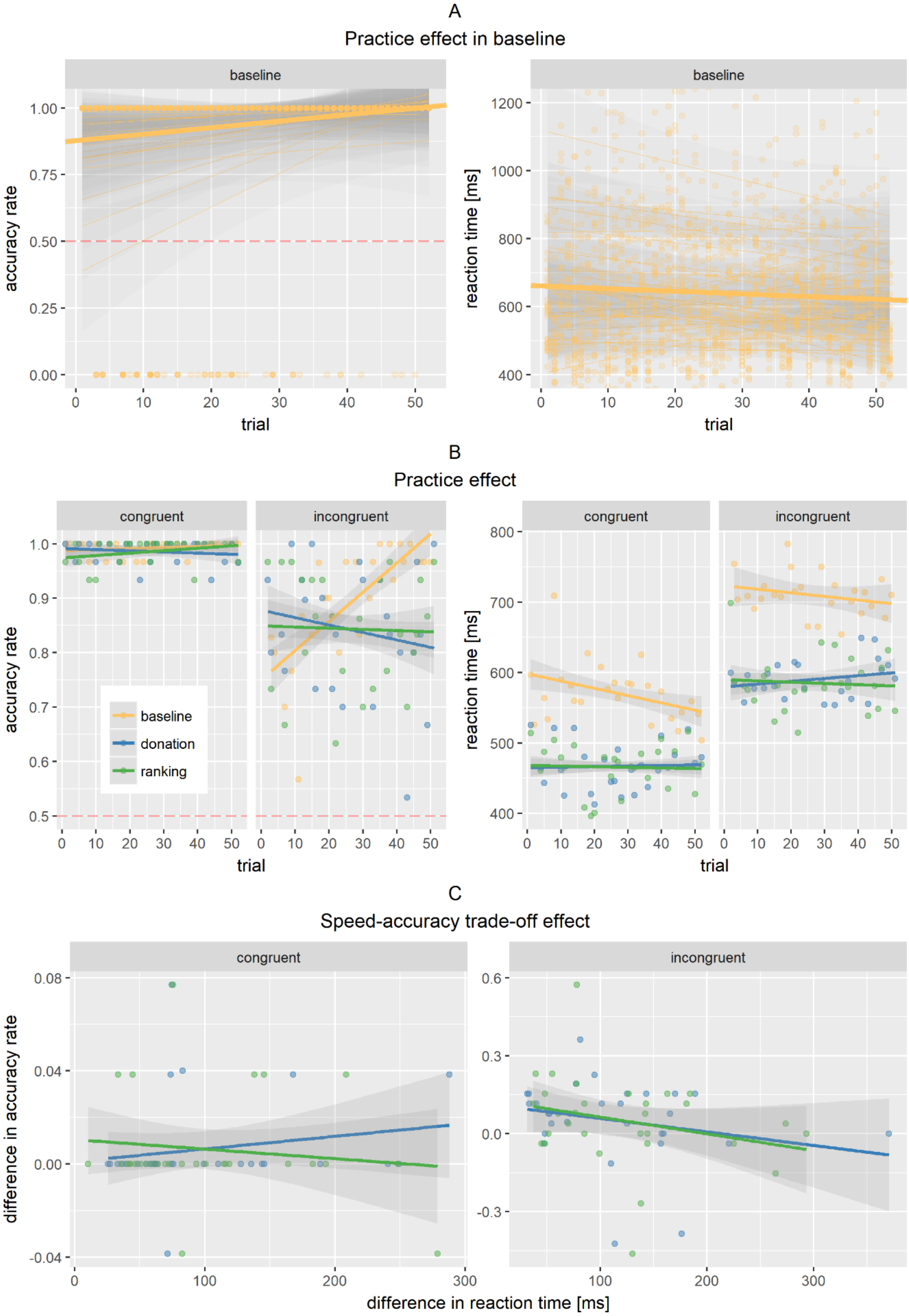
3.1.4 Correlation analysis

Some people become more stimulated, have greater motivational orientation and better cognitive resources than others. They might be equally sensitive to the donation and ranking conditions, while others are less sensitive to both. To analyse this issue, we conducted a *correlation analysis between the differences in the donation and ranking conditions relative to the baseline among accuracy rates and reaction times depending on congruency*. The results show no significant correlation between the donation and ranking conditions for accuracy rate for the congruent trials, $r = .13$, $p = .504$, since participants performed at maximum, and a strong and significant positive correlations for incongruent trials, $r = .79$, $p < .001$, and reaction time for the congruent and incongruent trials, respectively, $r = .92$, $p < .001$, $r = .87$, $p < .001$ (see Supplementary Figure 4). Overall, the significant positive correlation coefficients suggest the subjects were equally sensitive to both social incentives.

3.2 Supplementary Figures

3.2.1 Practice and speed-accuracy trade-off effect

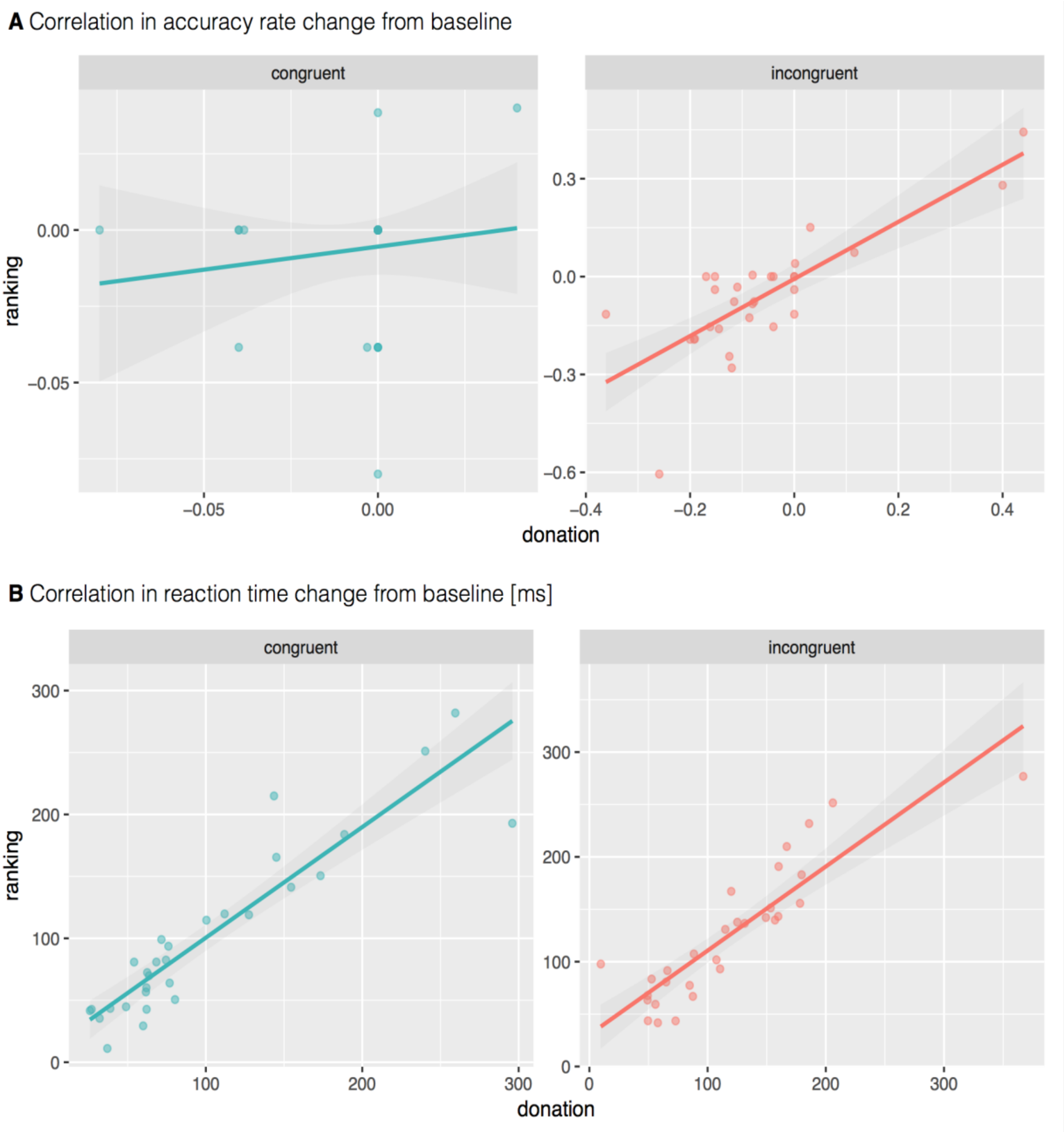
Supplementary Figure 3: Practice and the speed–accuracy trade-off effect across conditions



Note: The effect of practice and the speed–accuracy trade-off across experimental conditions. **A** The logistic regression of accuracy and linear regression of reaction times of correct responses collapsed over the congruency type for all trials are shown in aggregated form for all subjects in the baseline condition. **B** The logistic regression of accuracy and linear regression of reaction times of correct responses depending on congruency type for all trials are shown in aggregated form for all subjects in the baseline and two incentive conditions. **C** Relationship between differences reaction times and accuracy rates depending on congruency type between two incentive conditions compared to the baseline. Positive values indicate an improvement in reaction times (shorter reaction time) and accuracy (lower error rate) under the social incentive condition.

3.2.2 Correlation between experimental conditions

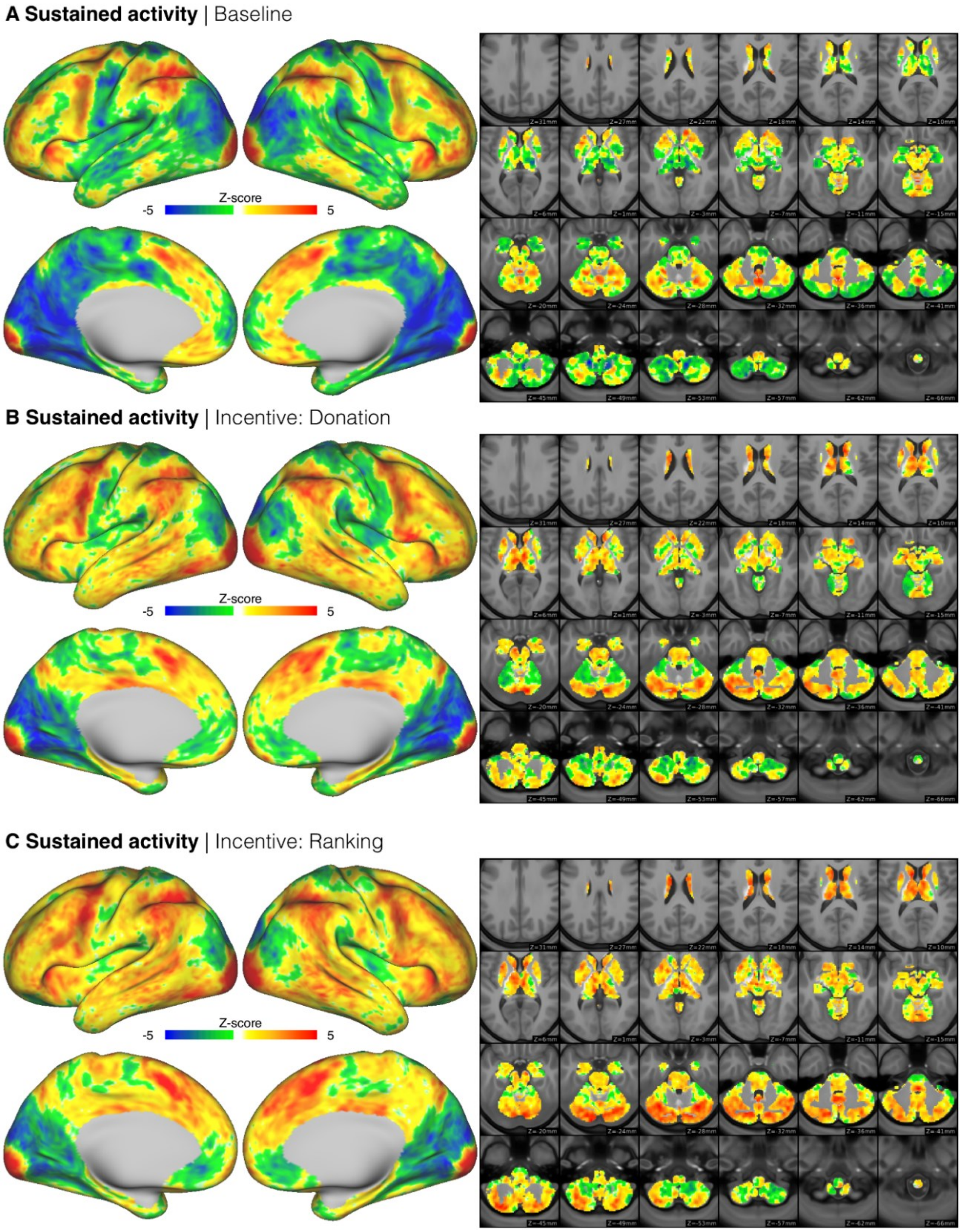
Supplementary Figure 4: Correlation in improvement between the two incentive conditions



Note: Relationship between performance changes in the two incentive conditions compared to the baseline for accuracy rates (**A**) and reaction times (**B**) separately for the congruent and incongruent trials. A positive correlation indicates the subjects were equally sensitive to both social incentive conditions under comparison.

3.2.3 Sustained activity

Supplementary Figure 5: Sustained activity during task performance e



Note: Sustained activity during task performance in the baseline (**A**) and the two incentive conditions – donation (**B**) and ranking (**C**). Unthresholded maps of Z-scores.