The Effect of Interpersonal Power on Cognitive Processing: A Behavioural and Neural Perspective

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Short Abstract

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Interpersonal power, defined as the asymmetrical control over valued outcomes, has important effects on the way cognitive processing unfolds. This work explores the effect of power on basic cognitive processes, in addition to broader processes that appear at the level of social behaviour. I begin this thesis with an introductory chapter, followed by a chapter describing the theory and practice behind electro-encephalogram recordings. In Chapter 3, I explore the effect of power on attention selection using a task that requires the ability to focus or divide attention in space, while varying the amount of distractors. The results suggest that low-power participants (subordinates) are more susceptible to the presence of distractors, regardless of whether the task necessitates focused or divided attention. In this context, inhibition accounts for the results to a greater extent than spatial orienting. In Chapter 4, I explore the effect of power on early inhibition processes in the context of executive control, in a task which allows participants to allegedly observe each others’ performance and receive feedback. The results show that high power is associated with reduced behavioural accuracy on trials that require executive control. Event-related potential analyses show that power-holders devote reduced motivational resources to their targets compared to subordinates, but do not differ at the level of early conflict detection. Their feedback potential results show a greater expectation of rewards, but reduced subjective magnitude attributed to losses. Subordinates, on the other hand, are asymmetrically sensitive to power-holders’ targets. They expect fewer rewards, but attribute greater significance to losses. In Chapter 5, I show that subordinates are asymmetrically competent at remembering diagnostic choices made by power-holders. In a final general discussion chapter, I integrate the findings of the experiments, which point to multi-layered effects of power, conferring those who possess it and those who lack it with distinct cognitive processing styles that suit their adaptive needs. The results are consistent with a hypothesized link between subordination and up-regulation of vigilance and environmental sensitivity. Limitations and future directions are discussed.

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Table of Contents

1 Chapter 1-General Introduction

1.1 Foreword

Power is fascinating. It is a fundamental aspect of society; dictating the way human interactions occur, health, and the rise and fall of empires. Power is present in the animal kingdom, predicting behavioural patterns and survival strategies of the dominant and subordinate members of the species. Power is an important influence on the economy, with a potential to precipitate financial crises that affect millions. It is not surprising, therefore, that power has received interest from a wide array of academic disciplines: sociology, anthropology, economics, social psychology, evolutionary psychology, and, more recently, neuroscience.

This thesis explores how power can fundamentally change an individual’s mental world. The same physical environment, from the perspective of a manager and an employee, looks and feels very different. With possession and lack of power, different bits of information are prioritized, receiving attention and action in different ways. Importantly, there are also differences in the *way* this information is processed (Guinote, 2013; Guinote & Vescio, 2010). By subjecting enduring questions to the rigour of laboratory experiments and neuroscientific methods, I try to shed some light on how power and subordination change the way that people perceive and react to their environment.

The experiments in this thesis move on a trajectory of emphasis from relatively simple to relatively more situated and interactional forms of cognition. Hopefully, it will become obvious that the findings at the level of basic cognition are consistent, and predictive of, the social consequences of power. Also, this thesis argues that the literature on power and the literature on control deprivation are intimately linked, due to the impact of power and subordination on a basic need: the need to control and predict environmental outcomes (Fiske, 1993; Guinote, 2007a).

After some general remarks on cognition in a social setting, I proceed to define power and the dominant theories that have attempted to conceptualize it and describe its consequences. Afterwards, I describe the effect of power on cognitive processes at a basic level, moving onwards to its broader effects at the level of social phenomena.

1.2 Cognition is attuned and flexible

The aim of cognition is to form representations of the sensory world and utilize memories and acquired knowledge in order to adapt and satisfy an individual's basic needs (e.g. Gazzaniga, 2010). Information processing does not occur in void, but is rather tightly linked to the motivational state of the individual. An influential framework to understand social perception proposes than human beings are 'motivated tacticians' who manage their limited cognitive resources according to their adaptive needs (Stevens & Fiske, 1995).

Power is a key factor that defines the motivations, affordances, and constraints for those who lack it and those who possess it. There is nothing magical and transformative about power, except the fascinating way in which it attunes individuals to their environment. For people who lack power, cognition unfolds in ways to avoid further loss and harm, and to maintain what small level of control they have (Fiske & Dépret, 1996). For people who possess power, their cognition unfolds in ways that allow them to pursue what desires and goals they have at the moment, as they are spared the necessity to worry about how much control they have over their affairs.

Before a more elaborate description of how power shapes cognition, it is important to clarify: What is power?

1.3 Definition of power

Most writings on power will mention Russell's (1938) quote that power is as fundamental to social sciences as energy is to physics. Although it seems rather intuitive as a concept, finding one standard definition that captures the essence of power is slightly problematic. Depending on the approach and the discipline, power can be construed as a personality variable, as an interpersonal variable, and even as a product of group dynamics (Overbeck, 2010). One common thread among all conceptualizations of power, however, is an emphasis on influence, dependence, and control (Guinote & Vescio, 2010).

Traditionally, there was a tendency to define power as a fixed variable, where some people are ‘powerful’ and others are not. Seminal work in the area of philosophy by Nietzsche (1968) describes a ‘will to power’, where self-mastery derives from a basic human motive. Power has been seen to reside ‘within a person’ to a certain extent, deriving from individual-difference variables such as authoritarianism (Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950), dominance, and motivational style (Winter, 1973; 2010).

If one is to describe the societal consequences of power, however, it becomes difficult to adopt a static conception. There are a host of social forces that determine whether power emerges in an observable manner. Weber (1946) ‘socialized’ power by describing it as the probability that one actor will exert their will despite resistance from another, which later became a standard definition in sociology.

More recent social psychology theories of power emphasize the relativity of dependence in exerting influence on others in the way power is defined and operationalized. Every individual can be in a position of power at certain times, and in subordination on the other. The amount of a first party’s dependence on the second is compared with the dependence of the second party on the first. The party with the least dependence is the more powerful (French & Raven, 1959; Overbeck, 2010).

French and Raven (1959) defined power as the ability to influence others in psychologically meaningful ways. This definition still persists in the current literature, with the elaboration that this ability is conferred through giving or withholding of rewards and punishments (Fiske, 1993; Keltner, Gruenfeld & Anderson, 2003). Thus, power is a property of relationships, where one end is able to *control* the other’s outcomes, and the other end depends on the other for these outcomes.

These outcomes are not necessarily material or financial, although material resources are a highly valued, and usually necessary for survival. Power hierarchies can exist in interpersonal relationships, where one partner is relatively more dependent on the other for affection and emotional security. The less dependent partner is able to influence the other’s thoughts and behaviours to a greater extent than being influenced themselves (Anderson, Keltner, & John, 2003). There can also be asymmetries in knowledge, where one party can withhold desired information from the other, thereby influencing their thoughts and behaviour in an asymmetrical way. It becomes obvious that power's effects can be manifested only when the dependent party values the outcome, or needs it at a given moment (Overbeck, 2010). For example, if an individual depends on another for some information, and that information is no longer vital, then the withholder cannot exert power anymore.

Thus, one can see that power is dynamic and pervasive in several facets of society. Just as control over desired resources at the interpersonal level creates interpersonal power, asymmetrical possession of physical, social, and economic capital confers power asymmetries at the group level (Guinote & Vescio, 2010).

To summarize, power can be defined, in the broadest terms, as asymmetrical control over desired outcomes (Dépret & Fiske, 1999; Fiske, 1993). This definition is the basis of the operationalization of power and its manipulation in the series of experiments discussed in this thesis. I focus on interpersonal power, at the individual level, rather than on group processes. Group processes are less tractable within the confines of a laboratory experiment, especially with the use of neuroscience methodologies. Additionally, I focus on material outcomes, or monetary rewards. For human experiments, monetary rewards are an appropriate resource that can be incorporated in experimental paradigms, with a good level of ecological validity. In our current society, financial dependence is a prevalent basis for the existence of power hierarchies.

1.4 Power and control

The emphasis on control, in the current conceptualization of power, is one of the most fundamental themes that are accentuated in this thesis. I argue that understanding the psychological consequences of control and its deprivation is essential to understanding the consequences of power and subordination.

The literature on control, as a universal and basic need for individuals, has received input from developmental, social, clinical, and health psychology (Fiske & Dépret, 1996). The need for control is basic, present at birth, and essential for well-being (White, 1959; Lefcourt, 1973). The detrimental effects of control deprivation on mental health and cognitive performance may indeed suggest that a generalized need for control is central to human psychology (Fiske & Dépret, 1996).

Control deprivation has been empirically tested with a range of methodologies, which includes non-contingency between actions and outcomes, non-veridical feedback, unexpected negative events, and even naturally occurring differences in depression (Pittman & Heller, 1987).

Loss of control immediately up-regulates cognitive activity and information-seeking (Pittman & Agostino, 1989). Pittman and Heller (1987) argue that control motivation has a homeostatic character; meaning that the up-regulation of cognitive activity serves the purpose of restoring control, or at least predictability. If one lacks control, one makes an effort to understand those who have it, and pay careful attention to their environment, to be able to anticipate their actions and act accordingly.

Similarly, a tradition in the study of the consequences of power has linked lack of power to vigilance, which will be referred to as the vigilance hypothesis (Keltner et al., 2003). Early naturalistic studies displayed that low power individuals attend to others and to their environment more carefully, due to the threatening nature of their environments (e.g., Chance, 1967; Ellyson & Dovidio, 1985; Emory, 1988). The adaptive up-regulation of cognitive function, which occurs with subordination, is crucial to understanding the consequences of power.

1.5 Power manipulations

It will not come as a surprise that, over a long course of research on power, this complex construct has been operationalized and manipulated in different ways. For the purposes of this thesis, studies where individuals were chosen on the basis of existing power (i.e., real-life managers and employees) will not be discussed. I will focus on manipulations where power is allocated in the course of the experiment. It is not possible, or arguably necessary, to decide which power manipulation is the most ‘powerful’. However, it is important to keep in mind that different manipulations may have different effects on the dependent variables of interest. This may make comparison across studies quite difficult. Nevertheless, this is not a situation unique to power. In fact, most social constructs face this difficulty.

Another potential difficulty is that it may be difficult to separate power from other constructs, like status for example. If we define power as control over a desired resource, status is an evaluation of characteristics that produces differences in respect and prominence, which in part may determine resource control, or power (Blieszner & Adams, 1992; French & Raven, 1959). However, power and status may occur independently (Keltner et al., 2003), with varying effects on cognition. Dominance is the interpersonal behavior that aims towards acquisition of power, yet power can be attained without performing acts of dominance, through a fair-minded prosocial orientation (Keltner et al., 2003).

An additional constraint is that power has to be allocated randomly, but has more observable psychological consequences if it is perceived as non-random. A manipulation which is known to be allocated on a random basis runs the risk of being perceived as illegitimate. Legitimacy is important in the context of power. As will be elaborated in the section on major theories of power, the perceived legitimacy of power predicts whether subordinates will try to break the hierarchy or not (reviewed in Spears, Greenwood, de Lemus, & Sweetman, 2010). This will naturally lead to different patterns of information processing. Indeed, recent studies are showing that legitimacy moderates the cognitive effects of power that are reported in the literature (Lammers, Galinsky, Gordijn, & Otten, 2008; Willis, Rodríguez-Bailón, & Lupiáñez 2011).

A common way to manipulate power has been through the use of priming, where participants are told to write essays about a time when they were in control of a situation/others versus times when someone else had control over them (Guinote, 2007b; Smith, Jostmann, Galinsky, & van Dijk, 2008). The motivation for such an approach is that priming power is reported to have similar effects to manipulating control over outcomes (Bargh & Raymond, 1995; Chen, Lee-Chai & Bargh, 2001; Galinsky, Gruenfeld, & Magee, 2003). This method has indeed produced very interesting behavioural differences between those who wrote about times when they dominated versus took orders, which were not inconsistent with those under different power manipulations. Another type of priming involves solving scrambled sentences (Smith & Trope, 2006), where the words chosen may either prime participants with high power (e.g., authority, dominate) or with low power (e.g. obey). However, it is important to note that such a method has its limitations. Priming power may have rather untractable effects on mood and motivation, which may differ from person to person according to what experience they recalled and how big an effect it had on them at the given moment.

Several power manipulations in the modern literature are based on the clever paradigms described by Goodwin and Fiske (1995; Goodwin, Gubin, Fiske, & Yzerbyt, 2000). The first is referred to as the Springfield Evaluation Study paradigm. Participants were put on so-called evaluation committees in which they received resumés of students who were applying for an internship. In the high-power condition, participants' opinion accounted for 30% of the decision as to whether the student would be hired. In the low-power condition, the participant's opinion did not account for the decision at all. As all the applicants were fictitious, no participant was in a position of subordination.

The second manipulation, the Work Group paradigm asked students to participate in a study of task allocation in work groups, where there was a cash prize at stake. In this paradigm, participants were part of a group in which they evaluated people with both more power (allocators) and less power (executors) than themselves, as well as some power-irrelevant observers. Participants were given instructions that in work environments there are generally three types of people implicated in task-sharing: allocators, those who decide what must be done and who will do it; executors, those who execute what the allocators demand; and observers, people not really implicated in the task but indirectly influenced by it. Each person in the group, including the experimental participant, would fill each role at different times. The outcomes assigned by the powerful allocators to the powerless executors were the type of task, with different probabilities of obtaining the cash prize as a function of efficiency. This method, unlike the Springfield Evaluation Study, also placed participants in a position of subordination, rather than having high or low power exclusively.

The effectiveness of these methods stems from an ability to create, in an experimentally tractable way, different levels of outcome control, which are assigned without regard to individuals' personalities.

Another manipulation has been to allow participants to complete a bogus leadership questionnaire (Anderson & Berdahl, 2002; Guinote, 2007b); where participants are told that, on the basis of their responses, they are more suited to be a manager or a subordinate on a subsequent information-processing task. In reality, the roles were assigned randomly. The manager was allowed to evaluate the subordinates afterwards, because that was a role better suited to their personality on the basis of the questionnaire.

For the series of experiments included in this thesis, I decided to include a manipulation that is based on the definition of power as asymmetrical control over desired outcomes. I opted for monetary rewards due to the practicality of their implementation in an experimental setting. I also ensured that my manipulation of power was perceived as legitimate. A third aim was to have pre- and post manipulation measures on my cognitive dependent variables of interest. This was important due to the fact that I employed neural measures in a part of my experiments, which necessitated fewer participants (and hence lower statistical power) than would be practical in purely behavioural experiments.

To satisfy all these requirements, my manipulation went as follows: pairs of same-sex participants arrived at the laboratory, and were told that they would be competing on a task. The tasks were variations of standard cognitive paradigms, which tapped into my dependent variables of interest (attentional processes, feedback processing). They were told that scores on these tasks indicated important types of ‘abilities’, and that they should be considered as aptitude tests for different contexts (e.g., corporate world, army). They were told that the better player, based on a higher score, would earn the title of ‘boss’ or ‘commander’. The privilege of the winner would be the following: he or she would be able to allocate the joint winnings on a subsequent session of the task, with no constraints whatsoever on how this communal resource would be split between the two players, and regardless of how much each would contribute to this resource. In reality, no scores were calculated. The 'winner' was chosen randomly from the pair prior to the experimental session, but was told that they had a 2% or 3% higher score than the other player. In this manner, a power hierarchy was created based on the definition of power as asymmetrical control over a desired resource. Power was randomly assigned, but perceived as non-random. In a pilot study, post-manipulation questionnaires indicated that the manipulation was perceived as legitimate and fair.

1.6 Influential social psychological theories of power

1.6.1 Early approaches

One of the most cited frameworks of power comes from the seminal studies conducted by French and Raven (1959), who identified different bases, or forms of social power. According to this theory, agents of change include not just individuals and groups, but also norms and roles. Social influence can be observed as the outcome of the exertion of social power from one of five bases: reward power, coercive power, legitimate power, expert power, or referent power. These bases differ according to how observable the power differences within their context are, and how dependent the power is on structural conditions; i.e., the degree of internalization that occurs in the subordinates. Power conferred under these different bases results in different patterns of interpersonal processes.

In the same year, Thibaut and Kelley (1959) offered an interesting perspective on power from the angle of social interdependence. They introduced a framework that looked at social interdependence in interacting social dyads, by making use of pay-off matrices that conceptualized their response repertoires. Thus, in a given relationship, a person's power depended on the desirability of the alternative relationships they could enter. The authors made a distinction between fate control and behaviour control, where power-holders monopolized the outcomes and behaviour, respectively, of others.

These early theories had an important influence in conceptualizing and categorizing the complex concept of power, which persisted in the current literature and inspired current theories and approaches.

1.6.2 A Social Identity perspective

Social identity theory (SIT) (Tajfel & Turner, 1976) and self-categorization theory (SCT; Turner, 1982, 1985; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987) have inspired important contributions to the study of power. The theories are commonly referred to as the social identity perspective. According to this perspective (Turner, 2005), power does not stem from an individual’s internal qualities, or from their ability to confer resources, but rather from the person’s perceived position of intra and intergroup relations that define the identity of the group. It is argued that standard definitions of power conflate all types of influence into one of resource dependence; and that, in reality, people gain power not by possessing resources, but because they represent or stand for something, or are perceived to do so by at least some individuals. This, in turn, leads to asymmetries in resource allocation. This theory presents the opposite view from the standard perspective where influence stems from resource control.

Ng (1980) was a pioneer in the investigation of power within a social identity perspective. In this conceptualization, it was suggested that power, or control over resources, can be translated into favourable outcomes for one's group through in-group bias. To show this, participants were divided into groups to compete over a scarce resource. A calculator was identified as a "power tool", which was necessary to complete the experimental task. A committee was created which would allocate calculator time to the competing groups. In a politically plausible scenario, some of the groups had a majority representation on the committee, while others had a minority representation. The committee members who were part of the majority can thus be considered the more 'powerful'. It was found that these members allocated more calculator time to the groups they belonged to. This is a favourable outcome of power for the ingroup, where power is seen as a construct that cannot be divorced from the social identity of individuals.

For SIT theorists, legitimacy is a crucial element which provides constraints that justify power hierarchies, and predicts how they are maintained or defeated (Spears et al., 2010). Illegitimate power relations foster intergroup conflict, competition, and in-group bias among the different groups within a hierarchy.

1.6.3 Power as Control

One of the most influential theories of power, as it relates to person perception, is Fiske's Power as Control Model (Fiske, 1993; Fiske & Dépret, 1996; Goodwin et al., 2000)

This theory is consistent with earlier work on the social consequences of control deprivation and outcome dependency (Berscheid, Graziano, Monson, & Dermer, 1976; Pittman & Agostino, 1989), and describes how power can predict the extent to which people want to learn about others in social relationships. This theory has important contributions on how power affects the way attention is distributed among individuals in social hierarchies.

The theory, in short, states that in the default state, attention travels up the power hierarchy. Power-holders are disinclined to make an effort in thinking about subordinates, but subordinates are motivated to attend to the power-holders. This leads to differences in person perception, where power-holders, in general, are engaged in an asymmetrical stereotyping of subordinates

The theory starts by describing power-holders, indicating that they are prone to ignoring diagnostic information about others, due to a mutually reinforcing interaction between power and diminished attention, which occurs for three reasons:

1) Power-holders do not need to attend to subordinates because their outcomes do not depend on them
2) They may not be able to attend to them because their attention is typically overloaded
3) Power-holders may have a high need for dominance and may not be motivated to attend to others

The second part of the theory suggests that power-holders may even be inclined to stereotype subordinates *by design;* i.e., purposely attending to stereotype-consistent information about them (Goodwin et al., 2000), due to a motivation to maintain the status quo.

For complementary reasons, subordination up-regulates vigilance in social relationships. A social form of control deprivation is concern with outcomes that, partially at least, are controlled by others. Subordinates need and are motivated to attend to power-holders, in order to regain some predictability over an uncertain fate. Thus, they seek individuating information about them, and pay careful attention to their choices and actions.

Empirical evidence for this theory was received through experiments that employed the Springfield Evaluation Study paradigm and the Work Group paradigm, which are described in the previous section on power manipulations. Briefly, participants view descriptions of individuals who are either higher, lower, or equal in power to themselves. These target individuals were referred to by membership of a category (e.g., gender, nationality). Some of the descriptions conformed to the stereotypes of the category, while others were stereotype-inconsistent, which can be described as individuating information. By measuring the amount of time participants spent on processing each description, the experimenter could gauge the amount of attention participants allocated to stereotype-consistent or inconsistent information as a function of their power level. It was found that in the default state, power-holders are prone to default to stereotyping subordinates, without paying much attention to individuating information.

1.6.4 Power, approach, and inhibition

A well-cited theory in the field, with broad implications on cognition and behaviour, suggests that high status and power are associated with approach behaviour, while low power is associated with inhibitory behaviour (Keltner et al., 2003). This is largely based on the theory postulated by Gray (1987; 1991) that proposes two interacting motivational systems: the behavioural approach system (BAS) and the behavioural inhibition system (BIS). While the BAS regulates behaviour associated with rewards, such as the acquisition of food, sex and money, the BIS acts as an alarm system that is triggered by signals of potential punishment and inhibits behaviour that may lead to aversive or harmful outcomes.

Research has mainly focused on individual differences in BAS or BIS activation (Carver & White, 1994). However, Keltner et al. (2003) make the suggestion that social status can also influence the relative balance between approach and inhibition. In short, they suggest that high power activates approach-related processes, while low power activates inhibitory processes. The reason partly lies in the association between high power and relative ease of access to rewards, leading to an ability to approach these rewards. In addition, the powerful are less dependent on others to acquire these rewards, reducing any potential obstacles to attaining these rewards. One the other hand, those with low power are more inclined to inhibit approach behaviour. These low-status individuals lack access to material and social resources and experience more social threat and punishments. A major threat and constraint is the threat of being evaluated unfavourably by those having higher status. Because the environment of people with low status is characterized by a high degree of threat and limited access to rewards, they are more inclined to inhibit reward-seeking approach behaviour.

This is a theory with broad implications, where approach and inhibition can be associated with a range of characteristics, tendencies, and behaviours (Keltner et al., 2003). This theory has been gaining incremental support through a wide range of studies where power is allocated through priming or other manipulations, and associated with approach or inhibition related characteristics. Power-holders were shown to be more action-oriented (Galinsky et al., 2003), or more prone to act in order to achieve certain goals. They were more likely to take a card in a simulated game of blackjack, act against an annoying stimulus (a fan), and to action in a social dilemma. Power-holders were also shown to be more optimistic about risk and more prone to act in a risk-seeking manner (Anderson & Galinsky, 2006).

In more recent support for this theory, from a neural perspective, it has been suggested that the experience of power directly activates the motivational systems in the brain that regulate approach behaviour (Boksem, Smolders, & De Cremer, 2009). High-status participants showed a greater relative activation of left frontal–cortical areas, which have been specifically related to approach behaviour (Harmon-Jones & Gable, 2009).

1.6.5 The Situated Focus Theory of Power

The Situated Focus Theory of Power by Guinote (2007a, 2010) also derives its predictions from the fact that the need to control the environment is a basic need, and it leads to several hypotheses about the effect of power on cognitive functions. The theory argues that power affects processing focus. Power-holders process information more selectively in line with the primary constructs activated on a moment-to-moment basis. These constructs can be linked to goals, needs, subjective experiences, and information present in the environment. Furthermore, power-holders are flexible in their deployment of cognitive resources, and rely on more variable cognitive styles to guide their judgment and behavior. For example, depending on the task and how motivated power-holders are to engage in it, they can rely on heuristics or on deliberate forms of processing. Powerlessness, on the other hand, is associated with an indiscriminate information-processing style that is rather insensitive to the situation, leaning towards the more effortful side of the spectrum. These effects are proposed to extend to attention, memory, and reasoning.

These differences are proposed to arise from the different control needs, affordances, and constraints faced by power-holders and subordinates. Power-holders have more freedom, depend less on others, allowing them to focus on what is most pressing in the given situation. Due to the constraints and evaluative threat faced by subordinates, they are forced to pursue multiple goals and attend to multiple sources of information, which impairs their ability to focus.

Thus, they are proposed to be less able to distinguish between relevant and irrelevant information.

This theory can explain the discrepant results that are sometimes reported in the case of power. By concentrating on the different processing styles of power-holders and subordinates, it becomes possible to predict what changes emerge at the level of behaviour by taking into account the specific environmental circumstances and goals.

The Situated Focus Theory of Power has been gaining support through a range of well-controlled behavioural studies that rely on established paradigms from the cognitive psychology literature (e.g., Guinote, 2007b; Willis et al., 2011). The findings from these studies are elaborated in later sections on the effect of power on cognitive processing. In summary, however, participants allocated to positions of high power generally out-perform those allocated to positions on low power on tasks that require focus and inhibition of irrelevant information, demonstrating that power promotes processing focus in line with the demands of the situation. Subordination, on the other hand, leads to an inefficient and indiscriminate way of information-processing that proves detrimental for tasks that require focus.

1.6.6 A neurobiological perspective

The investigation of power from a neural perspective is still in its infancy, with diverse paradigms and approaches, in both human and animal studies. These studies are encompassed within the sphere of social neuroscience, which is already a result of the merging of two fields: social cognition and neuroscience.

A neural theory of power can define, for example, whether brain structure and function varies with different levels of power. Another benefit of neuroscience would be to employ what we already know about the neural underpinnings of cognition and behaviour to dissociate conflicting theories of power from social psychology and social cognition. The former aspect already has some input from neuroendocrinology and electrophysiology. The latter perspective is likely to receive greater attention from future studies.

Testosterone and cortisol have emerged as possible players in regulating the neuroendocrinology of power. Testosterone regulates masculine characteristics, and is associated with aggression. It was shown that a manipulation of power increased baseline testosterone levels, compared to subordination (Carney, Cuddy & Yap, 2010; Rivers & Joseph, 2010). Subordination, on the other hand, has been associated with a propensity to experience illness, and an increased level of cortisol, a stress hormone (Marmot et al., 2010; Sapolsky, 2004). The situation is reversed with power, which has been associated with decreased cortisol reactivity to stressors. It is complex to determine the causal pathways among hormones, behaviour, and the environment. It is likely, however, that these hormonal changes have an influence in creating appropriate conditions for power-holders in maintaining an influence on subordinates.

There is also emerging evidence of differences in brain activity between power-holders and subordinates. One neurotransmitter that might be relevant in the context of power is dopamine, which has important roles in motivation, learning, goal-directed action, and reward-seeking (Flaherty, 2005). Primate studies have shown an increased level of dopaminergic activity in superordinate brains (e.g., Kaplan, Manuck, Fontenot, & Mann, 2002; Morgan et al., 2002). In a very interesting study, Morgan et al (2002) allowed primates to be housed individually or in groups. Naturally, in the apes housed in groups, dominance hierarchies emerged. PET studies showed more D2 receptors for superordinate apes, indicating increased levels of dopamine activation. Interestingly, subordinate apes showed relatively greater propensity to self-administer cocaine when given the opportunity to do so. This finding is in parallel to research on human studies showing a larger degree of drug consumption in individuals at the bottom of the social hierarchy (Lemstra, 2008). This study has interesting implications, and poses questions about the self-reinforcing cycles between environmental constraints and the affordances of the environment.

Further evidence comes from electrophysiology. In a human study where power was induced by priming, EEG recordings showed left-lateralized activation in power-holders, and right-lateralized activation in subordinates (Boksem et al., 2009). The literature on hemispheric differences is wide and varied. It has been suggested that left sided dominance is associated with approach behaviour, whereas right sided dominance is associated with increased inhibition behaviour (Amodio, Shah, Sigelman, Brazy, & Harmon-Jones, 2004). The right hemisphere is also associated with vigilance and the processing of new situations (e.g., Goldberg, 2009). The lateralization question was also explored by a behavioural study (Wilkinson, Guinote, Weick, Molinari, & Graham, 2010). Power-holders and subordinates were told to balance a small tray and walk down a narrow passage. It was observed that subordinates showed a larger tendency to bump on the right side of the passage, indicating a preference for the left visual field, which in turn indicated right hemispheric lateralization. A control condition showed that these differences were induced by the subordinates. Although these studies are still part of a young field, they are not inconsistent with Keltner's theory of approach and inhibition. There is also support for the notion that subordination, or lack of control, provokes changes that may arise in the proposed differences at the level of behaviour between power-holders and subordinates.

1.7 The effect of power on cognitive processing

Power has an effect on an individual's mental world, whereby those who lack it and those who possess it perceive their environment and react to it in very different ways. Evidence of this claim does not come solely from the field of social cognition. In fact, an interesting line of evidence comes from evolutionary and cross-cultural psychology (reviewed in Guinote, 2007a). It has been suggested that societies or groups with fewer constraints, like hunter-gatherer societies, exert themselves more over their environment, show more processing selectivity than those who belong to agricultural societies, who tend to be more reactive to their environment (Berry, 1976; Kitayama, Duffy, Kawamura & Larsen, 2003; Witkin, Dyk, Faterson, Goodnenough, & Karp, 1962). Comparable evidence comes from research showing that societies that have greater freedom deploy their attention and memory in a more selective way than those who do not (Kitayama et al., 2003). Thus, different levels of power, with the different environmental affordances and constraints they ensue, can fundamentally alter an individual’s mental world. In this thesis, I will start by describing the effect of power on basic cognitive processes, and lead on to how these processes have effects that emerge at the level of observable social phenomena.

In the proliferating research on social cognition, power has been, so far, investigated in relation to a heterogeneous mix of dependent variables. It becomes clear that power affects both processes and content of the mind (Guinote, 2013). In other words, power affects the *way* information is processed, and *what* is being processed. For example, power-holders are proposed to focus attention more narrowly than subordinates (Guinote, 2007a); whereas the content of their working memory is more reward-related than that of subordinates (Keltner et al., 2003).

If one takes a quick glance at the power literature, there is an impression that, put simply, subordination is ‘bad for the brain’. In a seminal paper (Smith et al., 2008), the authors convey a straightforward and gloomy message through the paper’s title: “Lacking power impairs executive functions”. Executive functions encompass a wide range of cognitive processes; like planning, inhibition, and updating of information in working memory (Miyake et al., 2000). The paper conveys a pessimistic message that simply being put in a position of subordination somehow allows individuals to under-perform on a wide range of cognitive tasks compared to their more powerful counterparts. This was concluded from a series of experiments in which power was manipulated with different methods, like priming and assignment to managerial roles (as explained in an earlier section on power manipulations). Then, participants performed tasks that tapped into these executive processes, like the Stroop task (inhibition), tower of Hanoi (planning), and the n-back task (updating). In all of these studies, participants who were assigned to the low power position performed worse than their powerful counterparts. It seems like a dreary vicious cycle: subordination leads to weaknesses that may reinforce the position of subordination, and people stay in their place. The literature on power and attention (Guinote, 2007b; Willis et al., 2011) paints a similarly discouraging image, whereby subordinates are less adept than their powerful counterparts at orienting attention and inhibiting unwanted information. In a consistent manner, a recent study showed that a temporary elevation of a person's sense of social power can increase their math performance, possibly by reducing cognitive interference (Harada, Bridge, & Chiao, 2013).

It will not come as a surprise that, quite consistently, control deprivation is classically proposed to be detrimental for cognitive task performance. The information-processing model of learned helplessness (Kofta, 1993; Sędek & Kofta, 1990; Sędek, Kofta, & Tyszka, 1993) proposes that in an uncontrollable situation people engage in intensive but inefficient cognitive work. After a prolonged experience with no observable effect, participants would experience cognitive exhaustion, and resort to simplistic schemas of information processing. In such paradigms, control deprivation is induced by giving participants very difficult tasks, and the cognitive and emotional consequences are similar to what is observed in learned helplessness paradigms (Seligman, 1991). It is important to keep in mind that social subordination cannot be completely equated with control deprivation and learned helplessness. Many of the cognitive effects of subordination are provoked by a desire to regain control over outcomes, although prolonged subordination might lead to learned helplessness.

If one were to try and determine, from the available literature so far, what type of cognitive function is 'impaired' by subordination, the answer seems to involve processes that require some kind of top-down control. Cognitive processes are, however, complex and multi-faceted. It may be overly bold to claim that lack of power simply impairs all executive functions by deducing this from a series of behavioural studies. For example, a basic ability to detect conflict and override unwanted responses primed by visual stimuli also falls under the domain of executive control (Posner & Petersen, 1990). These processes may occur quite early in the information-processing stream, and require sensitive measures that may not appear clearly at the level of behaviour. It is yet unclear whether such basic processes are sensitive to power.

Additionally, after looking more closely at the literature, it becomes clear that there is also evidence for tasks which subordinates excel at. Evolution could not have been so cruel. There is evidence, for example, that subordinates actually out-perform power-holders on tasks requiring simple perceptual discrimination (Weick, Wilkinson, & Guinote, 2011). So what makes subordinates perform well on some tasks, and badly on many others?

As I argue in this thesis, the answer seems to lie in their hyper-vigilance (Keltner et al., 2003; Guinote, 2013). The positive relationship between subordination and vigilance receives support from both the animal and human literature (Keltner et al., 2003; Guinote & Vescio, 2010). Those who lack power are faced with a relative excess of situational constraints and difficulties. They are deprived of the need to have a sense of agency in the way their fate unfolds, and a need to have a sense of predictability over their outcomes. As an adaptive mechanism, they broaden their attentional windows to 'take in' as much information as necessary, in the hope that they will learn something that may confer some predictability (Guinote 2007a). What follows is an intuitive example from the social domain. Suppose that an employee faces an imminent decision as to whether her contract will be extended or terminated. This person definitely lacks power to a great extent, as her outcomes are under the control of an external agent. This situation is daunting, as it may be important to look for a new job, or deploy resources elsewhere. The adaptive step would be to watch out for multiple sources of potentially useful information: the boss's body language, the meaning behind statements, the situation of the company, or any other behavioural patterns in individuals that may have an impact on the contract. It is suggested that, in this manner, people who lack power face more difficulties than powerful people in discriminating information that is relevant from information that is irrelevant to the current situation (Guinote, 2007a). However, a point that will be referred to throughout this thesis is that broadening attentional windows is generally adaptive. Choosing what information to process also requires cognitive resources; which may put individuals at the risk of missing out on an important piece of information.

Of course, there is a down side, which probably explains the negative relationship between subordination and cognitive performance in general. The employee has to engage in this activity in addition to her other jobs and responsibilities. As cognitive resources are quite limited, there can be too much of a 'good' thing. Up-regulation of thought processes and vigilance can be detrimental when focus is necessary.

The link between subordination and environmental vigilance will be returned to at several points in this thesis.

1.7.1 Power and basic attentional processes

There is an infinite amount of information present in an individual's current environment, and in their memories and schemas. The characteristics of an individual's experience, at any moment in time, are shaped by the specific information which is selected for further processing (James, 1890). Since our cognitive capacities are limited, only small amounts of that information can be selected. This is determined by sensory characteristics of the environment itself, in a bottom-up fashion, or by diverse types of top-down mechanisms. For example, a red ball among green ones captures attention in a bottom-up fashion. When it comes to looking for a face in a crowd, top-down factors like goal intentions and expectancies guide attention selectively, such that relevant information receives more extensive processing than irrelevant information (Posner & Snyder, 1975; Yantis, 1998). Selective information processing has an important role in giving meaning and facilitating interaction with an individual's environment (Posner & Snyder, 1975).

Several processes are encompassed in the sphere of attention. A classic way to conceptualize such a complex construct is the three-network system proposed by Posner and Petersen (1990): alerting, orienting, and executive control. Alerting is involved in maintaining an appropriate sensitivity and vigilance to perceive and process stimuli. The orienting network involves the selection of information from among numerous sensory stimuli, while the executive control network specializes in conflict resolution and voluntary action control. These systems, although independent, also interact in important ways.

There is evidence that power has an effect on all of these systems (Willis et al., 2011). In other words, power affects the way in which people can orient their attention to different parts of the environment. Power can also affect the extent to which participants can inhibit information that they do not deem useful. Also, as elaborated in previous sections, power affects the extent to which people can regulate vigilance, which is corroborated from both human and animal literature (Keltner et al., 2003).

1.7.1.1 Orienting

An important function of attention is to orient processing to desired locations of the visual field (Posner & Dehaene, 1994). Once orienting happens, the perception of targets at the required destination is enhanced. There is evidence to suggest that power-holders are better able to orient their attention to specific spatial locations than are powerless individuals (Slabu, Guinote, & Wilkinson, 2012). Namely, when presented with spatial cues that were either valid or invalid, power-holders were better able to correct the misinformation provided by the wrong cues than subordinates. In a somewhat consistent fashion, it was shown that power-holders were better able to use orienting cues to resolve attentional conflicts (Willis et al., 2011). Namely, when orienting cues directed attention to a location in space where a response to a stimulus with perceptual incongruency was required (i.e., an arrow surrounded by distractor arrows pointing in a different direction), power-holders responded better than subordinates to the incongruent stimulus if their attention was cued to that location.

But can we conclude that power affects the orienting function of attention directly, whereby high power automatically triggers an enhanced ability to allocate resources to the appropriate locations in space? It would be interesting to explore whether power affects this function specifically, or whether such results may come about due to task difficulty and/or interaction with other attentional processes. This is an issue that is explored in Chapter 3 of this thesis, where an orienting task is presented in a context where distractor stimuli compete for attention, or without any distractors. It could just be that the up-regulation of cognitive function experienced by subordinates becomes detrimental when a task requires focus and inhibition, and beneficial when the task is simple, regardless of the type of attention probed. As discussed, evidence for subordination and environmental vigilance is abundant in the field (Keltner, 2003; Guinote & Vescio, 2010), and could provide necessary explanation for the effect of power on tasks that require attention, including orienting.

1.7.1.2 Inhibition

The possible links between power and inhibition have received more attention than the relationship between power and orienting. Inhibition is a crucial function for survival, and also encompasses a broad range of functions. In order to select environmental stimuli for further processing, it is also important to inhibit irrelevant information to prevent it from affecting behaviour in maladaptive ways. Recent studies suggest that power-holders may be at an advantage, compared to subordinates, when inhibition of information is necessary (Guinote, 2007b; Smith et al., 2008). Given the previous discussion, it may be the case that the difference comes about due to subordinates' propensity to up-regulate their cognitive activity, processing information that had better stay inhibited (Guinote, 2007a). Some of the first studies in this domain (e.g., Guinote, 2007b) were conducted under the hypothesis that power promotes processing selectivity, and are better able to ignore, or inhibit, peripheral information. Using a standard manipulation where individuals were assigned either to a manager or subordinate role, participants were presented with objects on a computer screen. The objects (cups, etc.) had handles that offered grasping opportunities, made easier using either the left or the right hand. The objects were either upright or inverted, and the task was simply to determine that by using either the right or left hand.

Past research (e.g., Tucker & Ellis, 1998) indicates that individuals are slower to respond when the response hand and the objects are in incompatible positions, compared to when they are in the same position. This study showed that subordinates experienced more interference than power-holders when the handle was in the opposite direction to the response hand. It was interpreted as a situation where power-holders were better able to focus on the relevant aspects of the situation and inhibit those that were not.

In a famous series of studies that demonstrate a debilitating effect of subordination on a diverse set of executive functions (Smith et al., 2008), participants performed a version of a Stroop task (Stroop, 1935) after being primed, by a set of anagrams, with high, low, or neutral power. The results showed that low power-primed individuals faced more Stroop interference, being relatively slower on incongruent trials where the word and the colour were different.

Moving to the auditory domain, in a recent study, participants were assigned to a manager or subordinate role, and performed a dichotic listening task (DeWall, Baumeister, Mead, & Vohs, 2010). In this type of task, participants monitor information coming through one ear, and ignore information presented to the other ear. Power-holders showed less interference from the unattended ear, which suggests greater attentional control in the ability to inhibit unwanted information.

The literature on power and inhibition seems fairly consistent: power-holders have superior abilities to inhibit unnecessary information. However, if that were the case in all instances, one would expect power-holders to out-do subordinates on tasks that employ the Flanker paradigm (Eriksen & Eriksen, 1974), for example. In this sort of task, target arrows that prime one response tendency are surrounded by distractor arrows that point either in a congruent or incongruent direction. In the latter case, responses are slower or incorrect. One would expect subordinates to be more influenced by the distractor arrows. So far, evidence for this is not clear-cut. Willis et al. (2011) show that power-holders outdo subordinates on this task only when orienting cues point them to the direction where the stimuli are. Without manipulating the orienting function, power-holders and subordinates do not differ.

The relationship between power and inhibition is explored further in Chapter 4 of this thesis, which draws on the cognitive neuroscience literature. By devising a relatively simple task that requires conflict detection and inhibition, based on the Flanker paradigm (Eriksen & Eriksen, 1974), combined with EEG recordings, it becomes possible to explore in more detail the effect of power on early inhibitory processes. The use of EEG provides a precise measure of early cognitive processes that may not appear at the level of behaviour, and may help disentangle the conflicting results in the literature.

1.7.2 Power in society

Classically, it has been common to cast power in a negative light (e.g., Kipnis, 1972). There is considerable evidence for a “dominance perspective” on power, which indicates that power is negative regardless of the way it is exercised (Overbeck, 2010). A large number of treatises on power refer to the famous quote by Lord Acton (1865):

"Power tends to corrupt, and absolute power corrupts absolutely. Great men are almost always bad men."

It is easy to subscribe to this view due to many examples from history of monarchs and politicians who wielded their power for selfish means. This is also corroborated by several lines of research, famously, the work of Kipnis (1972) who described the corruptive effects of power, and how those who wield power tend to manipulate others and use them as means to their ends.

This black picture of power seems to persist in the current social psychology literature, which, combined with the findings from the cognitive domain, is creating psychological prototypes of a power-holder and subordinate. The power-holder emerges as a sort of evil genius: a manipulator who can, as explored in previous sections, deploy cognition in sharp and focused ways. This stands in contrast to the image of the subordinate as a scatter-brained, empathic, and distressed individual.

Recent findings in social psychology have associated power with aggression and teasing (Keltner et al., 2003), and a default tendency to stereotype others (Fiske, 1993). Power-holders also “turn a blind eye to the suffering of others” (van Kleef et al., 2008), and even objectify their social targets (Gruenfeld, Inesi, Magee, & Galinsky, 2008). Power-holders are also described as poor perspective takers (Galinsky, Magee, Inesi, & Gruenfeld, 2006). A very interesting study probed the question of perspective taking by asking people assigned to high or low power roles to draw the letter “E” on their foreheads. It was found that high-power individuals drew the letter from their own perspective (which appeared as a mirror image of ‘E’), failing (or refusing) to take into account the perspective of the person watching them.

In general, power is said to change the way people perceive themselves and feel about their abilities in ways that can be described as self-serving, vain, and narcissistic. As reviewed by Guinote (2013), power is associated with pride (Schmidt Mast, Jonas & Hall, 2009), high self-esteem (Wojciszke & Struzynska-Kujalowicz, 2007) and confidence in one's judgments. Power-holders can misattribute successes to their own abilities, rather than the task or circumstances (Georgesen & Harris, 1998). They also view their persona as a coherent and consistent whole, compared to subordinates (Kraus, Chen & Keltner, 2011).

While there may be some truth to the prototypes, it comes as no surprise that the social psychology literature is not as uniform and consistent as some would find convenient. There are several examples one can think of where leaders are adept at taking the perspective of others, and exert their efforts for the good of others than for their own good. From an evolutionary perspective (e.g., Caporeal, 2004), power evolved to resolve social coordination problems that evolved in early societies. Leaders were necessary to maintain cohesion and peace within the group, resolve conflicts with other groups, and make decisions regarding relocation and movement (Van Vugt et al., 2008). There is also recent research showing that individuals who see power in terms of social responsibilities act more pro-socially when given power (e.g., Chen, Lee-Chai & Bargh, 2001). A more reasonable suggestion is that the disruptive effects of power are highly situational. It has been reported that when power was tenuous due to instability within the hierarchy, leaders high in dominance motivation prioritized their own power over group goals (Maner & Mead, 2010). This did not occur when dominance orientation was low, or when the power hierarchy was perceived as stable. Consistently, it has been suggested that a general state of disinhibition, which is said to occur with power (Keltner et al., 2003), can produce both prosocial and antisocial consequences (Hirsh, Galinsky, & Zhong, 2011).

In the end, there is nothing ‘magical’ about power. These discrepant findings likely occur because they reflect correlations of power with end-results of interactions between cognitive processes and environments. Power occurs in a rich context of relationships and resources, and its results are determined by the diverse interactions between them.

Another point, which is a central theme in this thesis, is that it might be misleading to look at the effects of power by focusing on the power-holder, although it is quite interesting that those who possess power receive a lot of attention to begin with. Many of the effects that occur in experiments with power dyads might be driven by subordination, rather than by power. The fact that subordination up-regulates cognitive activity is a simple yet surprisingly explanatory way for describing the different ways power-holders and subordinates act in society.

The equivalent of control deprivation, in a social type of setting, is subordination. It is a situation where one individual completely depends on the other for certain desired outcomes. Even if not explicitly investigated within the context of power and subordination, it was observed quite a few decades ago that asymmetrical outcome control between individuals has observable and interesting effects. In one of the pioneering studies in this domain by Berscheid et al. (1976), participants expected to date one of three people they could observe on a videotape, with varying degrees of dependence on them for their dating outcomes. When dependence on the prospective date was great, participants attended to them to a greater extent, remembered more information about them, and made more dispositional inferences about them.

Erber and Fiske (1984) investigated person perception in a scenario where task outcome dependence was manipulated, by allowing a participant to perform a creativity task together with a confederate, after which they were judged either together with the confederate or independently. They were told that the confederate was either competent or incompetent, and were then given some statements to read about them. Outcome dependency increased the level of information-seeking about the other, and increased the amount of attention to expectancy-inconsistent information.

1.7.4.2. Power and social attention

Fiske (1993) laid the groundwork of the literature on power and social attention by showing that, in the default state, power-holders are less inclined to attend to subordinates than vice versa. As a result, power-holders resort to heuristic processing and are prone to stereotype subordinates, whereas subordinates are motivated to seek individuating information about power-holders. There has already been some indication of these effects in earlier literature (e.g., Chance, 1967; Ellyson & Dovidio, 1985). For example, Henley and La France's (1984) "subordination hypothesis" proposes that women have less power, and are therefore more vigilant than men. As a consequence, women judge others' nonverbal behavior more accurately and express themselves more clearly.

While seemingly consistent with a sinister picture of power, the 'Power as Control 'theory (Fiske, 1993) offers some hypotheses regarding situations in which asymmetrical attention can be reduced or avoided. Namely, it is stated that power-holders attend less to power-holders because they can afford to, because they may be occupied with other responsibilities that come with power, and because they may generally be less motivated to do so. One can conceive, therefore, that if power-holders are not too cognitively burdened and are motivated to do so, they may be as adept in attending to subordinates as subordinates are in attending to them

The view that power-holders have a great deal of flexibility in their social attention is championed by Overbeck and Park (2001, 2006), describing power-holders as goal-focused, using social schema in ways that facilitate the attainment of their goals. It might be surmised that the generally-negative view that power-holders neglect subordinates may come about due to a bias in experimental procedures and experimental hypotheses. Overbeck and Park (2006) showed that, in an experimental setting simulating the atmosphere of an organization, power-holders were more able to extract individuating information about subordinates if people-centered goals were emphasized over product-centered goals. The authors claimed that power-holders were flexible and goal-oriented, rather than heuristic and automatic.

Guinote's (2007) 'Situational Focus Theory of Power' also offers a more flexible approach, saying that power endows its holder with a freedom from constraints, in order to pursue their most relevant goals at any one point. This can be manifested in pro-social or selfish means depending on the factors driving the situation at that given time.

1.4.4.3. Power and memory

An investigation of how power affects memory is tightly linked to how power affects attention. Attention determines what is encoded; whereas prior knowledge, or memories, structure and assign relevance to incoming information, guiding attention towards useful indormation (Chun & Turke-Browne, 2007). If attention is divided among too many environmental stimuli, memory for those items is sub-optimal (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996).

It is important to consider, however, that power occurs in the midst of affective and motivational factors, which also bias attention and memory in important ways. The moment-by-moment way in which these factors unfold has direct impact on the way information processing occurs, shaping individuals' thoughts and behaviour.

The final part of this thesis explores how power affects memory for social information, by varying the importance of information, and the degree of motivation individuals have in attending to each other.

It becomes clear that construing power and social attention in black and white terms may be misleading. The manifested effects of power vary depending on a host of interconnected social roles and motivations, which are fascinating to explore.

1.8. Conclusion

Power-holders and subordinates both live in challenging worlds, although the challenges are of a different sort. The primary aim is to survive. Our cognitive systems have evolved to meet the challenges in the best possible way, to reduce harm and maximize benefit. A power-holder's superior performance on an executive task, and a subordinates' more accurate characterization of a power-holder, are both consequences of adaptive changes in cognition to suit their immediate needs.

This thesis explores the possibility that a simple mechanism lies at the basis of many consequences of power. Namely, that the up-regulation of cognitive function and hyper-vigilance experienced by subordinates can get manifested in a variety of ways, resulting in personality and behavioural differences between power-holders and subordinates. This idea would stem from earlier literature on control deprivation and outcome dependency.

In this thesis, a tractable power manipulation with rigorous methodology is employed to explore the fascinating and variable ways in which power affects cognition. Chapter 2 is a broad methodological chapter that focuses on electrophysiological recordings and what type of information they can indicate about cognitive functions. In Chapter 3, the effect of power on attention orienting is investigated by varying the degree of task complexity. In Chapter 4, executive attention and performance monitoring are explored with the use of a dual EEG paradigm. In Chapter 5, the effect of power on memory for social information is investigated in a contextualized and interactional scenario. The final chapter, Chapter 6, reviews the findings and discusses them in the light of the theories and hypotheses presented in this chapter. The findings at the level of basic cognition and social behaviour are unified into a coherent role, and future research streams are suggested that can shed some light on power.

2 Chapter 2: Methods

2.1 Electro-encephalography

This chapter is concerned with describing, in brief terms, the theory and practice behind human electro-encephalogram (EEG) recording, which is used in two of the experiments described in this thesis. After a description of EEG physiology, the chapter continues with how event-related potentials (ERPs) are derived from the continuous electrical activity, and the advantages and disadvantages of using this method to understand human cognition and behaviour. The final section describes the use of EEG from the perspective of social neuroscience experiments, where data are collected simultaneously from pairs of interacting individuals.

Electrical signals from the human brain were first recorded by Hans Berger (1929). Although one of his aims was the study of telepathy, his study established one of the most important tools for measuring human brain activity, the EEG. EEG provides a measure of on-going neural activity, which appears as small voltage fluctuations recorded at the scalp with electrodes. Many decades of research have established the EEG as an important method in cognitive neuroscience and clinical studies. From this chapter, it will become apparent that the EEG serves as a good window to the mind, although, like every other method, it is compromised by technical limitations (Nunez & Srinivasan, 2006).

2.2 EEG Physiology

It is assumed that EEG signal is a distant manifestation of the activity of populations of neurons within the brain. This activity can be recorded from the scalp (via electrodes) because the tissues between the source and the scalp act as volume conductors (Cacioppo, Tassinary, & Berntson, 2000). As will be elaborated, the recorded signal reflects a very selective portion of on-going activity, biased towards post-synaptic potentials from predominantly cortical pyramidal neurons (Luck, 2005).

Electric signals travel along neuronal networks in two different ways, action potentials and post-synaptic potentials (PSPs), both of which contribute to information processing. However, it is commonly believed that EEG signal reflects the summation of PSPs rather than action potentials (Allison, Wood & McCarthy, 1986). Action potentials are active and regenerative sharp all-or-none potentials (1 msec) that propagate along the axon from the cell body to the axon terminal, where they initiate the process of neurotransmitter release. Post-synaptic potentials (PSPs) result from the ionic changes across the post-synaptic cell membrane, and this occurs when neurotransmitters bind to the post-synaptic receptors. These synaptic inputs can be of two types: those that make it easier for the target neuron to fire an action potential (Excitatory PSPs) due to the influx of positive ions, and those that act in the opposite manner (inhibitory PSPs), due to the influx of negative ions or efflux of positive ions. PSPs cover a longer time-course than action potentials, usually 10-100 msec (Kandel, Schwartz, & Jessel, 1991).

When EPSPs occur, current flow across the proximal dentrites (close to the cell body) allows the accumulation of positive charges inside and negative charges outside the neuronal space. The current forms a loop when, at the apical dentrites, negative charges are accumulated inside the neuron, and positive charges are accumulated outside the neuron. This creates an extracellular voltage difference along the axis of the neuron (Figure 2.1). Thus, every neuron can be thought of as a *dipole* with a specific voltage and orientation. A dipole is a simple electrical field caused by adjacent positive and negative charges thorough which current flows. The strength of a dipole's electric field is weakened with distance, which implies EEG recordings favour superficial sources in the brain (Hämäläinen et al., 1993).

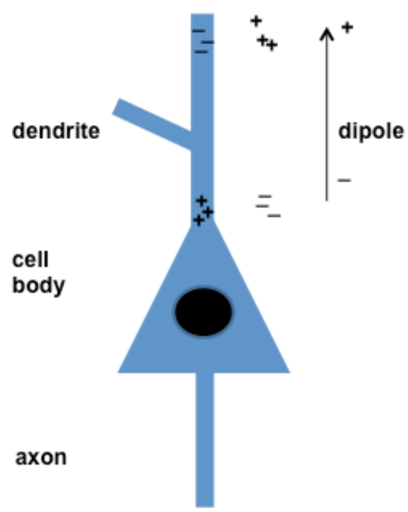

Figure 2.1: Example of a pyramidal cortical neuronal "dipole". EPSP at the level of the dendrite causes an intracellular current source (local positivity) and a current sink at the level of the cell body (local negativity) This pattern of current flow, repeated over many thousands of cortical neurons, is likely the main generator source for EEG.

Dipoles produced by one neuron are too weak to be picked up by sensors on the scalp. It is estimated that as many as tens of millions of neurons must be active in near synchrony to produce scalp potentials of a few microvolts (Cooper, Winter, Crow & Walter, 1965). The slower time course of PSPs, compared to action potentials, makes summation possible.

Another requirement is that the cells have to be well-aligned, because the dipoles would cancel each other if the neurons are randomly oriented (Lorente de No, 1947; Allison et al, 1986). These features tend to be present for cortical pyramidal neurons, which are well-aligned close to the scalp.

Even then, there are further limitations. Synchronous and aligned excitatory and inhibitory PSPs would still cancel out due to their opposing electrical properties. Lorente de No (1947) described the consequences of neuronal geometry on the EEG signal (Figure 2.2).

When neurons are radially oriented, modelling of the dipole interactions shows that their electric fields will sum to zero. This configuration is known as 'closed field', whose activity is unlikely to be detected from the scalp. On the other hand, 'open-field' configurations lead to a non-zero superposition of electric fields, and can be potentially detected at the level of the scalp. For this reason, EEG signal is thought to reflect synchronous activity along homogeneously oriented pyramidal cells in the cortex. This type of configuration can be described by an 'open field' geometry, or at least an 'open-closed field' one which only results in partial cancellation of electric fields. One would assume that 'open-closed' fields would result in a weaker signal measured at the scalp. Despite this, one should keep in mind that EEG signals have been reported to arise from the hippocampus, thalamus, amygdala, and thalamus; which have near-closed geometries (e.g., Cornwell, Carver, Coppola, Johnson, Alvarez, & Grillon, 2008; Llinas, Ribary, Jeanmonod, Kronberg & Mitra, 1999; Quraan, Moses, Hung, & Taylor, 2011; Tesche & Karhu, 1999).

The limitations of EEG are important to keep in mind, especially if one aims to investigate neural mechanisms behind sensory or cognitive processes.

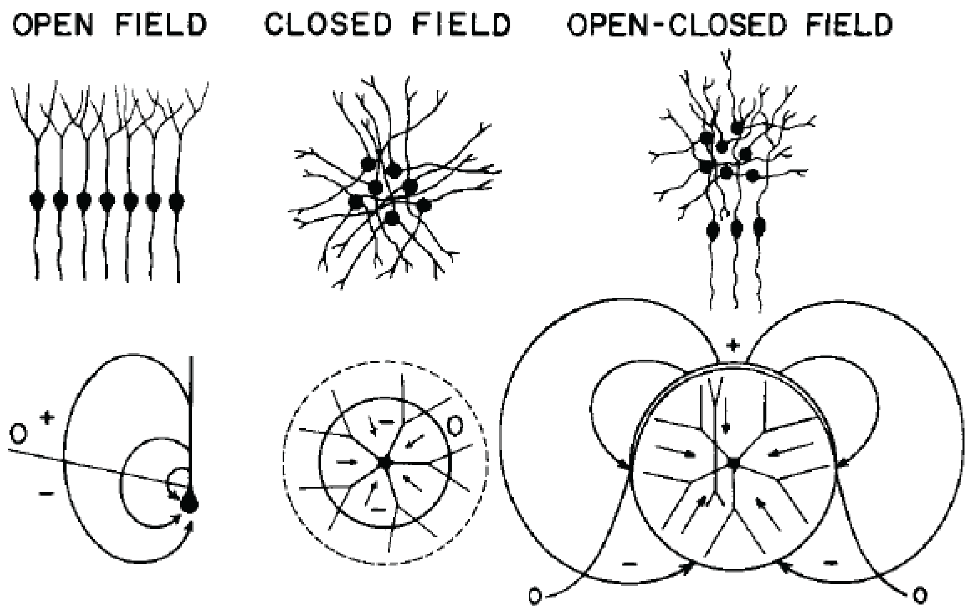

Figure 2.2: Theoretical depiction of current flow and potential fields produced by synchronous activations of neurons in several possible neuronal geometries (taken from Lorente de Nó, 1947; in Allison et al., 1986).

2.2.1 Event-related potentials (ERPs)

Event-related potentials (ERPs) have been studied for decades to understand aspects of the sensory, cognitive, and motor processes that underlie human thought and behaviour. ERPs are voltage fluctuations in the continuous EEG that are time-locked to an event, be it the onset of a sensory stimulus or a manual response (Luck, 2005). Although ERPs reflect the direct response to an external stimulus, they additionally depend on the state-dependent brain processing of the stimulus. ERPs can be obtained from the EEG signal, by time-locking it to specific sensory, motor, or cognitive events of interest, and ideally averaging it over many instances of the event.

2.2.1.1 ERP recording

There are several protocols in recording, cleaning, and pre-processing EEG data. Although there are different preferences in how these methods are implemented, a certain amount of consistency is important for comparing results.

Electrodes are typically arranged on the scalp according to the 10-20 system (Jasper, 1958), and data can be recorded at a frequency ranging from 100 to 10000 Hz (Cacioppo et al., 2000). For the experiments described in this thesis, 1000 Hz was employed. The potential from each scalp location is recorded with respect to a chosen reference site, where the reference electrodes is placed (Nunez, 1981). The reference sites are chosen to be unaffected by task-dependent electric activity, which enables the removal of common background noise from the waveforms recorded by the scalp electrodes. Popular reference sites are the nose, earlobes, and mastoid bones behind the ears.

The recorded EEG activity comprises signals characterized by different frequencies over time. A large body of literature focuses on frequency analysis of data, which will not be elaborated in this dissertation.

Event-related potentials (ERPs) can be extracted from the recorded activity by time-locking data around particular events of interest (stimuli, responses). The act of extracting this piece of signal is called “epoching”. The resulting trials or epochs still contain a lot of unwanted noise resulting from eyeblinks, eye movements, and drifts in the signal. This can sometimes be amended by corrective methods (Luck, 2005), or, alternatively, these epochs can be removed from the analysis. It is commonplace to have electro-oculogram (EOG) recordings in addition to the EEG. In the studies described in this thesis, electrodes were placed on the left and right horizontal canthi, and a vertical electrode was placed below the right eye. EOG tracks eye blinks and eye movements, which allows the identification (and elimination) of epochs which are contaminated with them. Additionally, trials where the voltage amplitude rises too much above or below a pre-defined limit (ie, 50 microvolts) can be removed from analysis. It is also common to filter out excessively high or low frequencies that do not not to contribute to the waveforms measured with ERPs.

Even with all the methods described above, the task-relevant activity in each trial is too small compared to uncontrollable sources of noise (neural and external) in the data. Many trials have to be averaged to reveal the relevant activity of interest. However, the trials have to be time-locked to similar or compatible events. This is why a typical experiment involves many repetitions of the same stimulus presentation or required response. When averages are taken across participants, it is usually the case that the waveform appears smaller than in the individual-subject data. The reason is partly because peaks may appear at slightly different latencies within each participant, resulting in a smaller smeared average. Latencies may be difficult to compare reliably across conditions, but averaging is nevertheless necessary.

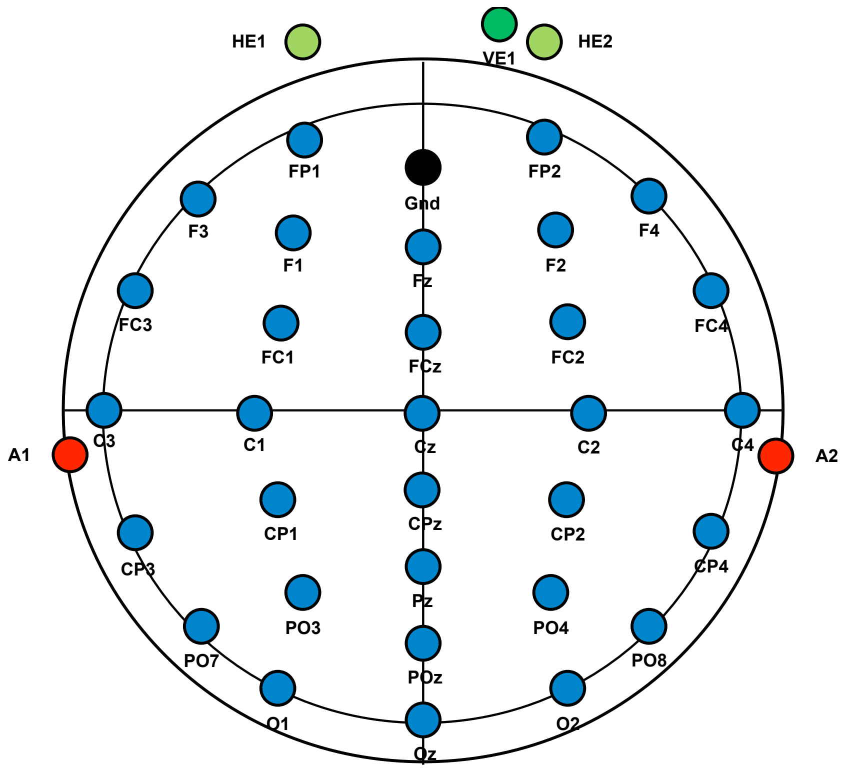

Figure 2.3: Electrode montage used in the experiments of Chapter 4, positioned according to the 10-20 International System. The mastoid reference electrodes are coloured red. EEG was recorded relative to one mastoid (right), and then re-referenced to the average of the two mastoids. The ground electrode is coloured black. Eye movements are monitored by recording the horizontal and vertical electro-oculograms. The two horizontal eye channels are coloured light green, and the tvertical eye channel is coloured dark green. Horizontal eye movements are derived from the recorded activity of the two HEOG channles, whereas vertical movements and blinks are derived from the recorded activity of the vertical eye channel and FP2.

2.2.1.2 Interpreting ERPs

Averaged and cleaned ERP waveforms consist of peaks which are referred to as components. These components can be described in terms of their polarity, latency, or source. For example, the P300 is a positive peak with a latency of 300 msec. Another labelling system also uses polarity followed by a number describing the ordinal latency (P3: 3rd positive peak in the waveform).

Other descriptors can also be used, like frontal P3 (indicating source) or novelty P3 (indicating experimental condition).

Notably, polarity has no significance in the absolute sense. A positive peak does not necessarily represent EPSPs rather than IPSPs. Polarity rather depends on the position of the active and reference electrodes relative to the neurons generating the signal (Allison et al, 1986). The information provided by polarity and latency must be treated with much care. An ERP emerges as an effect of both spatial and temporal summation. Since the brain acts as a volume conductor, activity at a certain scalp location might reflect the summation of activity at multiple different locations. Also, voltage signals have different time courses which may interact over time until the signal propagates from the source to the scalp, and may be represented very differently in the resultant waveform. Thus, we cannot say that an ERP reflects a well-defined stage of information processing derived from a well-defined neural ensemble.

2.2.2 Advantages and disadvantages of EEG

Like every imaging method, EEG has both advantages and disadvantages. Although it appears outdated compared to functional magnetic resonance imaging (fMRI) or magneto-encephalography (MEG), the fact that it still features in so many research articles indicates that it is not without its benefits. One of the most common statements regarding EEG is that it has excellent temporal resolution with poor spatial resolution. These and other merits and caveats will be outlined in more detail below.

One of the most important disadvantages of EEG is that derived measures like ERPs are essentially correlational in nature. Although an ERP modulation may perfectly coincide with a cognitive process of interest, one cannot rule out the possibility that intermediate processes are also involved. Nevertheless, this is a caveat also shared by other imaging methods (fMRI, MEG, Positron emission tomography (PET), etc.). Another disadvantage is that one cannot deduce much from an absence of effects. As explained above, EEG is only sensitive to a subset of types of neural activity, leaving the possibility of modulations that are simply not revealed by this method. Spatial resolution is also compromised in EEG. It is very difficult to underpin the unique neural sources of observed ERPs. As explained above, an ERP emerges as a result of spatial and temporal summation of neural activity. This is the reason why there is an "inverse problem": an ERP can be explained by different neural events, or by combinations of these events (Cacioppo et al., 2000). A final disadvantage is that, despite all the filtering methods used to clean EEG signal, the signal-to-noise ratio is quite low. As several trials are required to measure accurate waveforms, this excludes several research domains where a large number of trials are not possible to collect, as may be the case with some types of patient studies.

It is important to mention that other imaging methods which may surpass the EEG in some aspects still suffer from similar caveats. For example, in MEG, while the signal-to-noise ratio is improved, the inverse problem still exists (Hämäläinen & Hari, 2002).

An advantage of EEG that cannot be stressed sufficiently is the excellent temporal resolution (Cacioppo et al., 2000; Luck, 2005). EEG provides a measure of ongoing stimulus processing at the millisecond time scale. This allows the capturing of short-lived events, and allows us to indicate at which level of cognitive processing neural signals become sensitive to task manipulations. It is important to mention that, in spite of the fact that the peaks observed in ERPs do not necessarily reflect peaks of activity extracted from well-identified sources, it is still possible to deduce whether the task-related neural modulation occurred at a relatively late or early stage of cognitive processing (i.e., perceptual vs. motor). EEG can also be used to investigate the processing of stimuli that occurs below the conscious level. Going back to the problem of poor spatial resolution, it is still possible to record activity from a large number of scalp locations, creating macroscopic topographies of neural activity that allow a reasonable comparison across different conditions. Finally, from a practical perspective, EEG is portable, efficient, easy to apply, and relatively inexpensive. For these reasons, EEG still persists as a method of choice in neuroscience research.

2.2. EEG in Social Neuroscience

Although the social nature of humans has been the subject of several disciplines for a very long time, it is only in the last decades that neuroscience has started to investigate brain activity during social interactions (Cacioppo & Bernston, 1992; Cacioppo et al., 2000; Babiloni & Astolfi, 2012).

Interactional paradigms, where two or more individuals engage in a common task, are a popular tool to understand the mechanisms behind social behaviour. Behavioural data, however, provide a limited avenue to portray that the way an individual reacts to another is linked to the type of relationship between the two individuals. Optimally, a direct observation of the interaction emerging between the brains of the individuals is needed (Babiloni & Astolfi, 2012). As mentioned in a recent review, “much of the fleeting, moment-to-moment information of social interaction remains beyond the reach of studies involving limited stimuli and tasks. The current challenge for brain imaging is to bring every day human interaction, occurring in a complex natural environment between two or more subjects, into the laboratory” (Hari & Kujala, 2009).

At our current stage of technological development in neuroscience methodologies, this can be addressed by measuring brain activity of participants simultaneously during proposed tasks (Babiloni & Astiofi, 2012). In a seminal publication, Montague et al. (2002) performed simultaneous fMRI recordings of cerebral activity during simple interactions between two individuals, using two fMRI machines. This method, the simultaneous acquisition of brain data from two interacting participants, was named hyperscanning (Montague et al., 2002). Although hyperscanning seems to be a cutting edge development in the field, the idea is not new. As early as sixties, Duane and Behrendt (1965) performed multiple EEG recording in a series of twin pairs. Regardless of the fact that the aim of that research was of a pseudo-scientific nature (proof of a psychic connection between the twins), it is the method that is of interest in this context.

2.3 Hyperscanning

Making sense of simultaneously collected, linked data sets is a non-trivial matter. In a recent review of the published literature on the hyperscanning methodologies in both EEG and fMRI (Babiloni & Astolfi, 2012), the authors discuss the current state of the hyperscanning literature, which has mostly involved fMRI studies (as inspired by the Montague publication), in addition to several EEG, NIRS, and PET studies.

In general, hyperscanning is performed to glean information about the temporization of the neural processes involved in the two brains during the interaction. There are two main types of interactional paradigms that are used with hyperscanning. In the first, one individual performs an action that is observed by the other individual, like a facial expression or a hand gesture (Schippers, Roebroeck, Renken, Nanetti, & Keysers, 2010; Anders, Heinzle, Weiskopf, Ethofer, & Haynes, 2011). This is sometimes referred to as an actor-observer paradigm. In the second type of paradigm, the two individuals act together towards a common goal, of which decision-making tasks are notable (e.g., Astolfi et al., 2011). Much of the research under this type of paradigm is related to the hypothesis that synchronous brain oscillations can sustain synchronous or coordinated behavior between the participants (Babiloni & Astolfi, 2012). In EEG studies, most of the research has involved frequency analysis (Astolfi et al., 2011; Dumas, Nadel, Soussignan, Martinerie & Garnero, 2010; Tognoli, Lagarde, DeGuzman, & Kelso, 2007).

A notable challenge of hyperscanning is related to the technical difficulties related to the synchronization of the acquisition devices in multi-subject recordings. Since the hypotheses explored usually support the notion that synchronous brain activity sustains coordinated behaviour, there is a need for a methodology that pools together neural activity from multiple subjects in response to a similar stimulus, or supporting a joint action. Limiting the discussion to EEG, this has usually been addressed by an external trigger that reaches all of the acquisition machines, or by feeding the data into a unique device (Babiloni & Astolfi, 2012) (Figure 2.4). The fact that all interacting participants are usually in the same room in such studies made this procedure possible. The challenges related to analysing the data will not be explored in this thesis, but will generally vary according to the specific experimental question.

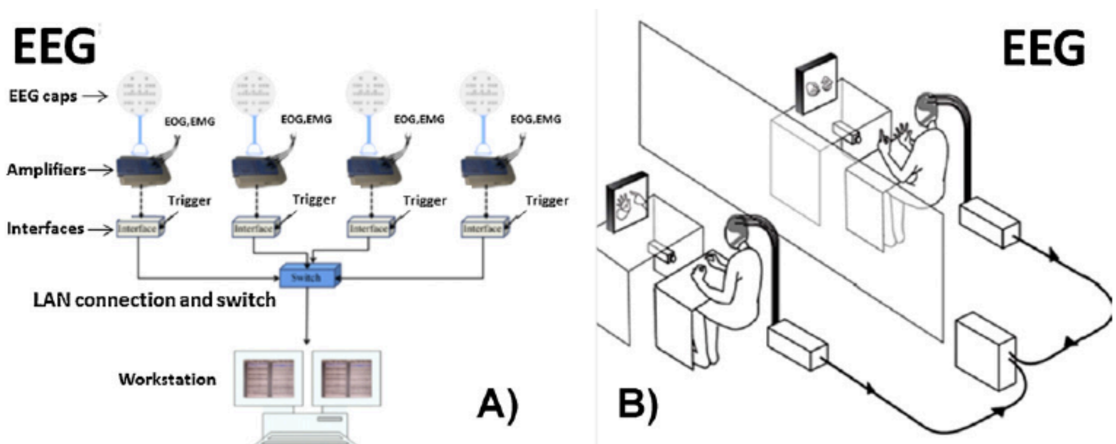

Figure 2.4: Different hyperscanning architectures employed for EEG recordings (adapted from Babiloni & Astolfi, 2012)

Especially in the context of hyperscanning, which usually supports experimental questions of a social nature, there is another challenge related to making the experimental design ecologically valid, while still maintaining the rigour required for valid neural data. It is difficult to glean social processes like empathy, trust, or competition in a contrived setting where participants are donning EEG caps, observed by an experimenter, and restrained in their movements. There is hope, however, that with the advancement of neuroscience technologies, the acquisition machinery will reach a stage of unobtrusiveness that will allow for a more realistic laboratory interaction between the participants.

2.3.1 The current studies

The technical challenges of hyperscanning were bypassed in the experiments described in this thesis by using two independent EEG setups (Figure 2.5), and by using programming simulations and deception to induce the impression that the two participants were interacting and observing each other's performance.

The specific experimental questions of the research described in thesis could be sufficiently addressed if participants simply believed that they were interacting, without an interaction necessarily taking place. The experimental question addressed social group differences with respect to stimulus and feedback processing, and the analysis was conducted using ERP analysis (e.g., Koban, Pourtois, Vocat & Vuilleumier, 2010). In the experimental task, pairs of participants were induced to believe that their computer screens mirrored each other (e.g., they could perceive the same task), and that they took turns to perform by responding to targets with a button press. Each participant was allocated to a different group with a social power manipulation. Although they could not see the other's response, they saw symbols that coded positive or negative feedback. In this way, they could infer performance accuracy of the other. Thus, targets and feedback were attributed to the self or the other, and it was sufficient for the participants to *believe* that the feedback symbols they were perceiving corresponded to the other's performance, and that certain targets were corresponding to the other's turn in the interactional game. In reality, both participants were acting independently with a programmed computer simulation, which approximated their own behavioural accuracy. A full description of the task is detailed in Chapter 4 of this thesis.

To conduct this research, individuals were seated in separate booths, with separate EEG machines (Figure 2.5).

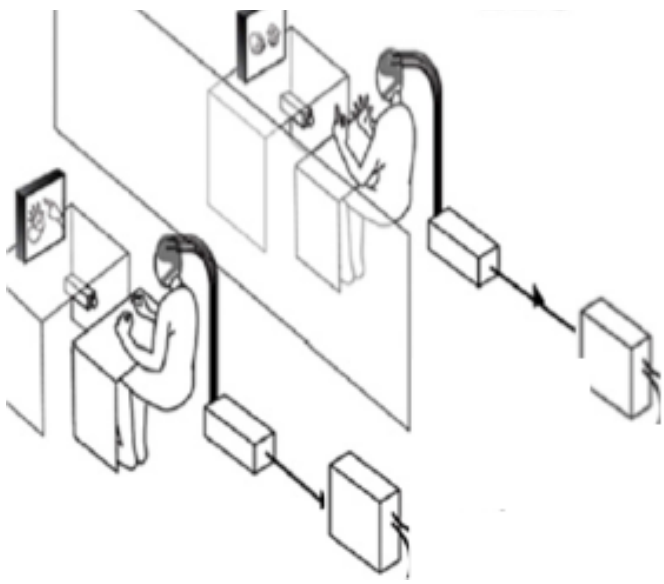

Figure 2.5: Simultaneous EEG architecture used in the experiments described in this thesis, which comprised of two independent setups.

This setup significantly reduced the number of challenges related to synchronizing the data sets and performing paired analyses. To ensure that the deception was successful, a few procedures were implemented.

Prior to data collection, the computer simulation was piloted until the timings of stimuli and feedback convincingly mimicked human performance to a human perceiver. In this manner, participants did not have the impression that the “other” was the computer. This deception was necessary because humans behave differently if they are aware that they are interacting with computers instead of with other people (Rilling, King-Kasas, & Sanfey, 2008). This was conducted by collecting behavioural data from 6 subjects performing the task in isolation, and using their performance measures to derive the simulation parameters.

During the experiment, the experimenter instructed the participants about the details of the task, which was said to be generated by the same processor, and provided bogus information about how their screens mirrored each other. After simultaneous EEG setup, with the help of research assistants, there was care given in starting the task and acquisition simultaneously. Bogus screen shots at the beginning of the task indicated to both participants that the system was ‘connected’. Also, the tasks were terminated at the exact same time, and participants were announced of task termination. Afterwards, a bogus score calculation was conducted which seemingly collected their performance from the same computer.

In this manner, participants believed that they were, in fact, interacting. Manipulation checks were conducted after the experiment to ensure that the manipulation was successful, and that the participants had no doubt that they were performing the task jointly. After data collection was completed, participants were informed of the deception in a group email.

Quoting Allport (1956), the real or implied presence of another leads to behavioural differences in human beings. In this thesis, technology was used to imply the presence of a human agent, with very interesting implications.

3 Chapter 3: Power and Attention Orienting

3.1 Introduction

As discussed in Chapter 1, cognitive processes are highly adaptive to the circumstances present in the environment (Smith & Semin, 2004). People who possess power live in very different worlds than those who lack it, with different affordances and constraints. This has an important effect on the way their cognitive processes unfold (Guinote & Vescio, 2010). The different motivations among these social perceivers may inform choices among cognitive strategies (Fiske & Taylor, 1991). It is proposed that repercussions extend to basic cognitive processes, where power-holders and subordinates have distinct strengths and abilities in the way they deploy attention (Guinote, 2007b, Weick et al., 2011, Wilkinson et al., 2011). In this chapter, I build on the previous literature to investigate, with a well-controlled task and paradigm, whether those who possess or lack power have different attention "powers".

There is increasing evidence that power can have distinct effects on the attentional systems of the brain (Willis et al., 2011; Guinote, 2007b). As a brief overview, one way to conceptualize attention is the three-network system proposed by Posner and Petersen (1990): alerting, executive control, and orienting. Alerting is involved in maintaining an appropriate sensitivity and vigilance over time to perceive and process stimuli. The executive control network is involved in setting and updating goals and resolving conflicts that arise during task performance and voluntary action control. The orienting network, which is the focus of this chapter, involves the selection of information that is appropriate to one's goals from among numerous competing sensory stimuli.

The greater part of orienting attention research has concerned visual spatial orienting, where a specific position in space is instructed, or cued, which contains visual events that are relevant to the task goals (Posner, 1980). Influential advances in exploring spatial attention orienting have been made possible through the experimental paradigm of Posner (1978), which explored how the focus of attention can be oriented towards a location in anticipation of the occurrence of a behaviourally relevant target. Predictive spatial cues result in accuracy and speed benefits for detecting targets appearing in correctly cued locations (Posner, 1980; Wright & Ward, 2008). Despite the focus in the literature on spatial orienting, it is also possible to orient attention to objects, features within objects, temporal intervals, and high-level associative attributes of stimuli (Nobre, Rohenkohl, & Stokes, 2011).

Within the orienting function, there are different types of biasing mechanisms that determine which information is selected for further processing. As described in the 'biased competition model' (Desimone & Duncan, 1995), biases can occur in a 'top-down' or a 'bottom-up' fashion. Top-down biases are goal-driven mechanisms favouring stimuli that are relevant to current task performance. Representations in high-level associative areas exert these biases through feedback connections, thus influencing perceptual processing. For example, spatial orientation operates in a top-down fashion, facilitating discrimination of targets at the attended location. Bottom-up biases are sensory driven, favouring events that are physically dominant, whose stimulus energy outweighs that of surrounding stimuli, thus progressing their way upwards in the perception hierarchy. An example is a red dot amongst grey dots, which 'captures' attention through its own visual attributes. However, attention can be 'captured' by stimuli with task-defining features, implemented by a top-down set, even if there are no other low-level physical features that make these stimuli pop-out in the display (Brignani, Lepsien, & Nobre, 2010; Folk & Remington, 1998; Folk, Remington, & Johnston, 1992; Yantis, 1993). For example, a task may require the detection of the letter 'A' amongst many letters that have the same stimulus intensity (size, shape, colour). Contingent capture by these letters operates even when there is a significantly reliable pre-established spatial focus at another location (Brignani et al., 2010), and may even trump the presence of visually salient stimuli (Serences et al., 2005). Therefore, a top-down attentional set identifying the task-defining *features* is a strong determinant of the amount of attention capture that a stimulus will trigger and the degree of processing it will receive.

There is increasing evidence that power and subordination lead to different strengths within the orienting function (e.g., Weick et al, 2011; Willis et al., 2011), in a way that adaptively meets their needs in the current environment. In general terms, it is proposed that the major drive behind the different cognitive styles of power holders and subordinates is the fundamental need to control environmental outcomes (Fiske & Dépret, 1996). Subordinates, having little control and therefore, predictability over outcomes show increased vigilance and closer monitoring of the environment, compared to power-holders (Fiske, Fiske, Gilbert, & Lindzey, 2010). While vigilance to environmental stimuli is a functional adaptation, it is proposed that it over-burdens subordinates' cognitive resources, reducing their performance on difficult tasks that require the ability to deploy attention in a flexible manner (Guinote, 2007a).

With respect to the specific function of orienting, the line of research linking it to power is still at its initial stages. There have been some interesting results on the effect of power on the voluntary deployment of attention to a particular location in space. In a recent study (Slabu et al., 2012), power was manipulated by telling participants that they had substantial (high-power) or trivial (low-power) influence on an important decision. Participants were then requested to perform on a visual spatial attention Posner-style task (Posner, 1980), which involves cues that orient attention to a particular spatial location. The task included valid cues, which correctly oriented participants to the location of a target, in addition to invalid cues, which provided incorrect information as to where the targets were located. It was found that power-holders were better able to override misinformation from the invalid cues and indicate the location of targets, which was interpreted that social power increases flexibility in orienting spatial attention. In a different study (Willis et al. 2011), power was manipulated by allowing one participant (high-power) to evaluate the other's performance (low-power). In a more complex attention task, it was shown that power-holders were better at using orienting cues to improve their executive control (Willis et al., 2011). In the type of task they employed, cues could orient participants to two different types of stimuli that required response: incongruent stimuli (a target arrow surrounded by distractor arrows pointing in the opposite direction), or congruent stimuli (where the target and distractor arrows pointed in the same direction). Participants had to indicate the direction in which the target arrow pointed to. Incongruent stimuli elicit a conflict, which leads to more errors and slower reaction times (Eriksen & Eriksen, 1974). It was found that, when the orienting cues were valid, power-holders showed improved performance on incongruent trials. The results were thus interpreted that power-holders are better able to use orienting cues in a way that improves conflict resolution.

Subordinates have their strengths, too. In a recent study where power was manipulated by priming through descriptive essays (as described in Chapter 1), Weick et al. (2011) showed that subordinates performed better than power-holders in a visual search task in which targets differed on basic features to distractors, such as colour, size or texture. For example, subordinates were faster than power-holders to detect a green object among black and white ones. Interestingly, however, there was no difference in performance when targets differed from distractors in non-perceptual dimensions, such as function (targets and distractors were tools). The authors propose that the increased vigilance experienced by subordinates facilitates perceptual discrimination.

Although more evidence about the effect of power on orienting is needed, it is not surprising that such an effect exists. It has been demonstrated that top-down and bottom-up biasing mechanisms are sensitive to situational and motivational factors (Bishop, Jenkins, & Lawrence, 2007; Pessoa, 2009; Pessoa, Padmala, & Morland, 2005). For example, anxiety, which has been linked to subordination (Keltner et al., 2003), has been proposed to alter the equilibrium between the bottom-up and top-down systems by lowering the influence of the former and increasing that of the latter (Eysenck, Derakshan, Santos, & Calvo, 2007a). Trait anxiety has also been proposed to lead to an over-functioning of the alerting and orienting systems (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). In this manner, power and subordination, which are intricately linked to the motivational systems of the brain (Keltner et al., 2003), may affect the way biasing mechanisms occur. Power-holders' relative lack of constraints and obstacles, compared to subordinates, is proposed to confer them with attention focus and flexibility (Guinote, 2007a). Power-holders are better able to focus their attention according to their behavioural goals, and to allocate their resources adaptively to the most relevant environmental stimuli at any given time. An outcome of the proposed cognitive flexibility experienced by power-holders is the increased ability to adjust their actions in line with changing contextual cues.

This study was conducted in an attempt to explore whether power-holders and subordinates possessed different strengths in the way they deployed attention, exploring both spatial orienting and orienting to task-relevant features. It was of interest to explore the hypothesis that power-holders are better able to focus on task-relevant material and have the flexibility to shift their focus as predictions changed. This was conducted by using a task that was based on previous paradigms that investigated orienting of attention (Brignani, Lepsien, Rushworth, & Nobre, 2009; Yantis et al., 2002). The task employed two conditions: Focused, which requires the staying of attention on one particular location in space and flexible shifting to another particular location; and Divided, where sustained global attention across multiple stimulus streams in required. Participants had to select targets among streams of distractor stimuli, where the targets were specified by task –relevant features.

Thus, this task surpassed the ones reported in previous orienting studies (i.e., Slabu et al., 2012) in complexity, in an attempt to explore the manner in which power affects the deployment of attention in a more realistic environment. When we operate in our daily lives, it is difficult to imagine spatial orienting and feature selection operating in solation. In line with what the spatial orienting literature suggested, I hypothesized that power-holders would surpass subordinates in the task where flexible shifting and focusing of attention is needed, while subordinates would outperform power-holders in the task where distributed attention to multiple sites is required. By equating the power manipulation, stimulus characteristics, and task setup across the Focus and Divide task, it was aimed to have a more sensitive measure of how power affects orienting across space. It was interesting, however, to explore how the need to select task-defined features among distractors, which is a different aspect of attention which is presumably affected by power, would affect the orienting function.

3.2 Experiment 3.1a

3.2.1 Methods

3.2.1.1 Participants

Fifty-eight (29 males) participants made up the initial sample. Each experimental session involved two participants of the same gender who were previously unacquainted. Six participants had to be removed from the analysis, either due to an error with the program, or due to participants not following or misunderstanding the task instructions. Participants were recruited from Oxford's population. The experiment was approved by Oxford's Central University's Research Ethics Committee (CUREC), and participants provided written consent.

3.2.1.2 Procedure

Power was operationalized according to the definition of asymmetrical control over a desired communal resource (Fiske, 1993). Within each pair of participants, one individual was pre-allocated to the powerful role and the other to the subordinate role randomly and without their knowledge. They performed one session of the task (see below) in a hierarchically neutral condition, under the guise that whoever performed better in terms of accuracy and reaction time would be allocated the title of 'Boss' and would be able to allocate the joint monetary reward on a subsequent session of the task. Having completed the hierarchically neutral session, the pre-assigned powerful participant was informed that they had won by a small percentage. Given the lack of feedback, the large number of trials, and the fact that participants could not see the other person's performance; this was a plausible statement.

Participants then performed a second session of the task, having been told that their combined performance would translate into a monetary reward (£6-£10) which the 'Boss' would be able to split between the two however s/he wanted. This second session of the task was identical in all parameters to the first session, except for the power hierarchy that had been established.

The task consisted of two spatial attention conditions, run across two separate sessions: a 'Divide' condition, and a 'Focus' condition. In both the hierarchically neutral and power sessions, participants either perform Divide then Focus or Focus then Divide. In other words, they do both conditions of the task in the same order, before and after the power manipulation. Assignment of condition order was balanced between pairs of participants within each gender. While completing the task, participants sat in isolated booths.

Presentation v10 (Neurobehavioural Systems, Albany, NY) was used for stimulus presentation and recording of behavioural responses. All statistical analysis was conducted with PASW Statistics 18.

After being told the 'results' of the first session, participants were asked to rate on a scale of 1-7 how much they thought the final winnings would depend on the other person rather than themselves, and how fair they thought their assignment was to their role. This was done on paper, which was not viewed by the other participant, or by the experimenter, to ensure truthful responses. This manipulation check procedure was based on the one proposed by Willis et al. (2011). Participants were debriefed of all aspects of the manipulation by email after data collection was completed.

3.2.1.3 Task

Participants viewed two visual arrays on a screen consisting of four letters each. The letters changed in rapid succession at independently randomized times, with durations also randomly varying between 150 and 200 msec. The letters were chosen among "A", "B", "C", "D", "F", "G", "H", "J", "K", "L", "M", "N", "P", "Q", "R", "T", "U", "V", "W", "Y", "Z". Participants had to try to detect either of two targets “£” and “$”, both of which could appear in two locations (surrounded by three distractor streams) as shown in Figure 3.1 below.

Participants always had to respond to a “£” sign by pressing the right arrow key on the keyboard, and a “$” sign by pressing the left arrow key; regardless of which side of the screen the target appeared.

There were two conditions for this task. In the ‘Focus’ condition, participants were required to maintain their gaze on a central fixation cross while focusing their attention on the stimulus stream on **one** of the two sides. At the beginning of each block, an initial cue (“1” or “2”) presented at fixation indicated the stream that should be attended (left or right, respectively). Participants would then only respond to targets on this side, ignoring targets that appeared in the unattended stream. As shown in Figure 3.1, targets would appear randomly every 1-2 seconds. Bilateral cues, symbolized as either blue or green “#” signs, appeared intermittently instructing participant to continue focusing on the same side or to shift attention to the other side. Within each block, there were around 4 bilateral cues which appeared with equal probability in a randomized order every

15-17 seconds. This condition contained 8 blocks, lasting around 10 minutes altogether.

In the ‘Divide’ condition, there were no shift or stay cues, identical bilateral symbols were still shown, in grey colour, to equate sensory requirements. Participants had to detect and respond to targets in either stream. Due to the fact that they were responding to both sides of the screen at once, the number of targets on each side was halved, and the timing between each target was doubled (to between 2-4 seconds). This was done to ensure that they were responding at an equivalent rate as in the Focused condition. This condition also contained 8 blocks, and lasted around 10 minutes.

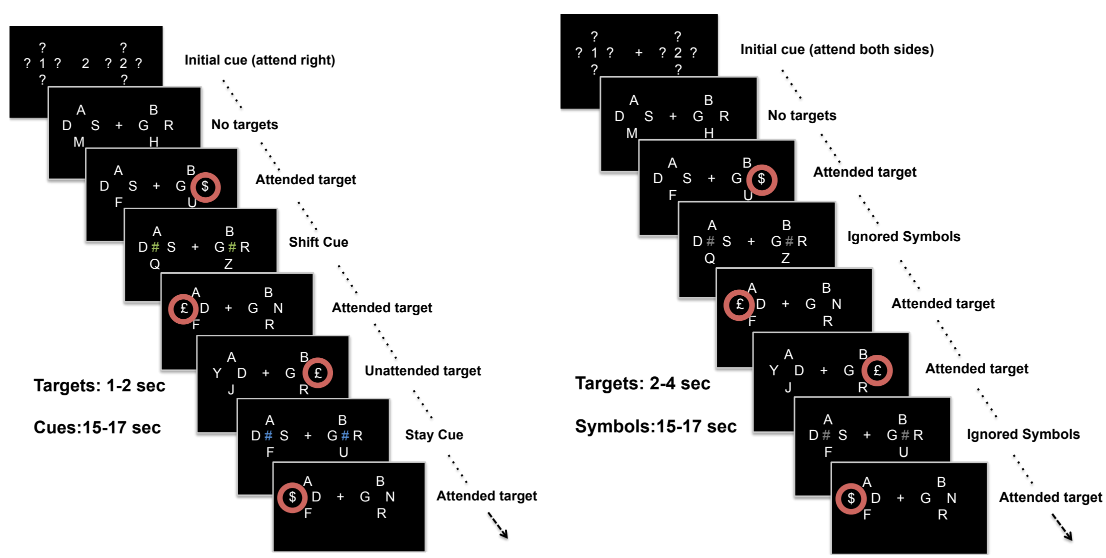

Figure 3.1: A schematic description of the orienting task in Experiment 3.1a, with the Focus condition (left) and Divide condition (right). Either target ($ or £ symbol) could appear in one of the two locations marked by circles. In the Focus condition, a green “#” cue, indicating the need to shift to the other stream, is shown in the 4th panel. A blue “#” sign, indicating the need to stay on the same side, is shown on the seventh panel. Each session consisted of 10 blocks, lasting roughly 10 minutes in total. Shift or stay cues appeared every 15-17 seconds, and targets appeared every 1-2 seconds. In the Divide condition (right), grey “#” symbols appeared every 15-17 seconds but had no function except to equate visual stimulation between both conditions. All targets were attended, and appeared every 2-4 seconds.

It should be noted that for both conditions, participants had to maintain their gaze on the central fixation point throughout. To ensure this, participants were informed that their eye movements were being monitored via eye-tracking cameras which were present in both booths. Practical considerations prevented eye tracking, an issue which was addressed in a follow-up experiment.

3.2.2 Results

3.2.2.1 Data Preparation

The data were inspected, and responses quicker than 400ms or slower than 1500ms were deleted as non-responses. There was an unfortunate order effect in the data. By chance, in the Divide-then-Focus group, power-holders performed significantly better in both conditions in the first session. This was mirrored in the Focus-then-Divide condition, in which subordinates performed significantly better in both conditions in the first session. There was a concern that this would render the analysis sub-optimal, as there was a difficulty to dissociate the order effect from the manipulation effect. There was a concern that significant differences at the pre-manipulation level would obstruct a sensitive measure of changes induced by the power manipulation, as people with different performance levels may respond differently to practice effects.

Two things were done in order to redress these problems: First, to have a sensitive measure of manipulation-induced change in performance, performance in session one was equated by subsampling the data, such that the cases on the tail end of the distribution were removed. This was done without taking into account performance in the hierarchical session. Only the Focus data from the Focus-then-Divide condition were used, and only the Divide data from the Divide-then-Focus condition were used. This was done because it is likely that the effect of power will be most evident in the first condition after the power manipulation, which is what the data now represent. The type of task used (Divide or Focus) hence became a between-subjects variable in subsequent analyses. The final sample consisted of 24 pairs of participants, with 12 pairs in the Focus condition (which was previously the focus-then-divide condition), and 12 pairs in the Divide condition (which was previously the divide-then-focus condition).

3.2.2.2 Manipulation Checks

After the power manipulation, participants were asked to answer three questions privately. The first was designed to probe whether participants were subjectively aware of their role; they were asked to rate on a scale of 1-7 how much they thought the final winnings would depend on the other person rather than themselves (1=not at all responsible, 7=extremely responsible). The results showed that subordinates thought that power-holders were significantly more responsible for the final winnings (M=4.00, SE=0.49) than power-holders felt about the subordinates (M=2.26, SE=0.31, t(1,43)=-3.02, p<0.01). The next two questions asked participants to rate the fairness and adequacy of the way power was allocated (1=extremely illegitimate/unfair, 7=extremely legitimate/fair). For fairness, power-holders (M=3.78, SE= 0.45) did not differ from subordinates (M=4.3, SE=0.36) in their ratings (p=ns). Similarly, for adequacy, power-holders

(M=4.14, SE=0.49) and subordinates (M=4.47, SE=2.37) rated similarly. It is worth noting that, in all cases, participants judged the power manipulation to be legitimate and fair, with average ratings above 3.5.

3.2.2.3 Effects

Firstly, it was important to verify whether participants were actually using the cues to focus their attention, and whether the fact that they are focusing aids their performance. There was also an interest to see whether the power manipulation had an effect on performance. Two separate mixed-effects ANOVAs, looking at proportion of accurate trials (accuracy) and reaction time, were conducted with *type* of task completed (Focus or Divide) and *role* (Power-holder or Subordinate) as the between-subjects variables and *session* (neutral or hierarchical) as a within-subjects variable. All 24 pairs of participants were included in this analysis.

Participants found this task rather difficult, and missed a sizeable proportion of the low-contrast targets. For accuracy, there was a significant effect of type of task, $F(1,46) = 13.07$, $p = 0.001$, revealing that accuracy was higher on the Focus ($M = 0.675$, $SE = 0.031$) conditions than the Divide conditions ($M = 0.519$, $SE = 0.031$). This result confirmed that participants were using the cues to focus. There was also a significant effect of session, $F(1,46) = 66.26$, $p < 0.001$, revealing higher accuracy for second, hierarchical session ($M = 0.663$, $SE = 0.022$) than neutral session ($M = 0.531$, $SE = 0.024$). This is likely due to participants improving as they have time to practice and get used to the task.

Interestingly, there was also a significant three-way interaction between *type*, *role,* and *session*, $F(1,44) = 6.94$, $p = 0.012$. Further analyses were required in order to investigate the nature of this effect. Due to the hypothesized distinct effect of power on the Focus and Divide version, each of the two conditions was analyzed separately.

Looking at the Divide condition, a mixed-effects ANOVA was conducted with *session* as the within-subjects variable and *role* as the between-subjects variable. There was a significant role-by-session interaction, $F(1,22) = 4.14$, $p < 0.05$. Figure 3.2 below shows the difference between power-holders and subordinates over the two sessions for the divide condition. Pairwise comparisons showed that power-holders ($M = 0.650$, $SE = 0.048$) were more accurate than subordinates ($M = 0.536$, $SE = 0.048$) in the hierarchical session.

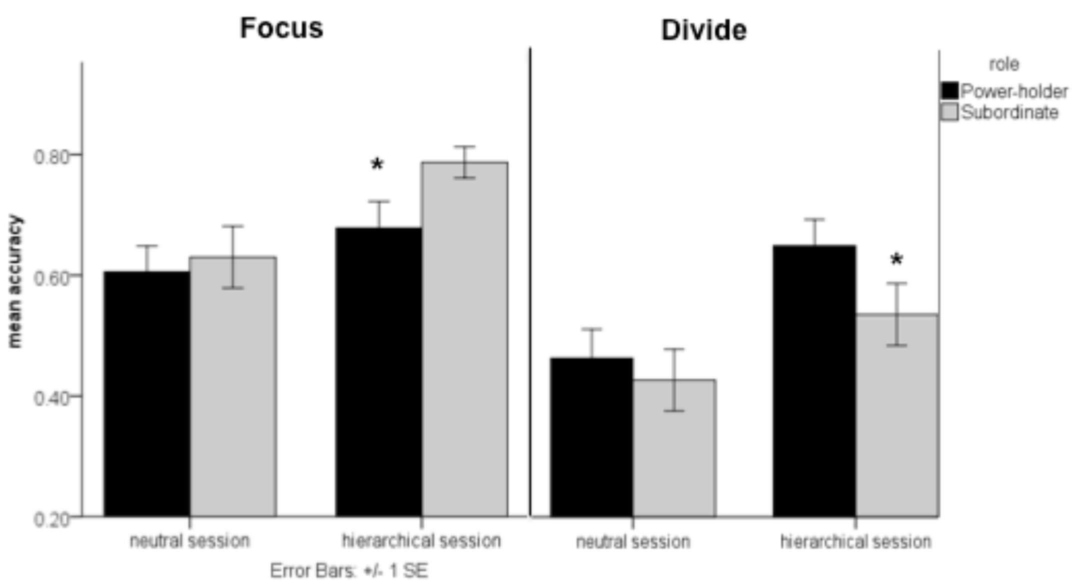

Figure 3.2: Graph displaying mean accuracy in Experiment 3.1a for both the Focus condition (left) and Divide condition (right) for power-holders (black) and subordinates (grey) in neutral and hierarchical sessions. Results show improvement of power-holders in the Divide condition, and improvement of subordinates in the Focus condition.

The Focus condition contained the added variable that targets could appear before or after a shift cue or a stay cue. The average accuracy of participants for the first 6 targets after a shift cue or after a stay cue was computed into a new variable. A mixed-effects ANOVA on *accuracy* was performed with session and cue-type (after a shift cue or after a stay cue) as within-subjects variables and *role* as a between subjects variable. There was a significant effect of role by session, $F(1,22) = 4.33$, $p<0.05$; but no significant interaction between session, role and cue-type.

Pairwise comparisons show that subordinates ($M = 0.898$, $SE = 0.043$) were more accurate than power-holders ($M = 0.759$, $SE = 0.043$) in the hierarchical session, regardless of whether the target appeared after a shift or a stay cue (Figure 3.2)

For reaction time, there was a significant effect of type of task, $F(1,44) = 17.37$, $p <0.001$, revealing that reaction times were shorter on the Focus ($M = 712.16$ $SE =21.66$) conditions than the Divide conditions ($M = 839.81$, $SE= 21.66$). There was a significant effect of session, $F(1,44) = 32.38$, $p < 0.05$, revealing shorter reaction times for hierarchical sessions ($M = 739.15$, $SE = 12.74$) than neutral sessions ($M = 812.82$, $SE = 19.76$) (Figure 3.3). This is likely due to participants improving as they have time to practice and get used to the task. There was no interaction with role, revealing that, unlike the results of accuracy, the power manipulation had no effect on reaction time in this study.

However, this also means that there was no trade-off between reaction time and accuracy for either group or condition. These findings reinforced the findings related to accuracy.

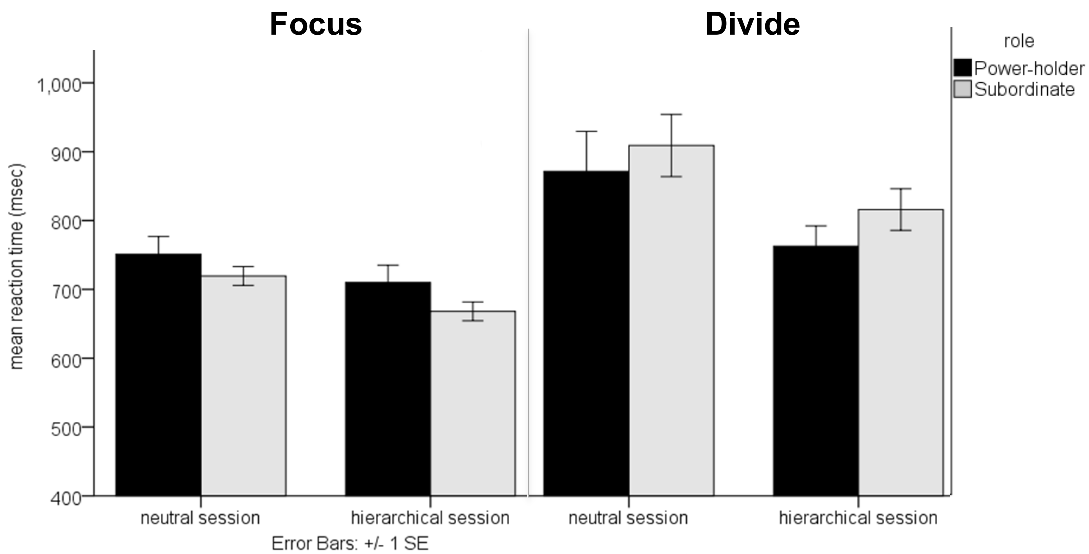

Figure 3.3: Graph displaying mean reaction time in Experiment 3.1a for both the focus condition (left) and divide condition (right) for power-holders (black) and subordinates (grey) in neutral and hierarchical sessions. Error bars are +/- 1 SE.

In sum, the task was working as planned, with participants showing higher accuracy in the Focus condition. There was a significant effect of role by type by session. Contrary to what might be predicted, power-holders were more accurate than subordinates in the hierarchical session of the divide condition, and subordinates were more accurate than power-holders in the hierarchical session of the focus condition.

3.2.3 Discussion

The fact that participants were more accurate in the Focus condition than the Divide condition supports the hypothesis that participants are able to use spatial cues to focus their attention on one peripheral stream, which facilitates the discrimination of stimuli (Brignani et al., 2009; Van Voorhis & Hillyard, 1977). Because participants in the Focus condition were not just dividing their attention but responding to the side indicated by the cue, the effect of power on shifting and dividing attention separately could be investigated. That there was a significant improvement in accuracy in the hierarchical session compared to the neutral session is understandable given familiarization with the task over time. This improvement can fairly be put down to practice effects.

Power-holders and subordinates did have distinct changes in accuracy in the hierarchical session, but the analyses showed that these changes were in the opposite direction to what was initially hypothesized. Rather than subordinates being more accurate in the Divide condition and power-holders being more accurate in the Focus condition, the opposite was found. While contrary to our hypotheses, the literature on power offers several possible explanations.

It is possible that the results can be explained due to the distractors. The Focus condition is less distractor-heavy than the Divide condition, as there are only three distractor streams on the attended side, rather than six distractor streams when attempting to attend to both sides. Subordinates have been shown to be more susceptible to distracting information (e.g., Guinote, 2007b) despite being careful discriminators (Weick et al., 2011), which may explain their superior performance on the Focus condition. There are fewer distractors to deal with, so they can focus on discriminating the targets. On the other hand, power-holders have been shown to be less susceptible to goal-irrelevant distractors, which would explain their superior performance on the Divided condition. Under such a hypothesis, it is assumed that the groups do not differ in the ability to orient attention to the relevant stream. This hypothesis was investigated in the next experiment.

Before this was conducted, it was necessary to address the possibility that subordinates performed better on the Focus version because they ‘cheated’ on the hierarchical session by moving their eyes. Given that one knows which side one is meant to be detecting targets, it would aid accuracy if one were to look at that side, rather than keeping gaze on the central fixation point. In the divided condition, there is no advantage to looking at either side as targets can appear on both sides of the screen, and it may in fact hinder accuracy. Participants were under the impression that their eyes were being monitored by eye-tracking cameras present in the booths. However, practical limitations prevented eye-tracking both participants simultaneously, although their eyes could be observed on the monitors. A control experiment was conducted (Experiment 3.1b) to test whether this was the case.

3.3 Experiment 3.1b

3.3.1 Methods

3.3.1.1 Participants

6 pairs (4 female pairs) of participants completed this control experiment, aged 18-23. Participants were recruited from Oxford’s population. The experiment was approved by Oxford’s Central University’s Research Ethics Committee (CUREC), and participants provided written consent.

3.3.1.2 Procedure

The same power manipulation and task instructions were used as in the first experiment. There was interest in whether power had an effect on how much participants saccaded during the shift cues. Therefore, participants only performed the Focus version of the task.

3.3.1.3 Electro-oculogram (EOG) recording and analysis

Eye movements were monitored by deriving bipolar recordings from electrodes placed horizontally to the left of the left eye and right of the right eye (HEOG); blinks were monitored by deriving bipolar recordings from electrodes placed above and under the right eye (VEOG). Two electrodes were placed on the right and left mastoids, and the right mastoid was used as the active reference site. An electrode placed in front of Fz (AFz) served as the ground. The signals were amplified with a low-pass filter 200 Hz by Neuroscan amplifier, and digitized at a sampling rate of 1000 Hz.

Data were re-referenced to the average of the two mastoids and re-filtered digitally with a low-pass of 40 Hz. VEOG epochs epochs started 200 msec before and ended 1000 msec after presentation of the shift or stay cues. All amplitude values were referred to the 200-msec pre-cue baseline. Trials were automatically eliminated if the voltage exceeded ±50 μV at VEOG.

Saccades were identified by inspecting the HEOG channels. HEOG epochs were visually inspected, and were labeled as a saccade if a sustained deflection exceeded ±10 μV from cue onset to 800 msec post-cue. These conservative parameters were implemented to make sure that the task was being performed accurately. For each participant, the proportion of shift or stay cues which with saccades was calculated from the total number of cues.

3.3.2 Results

To investigate whether power affected the tendency to saccade during the shift cues, we submitted the proportion of shift cues with saccades to a mixed-effects ANOVA with *role* as the between-subject variable and *session* as the within-subject variable. The interaction between role and session did not reach significance (p=0.16), but the means revealed that, if anything, power-holders showed an increase in the proportion of saccades, and the subordinates showed a decrease across session (Figure 3.4). This confirmed that the results of the first experiment were unlikely due to an effect of the power manipulation on the tendency to saccade.

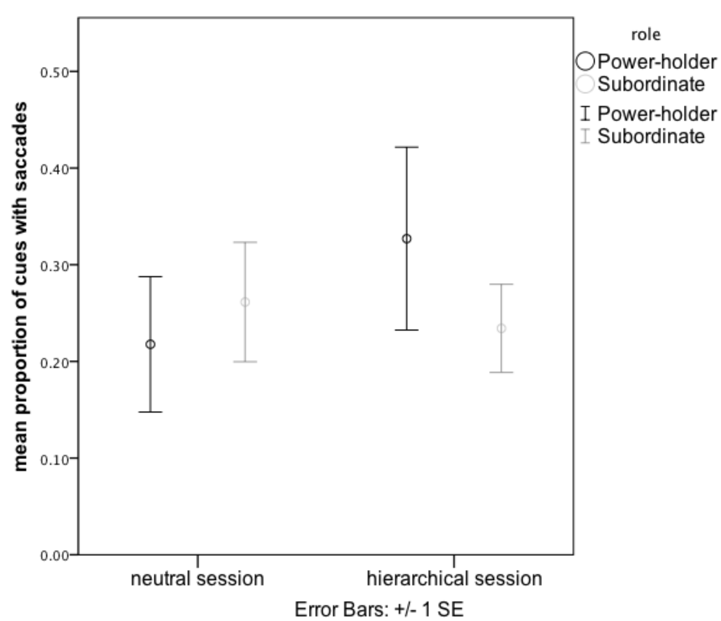

Figure 3.4: Graph displaying saccading behaviour in Experiment 3.1b, with proportion of cues with saccades (from cues without saccades) in the Focus condition, for power-holders (black) and subordinates (grey), in neutral and hierarchical sessions. Results do not suggest an effect of power manipulation on the tendency to saccade.

Accuracy was submitted to a mixed-model ANOVA with role as the between-subject variable, and session as the within-subject variable. There was a significant effect of session, $F(1,10)=21.49$, $p<0.001$, revealing higher accuracy for the hierarchical session ($M=0.49$, $SE=0.076$) than for the neutral session ($M=0.62$, $SE=0.065$).

3.4 Experiment 3.2

This experiment was conducted to test the hypothesis that the effects of power in the first experiment are better explained by different abilities to inhibit distractors.

3.4.1 Methods

3.4.1.1 Participants

Twenty pairs of participants completed this study, aged 18-24. Ten pairs completed the Divide version of the task, and 10 pairs completed the Focus version. Participants provided written consent, and the experiment was approved by the University of Oxford’s Central University Research Ethics Committee (CUREC).

3.4.1.2 Procedure

The stimuli and instructions were identical to Experiment 3.1a, except that the distractors immediately surrounding the two stimulus streams that could be relevant to behaviour were removed. Figure 3.5 is a schematic representation of what the task looked like for each participant. To avoid the order effects that arose from requiring participants to perform both the Focus and the divide conditions, each pair only performed one of the two conditions. The induction of the power manipulation was done in the same manner as in Experiment 3.1a.

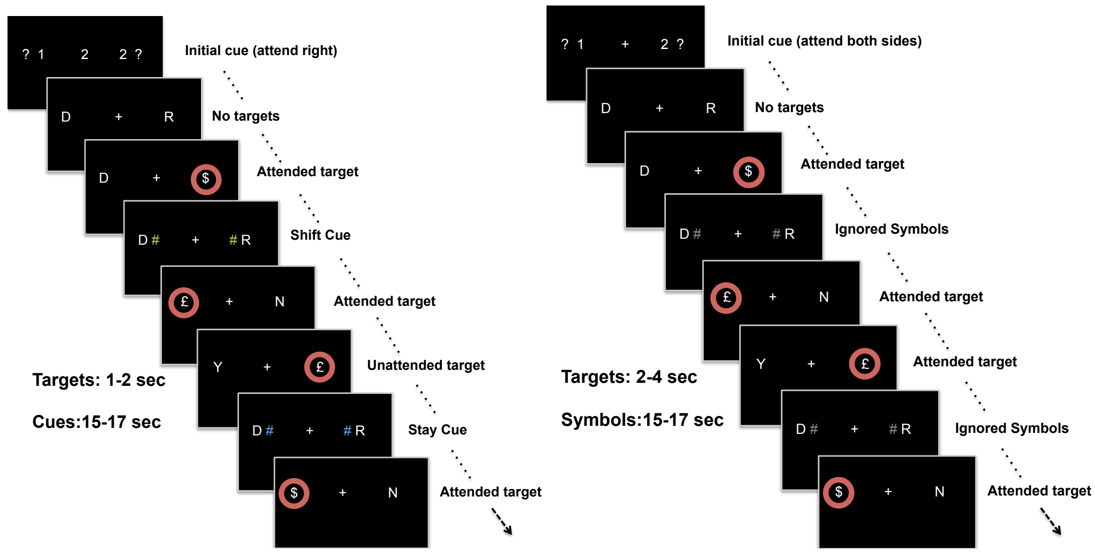

Figure 3.5: A schematic description of the orienting task without distractors in Experiment 3.2, with the Focus condition (left) and Divide condition (right). Either target ($ or £ symbol) could appear in one of the two locations marked by circles. In the Focus condition, a green "#" cue, indicating the need to shift to the other stream, is shown in the 4th panel. A blue "#" sign, indicating the need to stay on the same side, is shown on the seventh panel. Each session consisted of 10 blocks, lasting roughly 10 minutes in total. Shift or stay cues appeared every 15-17 seconds, and targets appeared every 1-2 seconds. In the Divide condition (right), grey "#" symbols appeared every 15-17 seconds but had no function except to equate visual stimulation between both conditions. All targets were attended, and appeared every 2-4 seconds.

3.4.1.3 EOG recording and analysis

The same procedures and parameters for EOG recoding and analysis were used as in experiment 3.1b. EOG recordings were also performed on the participants who performed the divided condition, to ensure that the task instructions regarding fixation were being followed. Although EOG recordings were not as essential as those in the Focus version, another reason they were conducted was to equate the participants' experience while performing the experiment in both conditions, to ensure that any differences in performance were related to the parameters being investigated.

The Divide version contained no cues instructing participants to shift their attention. However, the same “#” symbols were presented, at similar intervals, grey in colour, in an attempt to equate visual stimulation between the two tasks. Epochs of the EOG recordings were extracted by taking 200 ms before, and 1000 msec after the “#” symbols. Since the symbols appeared at the same timings as the shift and stay cues in the Focus version, saccade inspection was equated across task versions. These epochs were inspected for saccades, and the proportion of epochs with saccades was calculated from the total number of saccades.

3.4.2 Results

To ensure that the task was working as expected, there was an interest in whether participants were actually using the cues to focus their attention. The main aim was to identify whether the effects of power in the first experiment could be replicated here.

These points were investigated by two mixed-effects ANOVAs looking at proportion of accurate trials (accuracy) and reaction time separately, with *type* of task completed (Focus or Divide) and role (power-holder or subordinate) as the between-subjects variables and *session* (neutral or hierarchical) as a within-subjects variable. All 20 pairs of participants were included in this analysis.

For accuracy, there was a significant effect of type of task, $F(1,36) = 4.38$, $p < 0.05$, revealing that accuracy was higher on the Focus ($M = 0.60$ $SE = 0.039$) conditions than the Divide conditions ($M = 0.484$, $SE = 0.039$). There was also a significant effect of session, $F(1,36) = 77.30$, $p < 0.001$, revealing higher accuracy for hierarchical sessions ($M = 0.61$ $SE = 0.028$) than neutral sessions ($M = 0.48$, $SE = 0.029$). Role did not emerge as significant, either as an interaction with session, or as an interaction between session and type, revealing that, unlike the first experiment, the power manipulation had no effect on accuracy in this task.

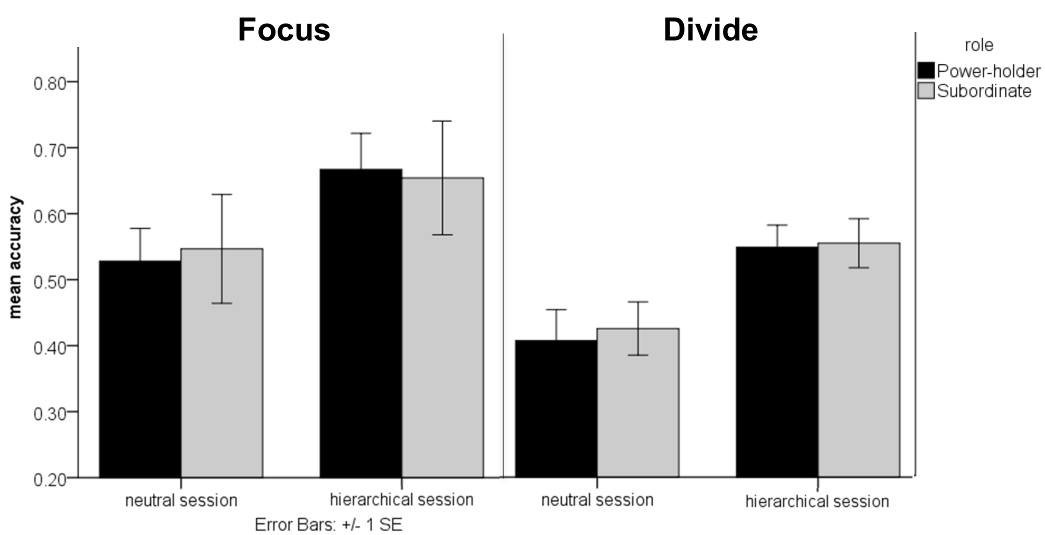

Figure 3.6: Graph displaying mean accuracy in Experiment 3.2 for both the Focus condition (left) and Divide condition (right) for power-holders (black) and subordinates (grey) in neutral and hierarchical sessions. Error bars are +/- 1 SE.

The manipulation, however, had an effect on reaction time. There was a marginally significant effect of type of task, $F(1,36) = 3.82$, $p = 0.058$, revealing that reaction times were shorter on the Focus ($M = 786.64$ $SE = 21.26$) conditions than the Divide conditions ($M = 845.39$, $SE = 21.26$). There was a significant effect of session, $F(1,38) = 5.53$, $p < 0.05$, revealing shorter reaction times for hierarchical sessions ($M = 790.76$, $SE = 14.76$) than neutral sessions ($M = 841.27$, $SE = 16.76$). This is likely due to participants improving as they have time to practice and get used to the task.

type	role	session	Mean RT	Standard Error
focus	power-holder	neutral	820.25	33.52
		hierarchical	789.58	29.53
	subordinate	neutral	791.95	33.52
		hierarchical	744.79	29.53
divide	power-holder	neutral	832.79	33.52
		hierarchical	813.39	29.54
	subordinate	neutral	920.10	33.52
		hierarchical	815.31	29.53

Table 3.1: Table displaying mean reaction times and standard errors of the means in Experiment 3.2 across type of task (focus or divide), role (power-holders or subordinates), and type of session (neutral or hierarchical).

There was a significant interaction between role and session, $F(1,36) = 6.89$, $p < 0.05$. To simplify the analysis, the change in reaction time (RTchange) was calculated by subtracting the reaction times of the neutral session from those of the hierarchical session. RTchange was compared between the power-holders and subordinates by an independent samples t-test. Subordinates showed significantly more decrease in RT (M=-75.97, SE=16.21) than power-holders (M=-25.04, SE=11.80, $t(1,20)=2.31$, $p<0.05$) (Figure 3.7).

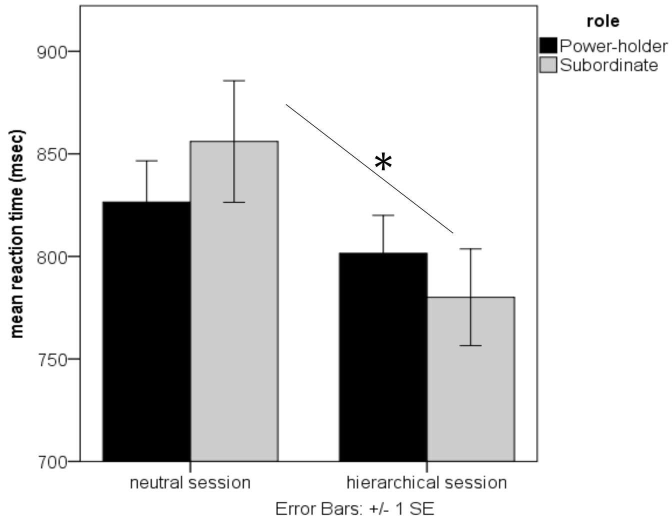

Figure 3.7: Graph displaying mean reaction time in Experiment 3.2 for the average of the Focus and Divide condition, for power-holders (black) and subordinates (grey) in neutral and hierarchical sessions. Results show improvement of subordinates (significant shortening of reaction time across session).

There was no interaction with type of task, indicating that this effect was present for both the Focus and Divide versions. This differed from the results of Experiment 3.1a showing distinct effects of power on the Focus and Divide versions.

As in Experiment 3.1b, I investigated whether any result could be attributed to an effect of power on saccades.

For the Focus condition, after calculating the proportion of cues with saccades, the values were submitted to a mixed-effects ANOVA with *role* as a between-subject variable and *session* as a within-subject variable. There were no significant effects, revealing that the manipulation had no effect on saccading behaviour. A similar analysis was conducted for the Divided condition. As specified in the methods section, epochs were extracted from the EOG recording, resembling the number and frequency of cues in the Focus variant of the task. Again, no effects emerged as significant (Figure 3.8), revealing that power did not have an effect on participants' propensity to saccade.

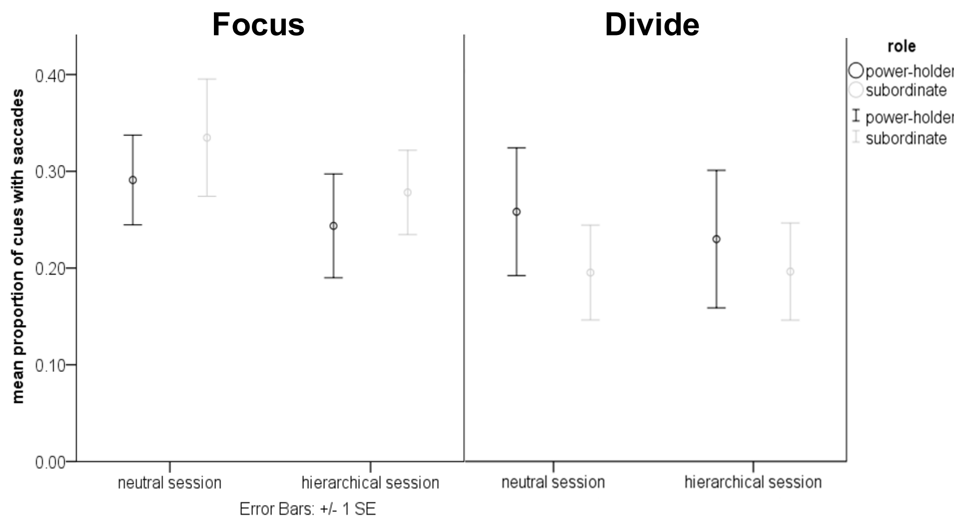

Figure 3.8: Graph displaying saccade behaviour in Experiment 3.2, with mean proportion of cues with saccades for the Focus condition (left), and proportion of intervals with saccades in the Divide condition (right), for power-holders (black) and subordinates (grey) in neutral and hierarchical sessions. Error bars are +/- 1 SE.

3.4.3 Discussion

This task showed the expected patterns of behavioural responses for an orienting task, along the lines of the first experiment. Higher accuracy and lower reaction time for the Focus condition indicated that participants were actually making use of the cues to orient their attention towards the desired location. With respect to the effect of the power manipulation, the lack of distractors provided a different pattern of results than those of Experiment 3.1a. In this study, subordinates were faster in both the Focus and Divide version showing no effect of power on orienting per se. There were no differences in accuracy, showing that there was no speed-accuracy trade-off. Eye movement data showed that the results could not be attributed to different tendencies to saccade.

3.5 General Discussion

This study was conducted in an attempt to investigate whether power leads to distinct pattern of deployment of attention to those who lack it, and those who possess it. This has been hinted in previous studies, by showing superior abilities in power-holders to orient their attention flexibly to goal-relevant information (e.g., Slabu et al., 2012), and superior abilities in subordinates to discriminate details in stimuli present within a broader attention window (Weick, Guinote, & Wilkinson, 2011). This study employed a complex task that could probe both of these suggested ideas, equating overall task goals and stimulus characteristics otherwise. The importance of this lies in the fact that different power manipulations, different task instructions, and different stimuli have important effects on a task, especially when the variable of interest is as complex and multifaceted as power.

In the first experiment, a task was used where participants had to identify targets in two peripheral streams, surrounded by distractors. In one condition, attention was directed to one stream at a time by orienting cues. This task required flexible orienting of attention and focus, and it was initially hypothesized that power-holders would surpass subordinates in the speed and accuracy with which they perceived targets. In the second condition, participants were required to divide their attention between the two streams and identify targets on both sides. Since this task required discrimination of targets present within a broader attentional window, it was hypothesized that subordinates would surpass power-holders. Distractors were added to avoid ceiling performance, and to keep the task similar to those used in other studies that investigate shifts of spatial attention (Brignani et al., 2009; Yantis et al., 2002). The results, however, were counter-intuitive: power-holders were more accurate in the version that required attention to multiple sites, whereas subordinates were better at the version that required focusing attention to one site at a time. This was the case regardless of whether the targets appeared directly after a cue to shift attention, or a cue to stay in the same location. A subsequent control experiment, which employed EOG recordings, eliminated the possibility that the results could be explained by an effect of power on the tendency to saccade.

It was then hypothesized that feature-based attention could have a role in explaining these results. As outlined in the introduction, the task employed here diverged from classical orienting tasks by incorporating feature selection from among competing distractors. The presence of distractors, affecting perceptual load, could explain the results of the first experiment. It has been suggested that subordinates process environmental information rather indiscriminately, with less ability than power-holders to inhibit distracting information (Guinote, 2007a; Smith et al., 2008). In the task used in the first experiment, the Divided version involved more distractors to deal with in the attended area than the Focus version. The Focus version, despite requiring the orienting of attention to either location, involved fewer distractors, and had higher accuracy in general. It was possible that the amount of information that necessitated inhibition would dictate at which task power-holders versus subordinates would excel. This would imply that the groups do not differ in their ability to orient attention towards a particular spatial location. To test this hypothesis, a second experiment was conducted, which was identical to the first, but distractors were removed from the stimuli. EOG recordings were also implemented for all participants to ensure that the results could not be attributed to changes in the pattern or number of overt gazes across groups.

The second experiment revealed that subordinates provided faster responses than the power-holders in both the Focus and Divide conditions. There was no clear effect of power on the ability to orient attention in space. Even in the Focus version of the first study, subordinates surpassed power-holders, regardless of whether the targets appeared after a cue to shift attention or to stay in the same location, making the results attributable to orienting per se unlikely.

The results contribute evidence to the fascinating ways in which power affects the selection of information from the rich environments we operate in. Attention selection is itself a complex and multi-faceted mechanism. According to the perceptual load theory (Lavie, 1995, 2000) the attention bottleneck, where selection for further processing occurs, varies according to how perceptually demanding a certain task is. When a task imposes few perceptual demands, distracting stimuli can still be processed at the early perceptual stage, while later stages towards conscious representation will be influenced. When the task is demanding, however, perceptual filtering can occur at a relatively early stage of perceptual analysis. Power-holders and subordinates may differ in the extent of how prone they are to process distracting information, whether their “bottleneck” occurs at different stages. This may be explored more robustly with neuroimaging. It may be possible to explore whether subordinates' attention is captured by the distracting stimuli to a similar extent as the targets, which may be achieved with an EEG study via analysis of the N2pc potential (e.g., Brignani et al., 2010).

It has been shown already that attentional capture by task-defined features can operate independently of orienting, and may override the spatial bias instructed by orienting cues (Brignani et al., 2010). It may be the case that feature-based attention is more susceptible to power than spatial orienting, although more evidence would be desirable. As mentioned at the beginning of this chapter, the tasks which have investigated power with respect to attention orienting have not employed feature-based attention to the extent that this study has done so. For example, in the study reported by Slabu et al. (2012), participants had to override the wrong information provided by invalid cues, and readjust their attention to location where the target appears. There is no particular need to identify task-relevant features, as the target either appears or does not. Despite the fact that previous tasks provide a purer measure of orienting, one would expect that, even in the current task, power-holders would be more accurate or faster at detecting tarts that appear directly after a shift cue. This result, however, was not found. It seems like readjustment of spatial attention after incorrect information, a good measure of flexibility, is more sensitive to power than the speed at which adjustment happens.

A theme that is gaining strength and support in the social and cognitive psychology literature linking subordination to up-regulation of cognitive function (Berscheid et al.,1976; Fiske et al., 2010; Keltner et al., 2003). The vigilance hypothesis states that subordinates are endogenously more vigilant than power-holders, due to the presence of more threats in their environment (Keltner et al., 2003), which serves to facilitate the discrimination of stimuli (Callejas et al., 2004). It is possible that this may be linked to the release of cortisol, which promotes heightened environmental sensitivity, especially to threatening stimuli (Bakvis, Spinhoven, & Roelofs, 2009). Subordinates who are exposed to stressors display higher baseline rates of cortisol (Abbott et al., 2003), and even an experimental induction of power versus subordination affects endocrine levels in a complementary manner (Carney, Cuddy, & Yap, 2010). This hypothesis is starting to gain empirical support from the attention literature, as subordinates were shown to be less responsive to cues that alert them to the presence of targets, supposedly due to an internally alert state (Willis et al., 2011).

The manifestations of an endogenously alert and vigilant state may lead to positive or negative outcomes, according to the type of environment these individuals operate in, and the situational demands. On the positive side, it facilitates the discrimination of stimuli. On the down side, it may impair the ability to focus attention on relevant items (Guinote, 2007a, 2007b), especially when the environment is high in perceptual load. This study adds some evidence in that direction. Subordinates become carefully attentive to their environments, taking as much detail as possible within broad attentional windows. Importantly, the consequences of this mechanism vary according to the type of environment that they are operating in, and how demanding it is. While this may be useful to discriminate stimuli, it may cause impairments when a task requires inhibition of irrelevant information (Guinote, 2007b; Smith et al., 2008). In environments where more inhibition of stimuli is necessary, broadly focused allocation of attentional resources comes at a price.

This study would have benefited from a control group that remains hierarchically neutral across two sessions. Although there is information to be gained from the fact that power-holders and subordinates in the current design move from a neutral state to a hierarchical state, a control group would have also been informative. A control group would allow a more precise investigation of whether it is power or subordination driving any behavioural effects; for example, it would become clearer whether power-holders become better inhibitors, whether subordinates become poor inhibitors, or whether both change. There are changes in cognitive processing that occur with practice across session that may be hard to disentangle from the effects of power. In the subsequent experiments, a control group is added to have a better understanding of observed effects.

It may also be relevant to explore whether motivational/arousal variables, or even anxiety, can account for the effects reported in this study. There is some evidence, for example, that anxiety has effects on attention selection, (Eysenck, Derakshan, Santos, & Calvo, 2007b). According to attentional control theory proposed by Eysenck et al. (2007), anxiety is associated with an increased influence of the stimulus-driven attentional system and a decreased influence of the goal-directed attentional system. This affects the outcome of the bidirectional influences of each system on the other. For example, the bottom-up system is influenced by an automatic tendency to process threatening stimuli, which reduces the influence of the top-down system. In addition, reduced influence of goal direction on attentional processes allows for more “hijacking” by conspicuous stimuli. Subordination has been linked to anxiety, to higher stress levels, and to higher levels of cortisol (Abbott et al., 2003; Keltner et al., 2003). It is not far-fetched to assume that an experimental manipulation of subordination comprises elements of state anxiety, which may facilitate the discrimination of salient stimuli. Although this has been proposed to operate for stimuli that elicit capture in a bottom-up fashion, we also know that task-defined features can also capture attention in a powerful way (Brignani et al., 2010). It would be interesting to manipulate anxiety without a power manipulation in a similar type of task.

With regard to the current study, it is also possible to question whether the effects here can simply be attributed to the confidence gained at ‘winning’ and the disappointment at ‘losing’, without having anything to do with asymmetrical control over a given resource. This can be tested with an identical paradigm where participants perform this task after allegedly ‘winning’ or ‘losing’, without a power hierarchy allocation. Win or loss may have motivational consequences, which would influence the way attention is deployed. However, for the purposes of this study, and in defense of the procedure used, a power manipulation which is based on random allocation to a role may be perceived as illegitimate, which moderates the effects of power (Lammers et al., 2008). Also, a practical operationalization of power by conferring actual control over resources arguably bears more similarity to real-life power than priming.

In conclusion, thus, the results of this study add some complexity to the hypothesis that power has a direct effect on the attention orienting system. This is not surprising, as attention is complex and multi-faceted, mediated by interacting neural systems. Social and motivational factors can affect the functioning of these networks (Pacheco-Unguetti et al., 2010), which is likely the case with power. The underlying mechanism is undoubtedly complex, and is likely to involve interactions among motivational needs to restore control, anxiety, and heightened vigilance.

4 Chapter 4: Power, Executive Control, and Feedback Processing

4.1 Introduction

After exploring the effect of power on attention in a paradigm where the power-holder and subordinate hardly interacted at all, it was time to move to a scenario with more ecological validity. Power is an inherently social construct, which can highly benefit from more contextualized and interactional scenarios (Bekkering et al., 2009). Individuals, in the end, do not act in a social void.

This study added a layer of complexity to the one discussed in Chapter 3, by having power-holders and subordinates ‘observe’ each other as they engage in a task that taps into attention processes, and receive feedback indicating monetary gains and losses. To measure aspects of information-processing that may not be available from behavioural response measures alone, a paired electro-encephalogram (EEG) paradigm was employed. Behavioural performance, although informative, is preceded by a complex chain of mental events that are also sensitive to power (Keltner et al., 2003). This study exploited the greater interpretative power provided by the fast temporal resolution of EEG, as discussed in Chapter 2. By measuring information-processing unfold on a millisecond time scale, it became possible to identify cognitive and motivational processes that might underlie the behavioural effects of power, in addition to affective processes that may not surface at the level of behaviour.

A paired EEG setup in which participants interact, or believe they interact, also allowed the creation of interesting dyadic contexts that may be present in a social environment. The power manipulation was similar to the one employed in the previous chapter. Under such a setup, the power-holder and subordinate work together towards a communal gain in the hierarchical session, and can see each other's incremental gains and losses. If one sets aside the fact that a power hierarchy exists at this stage, the fact that the two individuals are both contributing to the sum means that, in a sense, they are cooperating. Cooperation, in this context, refers to a scenario where power-holders and subordinates work towards a communal gain, without task interdependence. This scenario is relevant to understanding the work dynamics in institutions where power hierarchies exist, and poses the question of whether power allows for balanced cooperation. Who is the more diligent cooperator? Is it the power-holder, who is ultimately in control of the communal gains? Or is it the subordinate, who has to depend on the power-holder to obtain a share? How well do they perform on the task? Do they perceive joint losses and gains in the same way? Adding a control experiment, which employed the same task without a power manipulation, allowed these questions to be explored.

This setup, with the aid of EEG recordings, also allowed the investigation of how power affects feedback processing, tapping into motivational and affective self-evaluation processes, which are also very relevant to performance (Kluger & DeNisi, 1996).

This study, therefore, had multiple aims. In the first instance, it addressed the effect of power on cognitive processes by taking advantage of the precision conferred by EEG recordings. It also explored the effect of power on performance evaluation through feedback processing. Finally, it allowed the exploration of how power affects cooperative behaviour.

4.1.1 Power and executive control

As discussed, there is some evidence to suggest that power and subordination lead to different strengths in the attention systems of the brain (Guinote, 2007a; Smith & Trope, 2006; Weick, et al., 2011), to suit individuals' adaptive needs. In the previous chapter, I investigated the possibility that power affects the ability to orient attention to different locations in space. The results pointed to a possible role of inhibition in interpreting the results, where subordinates may be at a disadvantage when it comes to inhibit goal irrelevant information. Inhibition impairments have already been linked to subordinates in the literature (e.g., Smith et al., 2008; Guinote, 2007b).

Inhibition, however, is a complex function. Inhibition can be conceived as a property of orienting, where irrelevant, competing stimuli have to be perceptually filtered out. Inhibition may also refer to the cancellation of prepotent responses, as measured in paradigms like the go/no go task (Drewe, 1975). Inhibition is also part of executive control, which is concerned with filtering out primed stimulus-response tendencies (Botvinick, Cohen, & Carter, 2004). Inhibition may also involve broader, high-level processes, like disregarding social information that are not goal-relevant. Investigations of inhibition have employed a variety of behavioural paradigms, and it is generally assumed that each task involves a common, or at least closely related, inhibitory mechanism, although this is subject to debate (Chambers, Garavan, & Bellgrove, 1975).

A hypothesized effect of power on inhibition comes as no surprise. As discussed in the previous chapter, the different affordances and constraints faced by power-holders and subordinates are proposed to shape the relative strengths in the way which they deploy attention (Guinote, 2007a; Smith et al., 2008). A subordinate's world is full of constraints, uncertainties, and proneness to evaluation by others (Keltner et al., 2003). Control deprivation leads them to adaptively become more vigilant, paying careful attention to multiple stimuli in their environment to improve their chances of survival (Berscheid et al., 1976; Pittman & Agostino, 1989). Thus, subordinates are proposed to process information in a systematic yet indiscriminate way, which may cause impairments when a task requires the inhibition of unwanted information (Guinote, 2007a, 2007b; Smith et al., 2008).

The current literature on power and inhibitory processes is offering some interesting findings. In a recent study (Guinote, 2007b), subordinates were at a disadvantage compared to power-holders when they had to inhibit responses primed by peripheral information in a visual stimulus. In this study, participants were required to indicate whether certain objects with handles were upright or inverted. The results showed that subordinates experienced more interference than power-holders when the handle was in the opposite direction to the response hand, leading to slower responses. Consistently, Smith et al. (2008) showed that subordinates under-performed on a Stroop task, indicating impairments on inhibition of prepotent verbal responses. Similarly, De Wall et al.

(2010) showed that subordinates under-performed on a dichotic listening task, which also requires inhibitory processes.

However, other findings suggest that more research is needed to identify the effect of power on inhibition, especially in contexts where executive control is required, which has been proposed to be affected by power (Smith et al., 2008). Before continuing, it is important to define executive control and executive functions, especially within the context of inhibition. Executive control involves a group of adjustment processes, which includes detection and resolution of conflict, and maintenance of contextual information (e.g., Pessoa, 2009). Executive control is not unitary, and different mechanisms within it, or executive functions, can have their own limited processing capacities or resources. The partitioning of executive functions is supported by neuropsychological research, although the exact categorization is subject to debate, but probably involves at least three functions: inhibition, planning, shifting task sets, and updating (Miyake et al., 2000). Inhibition, in this context, involves relatively complex operations engaged during monitoring and resolving conflict between computations (Bush, Luu, & Posner, 2000).

The effect of power on inhibition as an executive function is not straightforward. In a recent study, Willis et al., (2011) explored the effect of power on attention using a complex attentional task. There were Posner-type orienting cues, which could cue participants to valid or invalid locations where targets could appear. Targets could either be surrounded by distractors which primed congruent, or incongruent, response tendencies. The executive control aspect of the task involved responding to targets that were closely flanked by distractors priming opposite response tendencies (Botvinick, Braver, Barch, Carter, & Cohen, 2001), which required the detection of conflict and inhibition of unwanted responses. The results did not show a simple effect of power on inhibition as n executive function, as would be expected from the literature. Power-holders did not out-perform subordinates in inhibiting or filtering out the distracting stimuli in general. Rather, only when orienting cues were valid, power-holders improved performance on trials that required inhibiting distractors. The authors interpreted this finding by stating that power-holders used orienting cues more efficiently to reduce the conflict effect arising out of the distractors.

In the current study, I explore the effect of power on the executive function of inhibition using a simple and well-defined task for this purpose. The task implemented is an adapted version of the Eriksen Flanker task (Eriksen & Eriksen, 1974). The task requires selective processing and responding according to the direction of a centrally presented arrow target amidst flanking distractor arrows, whose direction can be congruent or incongruent to that of the target. Incongruent trials have been shown to elicit slower response times, due to the need to resolve conflict elicited by the responses evoked by distractors. In this version of the task, different shapes of arrows were used, and each participant was assigned to one arrow shape. Participants could see each other's trials but were requested to respond on their trials only. The exact task parameters are elaborated in the methods section of this chapter.

Using this task, it was possible to investigate if subordinates experience higher conflict on their incongruent trials, indicating impaired inhibitory executive control. In addition to the information provided by the behavioural data, neural measures also provided an additional layer of data. Event-related potentials (ERPs) provide rich and direct measures of the different stages of information processing, from perception to response (Luck, 2005). Behavioural data, although informative, can be contaminated with other factors like motivation, fatigue, effort, etc. Additionally, ERPs allow access into motivational and affective states that may not surface at the level of behaviour.

4.1.1.1 Relevant ERPs

The N2 (Kopp, Rist, & Mattler, 1996) is a negative fronto-central potential, appearing 250-300 msec after a stimulus, which is thought to be an index of conflict detection (Van Veen & Carter, 2002). There is consensus that it reflects a need to control early incorrect response preparation primed by the competing distractors (Folstein & Van Petten, 2008). If subordinates show a more pronounced N2 than power-holders for incongruent compared to congruent trials, it would suggest they experience greater conflict, and poorer executive control (Heil, Osman, Wiegelmann, Rolke, & Hennighausen, 2000). If this is the case, we would also expect slower reaction times on incongruent trials (Yeung, Botvinick, & Cohen, 2004)

Later potentials may reflect top-down attentional and motivational factors that come after basic attention processes. The P3 is one such potential observed 300-600 msec after viewing targets (Polich, 2007; Sutton, Braren, Zubin, & John, 1965). Classically, P3 was thought to reflect processes related to context-updating in working memory (Donchin & Coles, 1988). The P3 is a multi-faceted potential, and it has been subdivided into P3a and P3b components. P3a follows a fronto-central distribution, and is generated when significant, rare, or physically alerting stimuli are present. P3b peaks later and has a centro-parietal distribution, and is thought to be generated when subsequent attentional resource activations promote memory operations (reviewed in Luck and Kappenman, 2011). A popular account is that P3 amplitude is sensitive to the attention paid to, or motivational significance attached to the stimulus (Nieuwenhuis, Aston-Jones, & Cohen, 2005; Polich, 2007).

By having data from N2 and P3b potentials elicited by the target, it is possible to determine whether any behavioural effects could be attributed to changes at a basic cognitive level, or to later, top-down processes (Luck, 2005). Additionally, P3b elicited by the other person's targets would provide information related to the processing resources devoted to these targets, in the absence of overt responses.

4.1.2 Power and feedback processing

From another perspective, it is unlikely that the effect of power on task performance happens exclusively through its effect on attention. Humans pursue goals in various affective and motivational contexts, and they receive feedback from the world around them. There is evidence linking subordination to heightened anxiety levels and negative mood (Keltner et al., 2003). Anxious individuals have been shown to perceive the same feedback as more negative and threatening than do non-anxious individuals (Smith & Sarason, 1975). The way feedback is processed and attributed may have important consequences on behaviour, where negative feedback becomes detrimental if it is thought to reflect on the self rather than the task (Kluger & DeNisi, 1996). Due to the suggestion that subordinates engage in high self-monitoring, and selectively attend to threat and punishment signals at the expense of rewards (Keltner et al., 2003), it is likely that feedback may provide an important avenue of exploration with bearings on task performance.

In a recent study (Boksem, Kostermans, Milivojevic, & De Cremer, 2011), the effect of social status on performance evaluation was investigated in a paradigm that bore many similarities to the one employed in this study. Participants performed a time-estimation task in groups of three, received bogus feedback, and were randomly ranked as best, medium, and worst player. This was the status hierarchy inducing session. Afterwards, they performed the same task again, where they were given similar feedback, which translated into a monetary gain that was split in three. EEG was recorded in this second session, and the authors showed that low status individuals showed a more enhanced "medial frontal negativity" to losses, which was interpreted as they experienced more social evaluation threat. Although the authors proposed the legitimacy of using status and power interchangeably, this may be problematic as status does not imply control deprivation.

Participants were given random feedback indicating monetary gains or losses after every correct trial (negative 25% of the time), which they believed to be signaling their true performance abilities, based on a changing speed criterion. The ERP literature suggests that feedback is processed at multiple levels, from both a decision-making, reward expectancy perspective and an affective/motivational perspective (Wu & Zhou, 2009; Yeung & Sanfey, 2004).

4.1.2.1 Relevant ERPs

The Feedback-related negativity (FRN) (Miltner, Braun, & Coles, 1997) is a negative central potential which is more negative for negative feedback, allowing a distinction between bad versus good outcomes. One of the most popular interpretations is that the FRN codes reward prediction errors (Holroyd & Coles, 2002), where reward expectation may be coloured by subjective/motivational factors (Gehring & Willoughby, 2002). In general, FRN is investigated in studies where participants had little or no control over their outcomes, where gambling is a popular paradigm (De Bruijn & Von Rhein, 2012). Another interpretation of the FRN is that it reflects how concerned subjects are over making mistakes, especially in a social context (Boksem et al., 2011).

The FRN can also be elicited when viewing other people's feedback (oFRN), and some studies suggest that it is sensitive to the relationship between the actor and observer (Itagaki & Katayama, 2008; Marco-Pallarés, Krämer, Strehl, Schröder, & Münte, 2010). These studies suggest that errors are processed according to the effect they have on the self, i.e., a competitor's gain may elicit an oFRN, or a cooperator's loss.

Using the FRN, it was possible to investigate whether power-holders and subordinates differed in the extent to which they cared about, and expected, monetary losses. oFRN would show how power affects the way other's gains and losses are processed.

Feedback stimuli also hold a subjective/affective value, indicating the personal magnitude of the encoded gains and losses. In general, emotionally valent stimuli, whether positive or negative, are associated with larger P3s than emotionally neutral stimuli (Johnston, Miller, & Burleson, 1986), and the feedback P3 has been shown to correlate with absolute reward magnitude (Yeung & Sanfey, 2004). Feedback P3 is interpreted to represent a top-down controlled process of outcome evaluation, into which allocation of attentional resources and reward valence and magnitude may come into play (Wu & Zhou, 2009). This potential would be helpful to indicate whether feedback coding the same wins and losses would be perceived as larger in subjective magnitude in one of the two groups.

By recording the neural activity of participants as they responded to targets and received feedback, it was possible to observe the effect of power on cognitive and motivational elements of task performance. The first experiment (Experiment 4.1) employed a power manipulation, while the second (Experiment 4.2) served as a control with no power hierarchy.

4.2 Experiment 4.1

4.2.1 Methods

4.2.1.1 Participants

The initial sample consisted of 24 healthy, right-handed males, aged 18-21. Each experimental session included a pair of participants who were previously unacquainted. Participants received 15 GBP, plus an amount (8-14 pounds) that was said to depend on task performance, and would be split by the power-holder. Five participants had to be removed because of excessive blinking, poor quality of EEG signal, or outlying behavioural performance. There remained 19 participants, of which 10 were allocated to the power-holder role. As the experimental sessions of each of the power-holder and subordinate, as elaborated in the subsequent sections, were actually independent, it was not a problem that there were unequal numbers of power-holders and subordinates. The experiment was approved by Oxford’s Central University Research Ethics Committee (CUREC), and participants provided written consent.

4.2.1.2 The Task

In the classical Eriksen (Eriksen & Eriksen, 1974) paradigm, five arrows are presented (>>>>>), in which a central arrow is surrounded by distractor arrows. Participants are required to respond by pressing either a “left” or “right” button according to the direction of the central arrow, while ignoring the distractors. Thus, within this paradigm, there are congruent trials (>>>>> or <<<<<), where all arrows are pointing in the same direction, and incongruent trials (<<><< or >><>>), where the central arrow points in the opposite direction as the distractors. Incongruent trials require the inhibition of the response triggered by the distractors, and are associated with longer reaction times and more errors (Eriksen & Eriksen, 1974). In the current adaptation, three different shapes of arrows were introduced (Figure 4.1a). One was assigned to each participant, and the third was assigned to neither participant. All assignments were counterbalanced. Trials, which we refer to as targets, could consist of any of the arrow shapes. Participants were seated separately and were required to respond to trials that consisted of their shape and to refrain from responding on the other trials.

Participants believed they were performing the same task in an interactive way, though, in reality, they were performing equivalent but separate tasks in parallel. Each participant interacted with an automated version of the program. Figure 4.1b depicts one player's trial, and what he perceived to be the other player's trial.

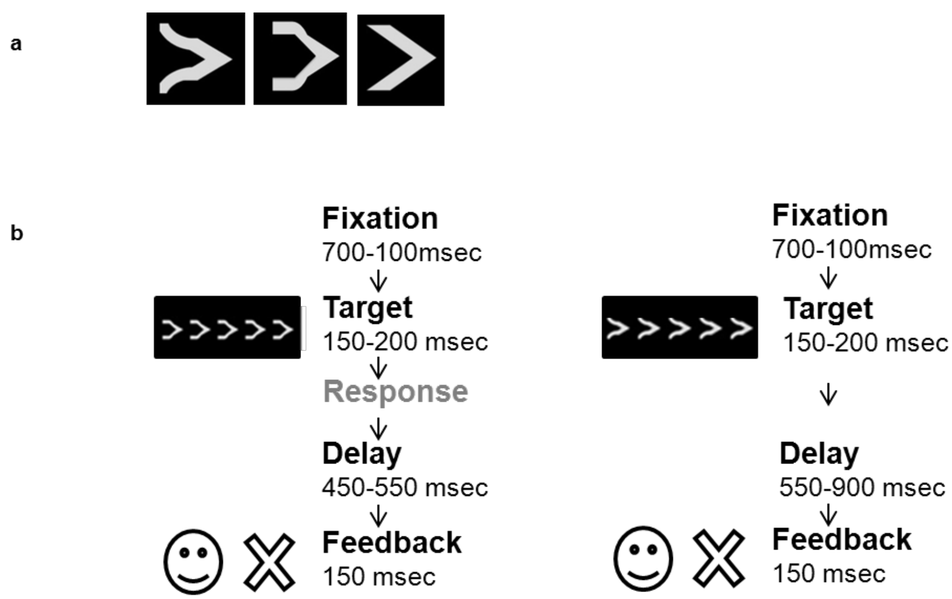

Figure 4.1 Schematic depiction of interactive Flanker task. a. The three different shapes of arrows, either two of them were allocated to the participants, counter-balanced across role. b. A player's trial (left) and an automated trial (right) which was believed to be the other person's trial. Arrow shapes were reversed for the player in the second booth. Negative feedback was presented on 25% of trials for both own trials and the "other's" trial. The 5 arrows array subtended a visual angle of 2.58 ° horizontally and 0.52° vertically, while feedback stimuli subtended a visual angle of 0.86° horizontally and vertically. The two sessions contained three blocks of 240 trials each.

Participants were told that the time window in which they were allowed to respond was constantly being adjusted to keep the task challenging; and that, provided they pressed the correct button, they would get positive feedback, indicating an incremental monetary increase, for trials in which they were on time, and negative feedback, indicating monetary loss, when they were late. In reality, positive feedback was provided on 75% of trials, and negative on 25% of trials, regardless of their actual performance. Participants were debriefed in a group email after the data collection was completed.

Presentation v10 (Neurobehavioural Systems, Albany, NY) was used for stimulus presentation and recording of behavioural responses. All statistical analysis was conducted with PASW Statistics 18.

4.2.1.3 Power manipulation

A consistent type of manipulation was used as in the studies described in Chapter 3. Within each pair, one participant was randomly pre-assigned to the power role and the other to the subordinate role, without their knowledge. They performed a session of the task described above, without any power allocation. They were told to compete for better performance, and that the winner would be able to allocate the joint rewards on a subsequent session. The scores were not actually calculated, and the pre-assigned power-holder was told that he won by a small percentage. This was plausible due to the large number of trials, the similar feedback probabilities, and the fact that participants couldn’t discern the reaction time of their rival accurately.

Afterwards, participants performed a second session of the task, with identical parameters. This time, they were told to cooperate, and that their joint score would translate to a monetary sum (8-14 GBP). The “winner” of the first session could allocate the joint winnings in whichever ratio he preferred. In this manner, a power hierarchy was created after the first competition session, since the alleged winner had control over joint outcomes.

4.2.1.4 ERP recording and pre-processing

The EEG was recorded continuously using NuAmps amplifier (Neuroscan, El Paso, TX) with electrodes mounted on an elastic cap from 33 standard locations according to the 10–20 electrode system. Scalp electrodes were F1/2, Fz, F3/4, FC1/2, FCz, FC3/4, C1/2, Cz, C3/4, CP1/2, CPz, CP3/4, P1/2, Pz, P3/4, PO3/4, POz, O1/2, Oz, PO7/8. Two electrodes were placed on the right and left mastoids, and the right mastoid was used as the active reference site. An electrode placed in in front of Fz (AFz) served as the ground. Blinks and eye movements were monitored by deriving bipolar recordings from electrodes placed to the left and right of the right eye (HEOG) and by a channel placed under the right eye (VEOG). The EOG signals were amplified with a low-pass filter (200 Hz), and digitized at a sampling rate of 1000 Hz. All further processing was done offline.

Data were re-referenced to the average of the two mastoids and re-filtered digitally with a low-pass of 40 Hz. Target- and feedback-related epochs started 200 msec before and ended 1000 msec after stimulus presentation. All amplitude values were referred to the 200-msec pre-cue baseline. Trials were automatically eliminated if the voltage exceeded ±50 μV at either the vertical or horizontal EOG channels or if it exceeded ±100 μV at any other channel.

Separate averages were computed for each type of target based on their congruency (congruent and incongruent) and ownership (own and other's), and for feedback based on its valence (positive and negative) and ownership. Topographical analysis and the previous literature were used to determine the time windows and electrodes for analysis.

Target N2 followed a fronto-central distribution and was analyzed between 280 and 300 msec post stimulus at FCz. Target P3 followed a centro-parietal distribution and was analyzed between 410 and 450 msec post stimulus at Cz and CPz. Feedback potentials were analyzed for own feedback only. FRN followed a central distribution and was analyzed between 230 and 250 msec at Cz. The feedback P3 followed a more frontal distribution and was analyzed between 370 and 410 msec at FCz and Cz.

As for other's FRN (oFRN), an exploratory analysis was conducted, but was limited to the second hierarchical session. This was done because the literature suggests that the oFRN is affected by whether the other is a competitor or a cooperator, which would be hard to disentangle from the hierarchical position of the other (Itagaki & Katayama, 2008). The same parameters, however, were used as for the FRN. Others' feedback failed to elicit an observable P3 peak, which precluded us from analyzing others' feedback P3.

4.2.1.5 Questionnaires

One week prior to the experimental session, questionnaire data were collected from participants online to ensure that the allocated power-holders and subordinates did not differ, prior to allocation, on variables that may have an effect on the experimental results. Different scales were chosen to measure participants' sense of power, approach/inhibition motivation, and empathy.

The Sense of Power Scale (Anderson & Galinsky, 2006) tapped into individuals' general sense of power as anchored in relational experiences. The scale consisted of a stem (‘‘In my relationships with others . . . ’’) and eight items, e.g.,: ‘‘I can get people to listen to what I say,’’ ‘‘My wishes do not carry much weight’’ . On this scale, responses are made on scales from 1 (strongly disagree) to 7 (strongly agree). Approach/Inhibition tendencies were measured by the BIS/BAS Scales (Carver & White, 1994), which are based on Gray's (1987) bio-psychological theory of personality. The BAS scale has three subscales: fun seeking (BAS-fun), reward responsiveness (BAS-reward) and drive (BAS-drive). The BIS scale has no such subscales. Empathy was assessed using the Interpersonal Reactivity Index (IRI), a 28-item questionnaire which contains subscales designed to measure four facets of empathy (Davis, 1983). These include perspective taking (tendency to adopt the viewpoint of others), empathic concern (tendency to experience compassion), personal distress (tendency to experience discomfort in response to distress experienced by others) and fantasy (tendency to imagine oneself in fictional situations).

4.2.2 Results

The two groups of participants will be referred to as power-holders and subordinates, although it should be kept in mind that in session 1 they were hierarchically equal.

4.2.2.1 Behavioural Results

Accuracy (calculated as a proportion of correct trials) and reaction time (RT) were analyzed for own trials only because participants were instructed to refrain from responding during the other's trials. Accuracy and RT were submitted to separate mixed-effects analyses of variance (ANOVAs) with a between-subject variable of *group* (power-holder and subordinate), and within-subject variables of *congruency* between central and distractor arrows (congruent and incongruent), *session* (session 1 and hierarchical session 2).

role	session	congruency	Mean RT	Standard Error
power-holder	neutral	congruent	499.98	10.13
		incongruent	530.20	10.82
	hierarchical	congruent	473.16	10.11
		incongruent	506.01	12.53
subordinate	neutral	congruent	505.55	10.68
		incongruent	533.06	11.41
	hierarchical	congruent	460.97	10.66
		incongruent	495.52	13.21

Table 4.1: Table displaying mean reaction times and standard errors of the mean in Experiment 4.2 across role (power-holders or subordinates), type of session (neutral or hierarchical), and congruency of trials (congruent or incongruent).

Accuracy results yielded the expected Flanker effect of *congruency*, $F(1,17)= 51.1$, $p<0.001$; with lower accuracy for incongruent ($M= 0.92$, $SE=0.01$)

compared to congruent trials (*M*=0.99, *SE*=0.002). There was a three-way interaction between *group, session*, and *congruency*, $F(1,17)=4.36$, $p=0.05$, indicating that the manipulation had an effect on performance. To simplify the analysis, a metric for the Flanker effect (FE) was calculated in each session by subtracting the accuracy of the incongruent trials from the accuracy of the congruent trials (which was almost at ceiling)[1]. Then, the change in FE (FEchange) was calculated across sessions (FEsess2-FEsess1). Power-holders showed an increase in the FE (*M*=0.038, *SE*=0.02) compared to subordinates (*M*=-0.02, *SE*=0.063), $t(17)=2.08$, $p=0.05$). As Figure 4.2 shows, FE in session 2 was carried by accuracy on the incongruent trials (*M*power-holder=0.88, *SE*=0.016; *M*subordinate=0.95, *SE*=0.017, $p<0.05$), and not by accuracy on the congruent trials (*M*power-holder=0.99, *SE*=0.004; *M*subordinate=0.98, *SE*=0.005, *p*=ns) (Figure 4.2). As for RT, the main effect of congruency was significant, $F(1,27) = 97.82$, $p < .0001$, revealing slower responses for incongruent (*M*=516.20 msec, *SE*=8.16) compared with congruent (*M*=484.91 msec, *SE*=8.16) trials. The power manipulation had no effect on the RT.

[1] Accuracy results for the congruent trials were almost at ceiling, which violated the statistical assumptions of homogeneity of variance. This was duly noted, and separate appropriate analyses were conducted for congruent trials and incongruent trials (which were homogeneously distributed). The pattern of results remained consistent, and the results were reported in the text in the current form because the FE is a useful measure to portray accuracy results in Flanker paradigms.

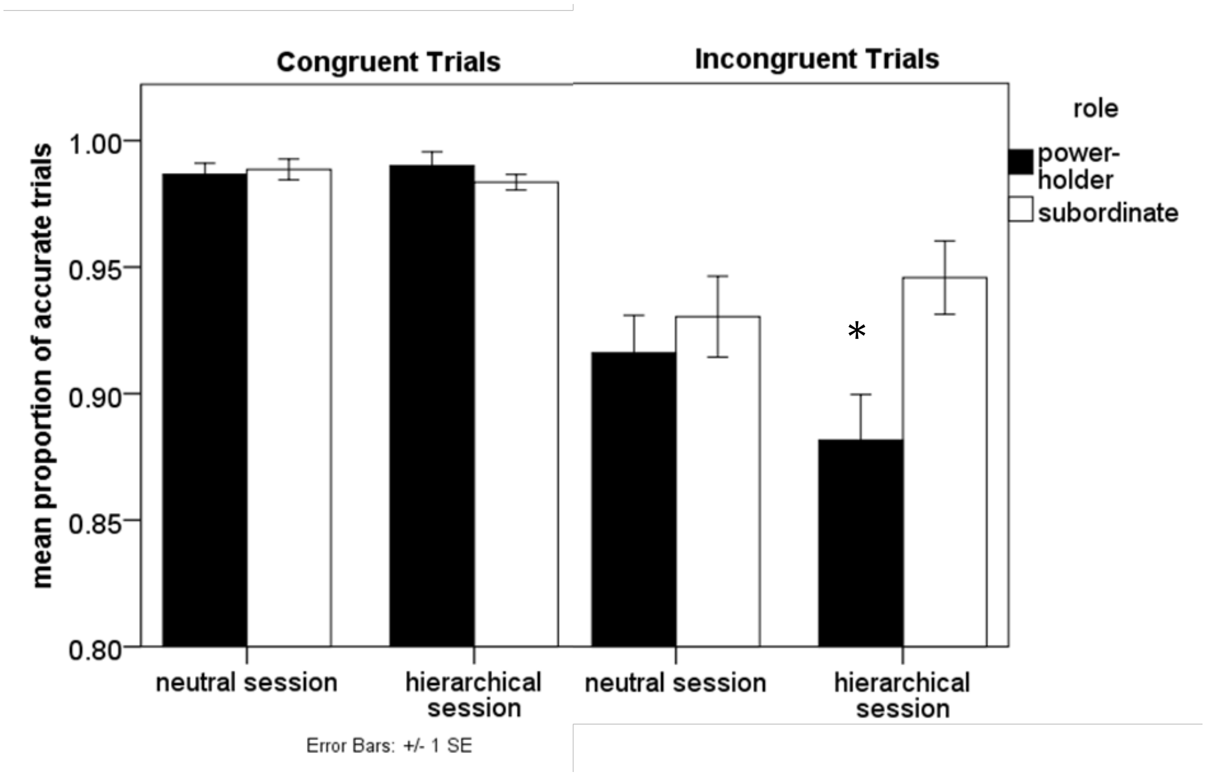

Figure 4.2: Graph displaying the mean proportion of accurate trials in Experiment 4.1, plotted separately for congruent trials (left panel) and incongruent trials (right panel). Within each panel, means in the neutral session are plotted on the left, and those of the hierarchical session are plotted on the right. After the manipulation, power-holders (black) show lower accuracy for incongruent trials compared to subordinates (white).

The proportion of false alarms (FA), or responses to the other's trials, was also calculated, and submitted to a mixed-effects ANOVA with the between subject variable of group and the within-subject variable of session. The interaction of session and role was marginally significant $F(1,17)=3.44$, $p=0.08$. FAchange across sessions was calculated, and it appeared that power-holders reduced their FAs to subordinates' arrows ($M=-0.04$, $SE=0.009$) to a greater extent than subordinates to power-holders' arrows ($M=-0.015$, $SE=0.01$, $t(17)=-1.85$, $p=0.08$).

role	session	Mean number of false alarms	Standard Error
power-holder	neutral	17.50	4.58
	hierarchical	4.70	1.99
subordinate	neutral	13.00	4.83
	hierarchical	7.56	2.10

Table 4.2: Table displaying mean number of false alarms and standard errors of the mean in Experiment 4.2 across role (power-holders or subordinates) and type of session (neutral or hierarchical).

4.2.2.2 Target-related potential results

The amplitude of N2s elicited by targets (mean amplitude between 280 and 300 msec at electrode FCz) was submitted to a mixed-effects ANOVA with within-subject variables of *session, congruency,* target *ownership* (own and other's), and a between-subject variable of *group.* Amplitude of target P3s (mean amplitude between 410 and 450 msec at Cz and CPz) was submitted to the same ANOVA, with the added within-subject variable of electrode (Cz and CPz).

N2: The typical effect of *congruency* on N2, where incongruent trials have more negative N2s than congruent trials, was visible for all participants, for both own and other's targets, and was statistically reliable, $F(1,17)=6.52$, $p<0.05$, $\xi2=0.28$. Thus, the expected main effect of *congruency* was established. The question of interest was whether the power manipulation had an impact on the N2, which would be characterized by an interaction between *group, session*, and *congruency*. This interaction was not found, $F(1,17)=0.19$, $p=0.89$. Neither was there any interaction with *ownership*, $F(1,17)=0.46$, $p=0.53$, indicating that there was no difference between the two groups in conflict pertaining to own or the other's trials.

P3b: P3b analyses showed a significant main effect of *ownership*, $F(1, 17) = 16.07$, $p<0.001$, revealing higher P3bs for own targets than for the other's targets. A main question of interest was whether subordinates would show different processing of both own and other's targets compared to power-holders, which would be characterized by an interaction between *group* and *session* on target P3bs. This effect was found, $F(1, 17)=7.16$, $p<.05$, $\xi 2=0.3$. To simplify the analysis, the session 1 values were subtracted from the session 2 values, to provide an index of change across sessions (P3bchange). A main effect of *group* $F(1,17)=7.2$, $p<0.05$ revealed that subordination increased P3b amplitude values for both own and other's targets ($M=3.85$, $SE=1.04$) to a significantly higher degree than power ($M=-0.005$, $SE=0.98$) which hardly had an impact on the P3b (Figure 4.3a & 4.3b).

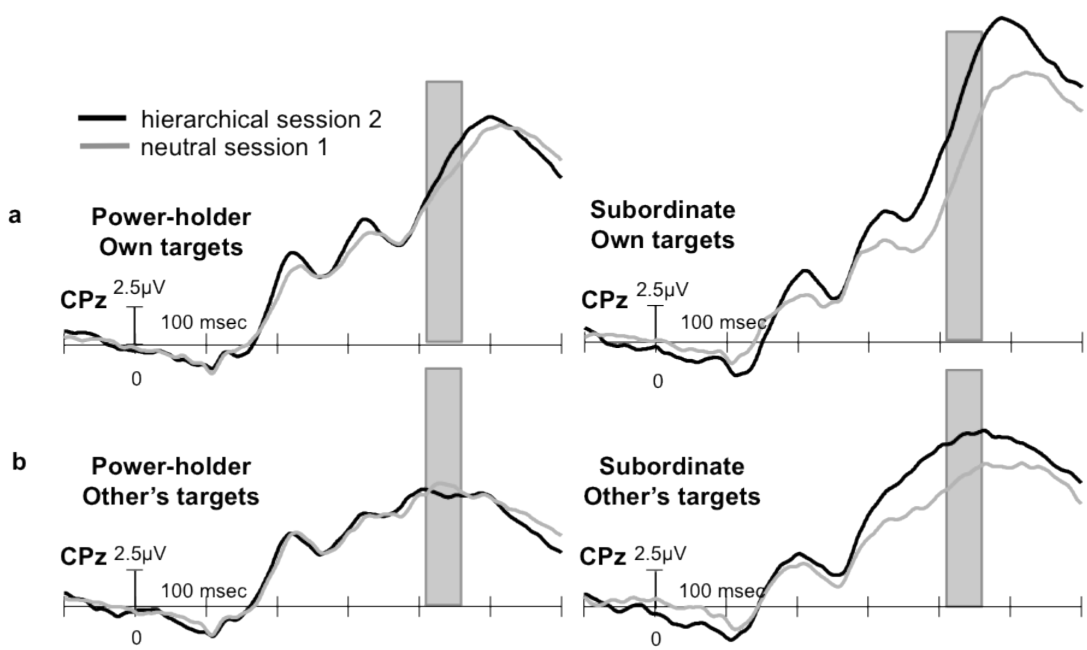

Figure 4.3: Target P3b potentials in Experiment 4.1. Grand-averaged waveforms elicited by own (3a) and other's (3b) targets at CPz for power-holders (left) and subordinates (right). Grey curve represents neutral session 1, and the black curve represents

hierarchical session 2. The rectangle represents the time window (410-450 msec) in which target P3b was analyzed.

4.2.2.3 Feedback-related potential results

FRN: The FRN effect is characterized by a negative potential for negative relative to positive feedback. Amplitude of the FRN (at Cz between 230 and 250 msec) was submitted to a mixed-effects ANOVA with within-subject variables of session, feedback valence (positive and negative), and a between-subject variable of group. The main effect of feedback valence, the FRN effect, was significant $F(1,17)=20.74$, $p<0.001$. There was interest in whether the power manipulation had an effect on the FRN effect. This analysis was simplified by calculating a metric for the FRN effect by subtracting the positive feedback potentials from the negative feedback potentials (FRNe) and submitting it to a mixed model ANOVA with a within-subject variable of *session* and a between subject variable of *group*. The interaction emerged as significant, $F(1,17)=5.24$, $p<0.05$. Pairwise comparisons showed that power increased the FRNe and subordination decreased it (Figure 4.4). In the hierarchical session 2, the effect of power on the FRN approached significance, $p=0.08$.

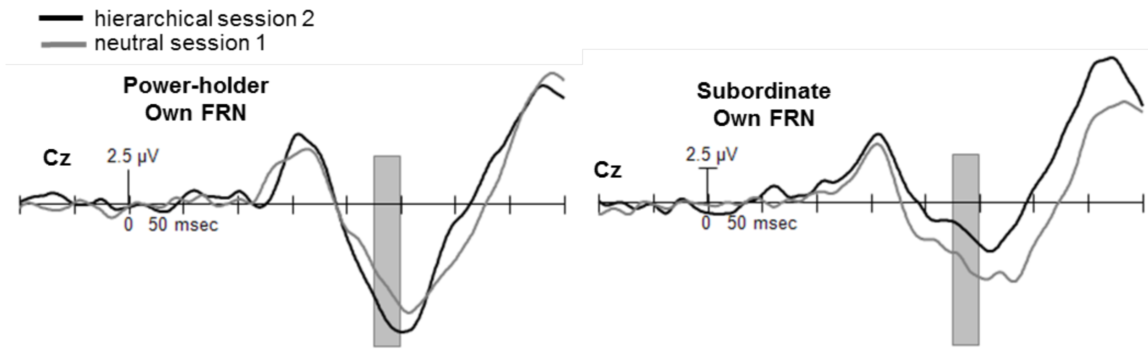

Figure 4.4: Own feedback-related negativity (FRN) potentials in Experiment 4.1. Difference of grand-averaged waveforms elicited by feedback at Cz (negative feedback minus positive feedback) for power-holders (left) and subordinates (right). Grey curve represents neutral session 1, and the black curve represents hierarchical session 2. The rectangle represents the time window (230-250 msec) in which FRN was analyzed.

Feedback P3: Amplitude of feedback P3s (between 370 and 410 msec) was submitted to a mixed-effects ANOVA with within-subject variables of *session,* feedback *valence* (positive and negative), *electrode* (FCz and Cz) and a between-subject variable of *group*. The analysis showed a main effect of feedback *valence* $F(1,17)=32.6$, $p<0.001$. P3s were larger after negative feedback than after positive feedback. The question of interest was whether the groups differed in the way they processed negative versus positive feedback, which would be characterized by an interaction involving *group, session*, and feedback *valence*. This interaction was indeed found $F(1,17)=7.44$, $p<0.01$. To simplify the analysis, the session 1 values were subtracted from the session 2 values, to provide an index of change across sessions (P3change). After making sure that the interaction between valence and group was significant, $F(1,17)=7.44$, $p<0.05$, adjusted pairwise comparisons showed that, for negative feedback only, subordination increased the feedback P3, to a significantly higher extent compared to power $p<0.05$ (Figure 4.5.) This effect did not emerge for positive feedback.

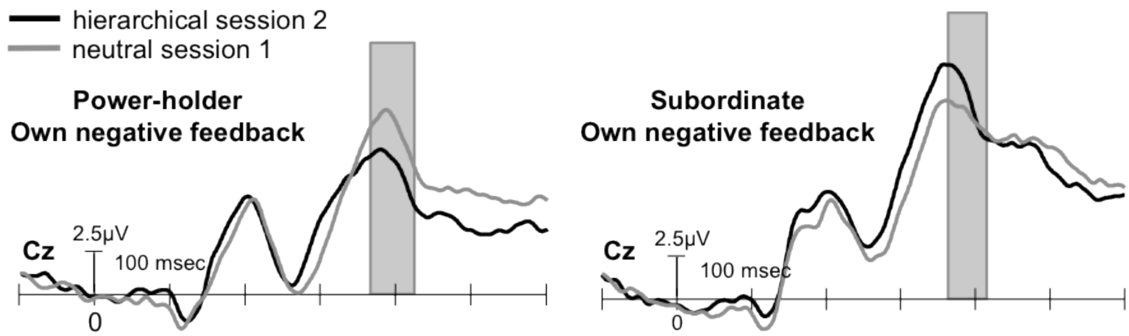

Figure 4.5: Own negative feedback P3 potentials in Experiment 4.1. Grand-averaged waveforms elicited by feedback at Cz for power-holders (left) and subordinates (right). Grey curve represents neutral session 1, and the black curve represents hierarchical session 2. The rectangle represents the time window (370-410 msec) in which feedback P3 was analyzed.

oFRN: As indicated, the oFRN was explored in the second hierarchical session only. Amplitudes were submitted to a mixed-effects ANOVA with *valence* as the between subject variable and *group* as the within-subject variable. The main effect of *valence* was significant $F(1,17)=9.076$, $p<0.01$, showing that others' feedback reliably elicited an FRN. Interestingly, there was a significant interaction between *valence* and *role,* $F(1,17)=7.47$, $p<0.05$, indicating that the manipulation had an effect on how others' feedback was processed. To simplify the analysis, a metric of the oFRN effect (oFRNe) was calculated by subtracting the amplitude of positive from negative feedback. An independent samples t-test revealed that power-holders had a significantly more negative oFRNe ($M=-4.62$, $SE=1.12$) than subordinates ($M=-23$, $SE=-1.15$, $t(1,17)=-2.17$, $p<0.05$) who hardly revealed an oFRN.

4.2.2.4 Questionnaire results

Two participants failed to complete the questionnaires, leaving a sample with 9 power-holders and 8 subordinates. Power-holders and subordinates did not differ, prior to their power allocation, on their General sense of Power (*M*power-holder=3.89, *SD*=0.30, *M*subordinate=3.71, *SD*=0.41, *p*=*ns*), on their approach motivation (*M*power-holder=4.87, *SD*=0.67, *M*subordinate=4.91, *SD*=0.72, *p*=*ns*), on their inhibition motivation (*M*power-holder=4.91, *SD* =0.72, *M*subordinate=4.71, *SD* =0.55, p=*ns*). They did not differ on the four subscales of empathy, perspective taking (*M*power-holder=31.22, *SD* =4.68, *M*subordinate=32.5, *SD*=3.33, p=*ns*), empathic concern, (*M*power-holder=30.44, *SD*=4.09, *M*subordinate=28.5, *SD*=3.21, p=*ns*), personal distress (*M*power-holder=27.77, *SD*=4.26, *M*subordinate=27.00, *SD*=5.071, *p*=*ns*), and fantasy (*M*power-holder=30.77, *SD*=5.80, *M*subordinate=28.50, *SD*=3.78, *p*=*ns*).

4.2.3 Discussion

If subordinates were more susceptible to the actions primed by the incongruent distractors, one would have expected a difference in their reaction times to power-holders on incongruent trials. This was not found. Furthermore, the ERP data, consistent with the reaction-time data, showed no difference in the conflict-sensitive N2 potential between the groups. Neither group, then, exceeded the other in the need to control incorrect response preparation (Folstein & Van Petten, 2008). Our results do not support a proposed effect of power on inhibition in the context of executive control, or the ability to resolve a response-related conflict arising from distracting stimuli (Posner & Petersen, 1990). The findings are, however, consistent with other literature that has not, to this point, showed a direct and simple effect of power on executive control (e.g., Willis et al., 2011).

Contrary to what was expected, the accuracy data showed that subordinates were more accurate than the power-holders on incongruent trials. In a recent study investigating status, which is often correlated with power (Boksem et al., 2011), the authors suggest that low status most likely does not impair executive control, but rather it is associated with a more reactive mode of behavioural control that can be adaptive. P3b is thought to reflect a heightening of attention, after a decision regarding the task-relevance of a stimulus (Nieuwenhuis et al., 2005). P3b is thought to be relevant to behaviour, as it represents an assessment as to whether a response should be initiated, after a decision regarding the relevance of a stimulus (Verleger, Jaśkowski, & Wascher, 2005). It is possible, then, that in the chain of cognitive events leading to behaviour, the groups were similar in the initial response preparation, but the different levels of top-down resources resources (Nieuwenhuis et al., 2005), attached to these targets by both parties allowed for different levels of performance. Since congruent trials require no conflict monitoring, such top down control was not necessary, and no differences in accuracy ensued.

Subordinates showed higher P3bs to the other's targets than power-holders, indicating greater resources devoted to the processing of these stimuli, with possibly more subjective motivational significance assigned to them (Nieuwenhuis et al., 2005). This supports the hypothesis that subordinates process information in a rather indiscriminate fashion (Guinote, 2007a), even when task-irrelevant. In this task, however, the other's targets may have a more "subjective" importance. The social psychology literature demonstrates that attention travels up the power hierarchy, from subordinates to power-holders (Fiske, 1993). This phenomenon may also extend to items associated with the power-holders, despite the fact that they are not relevant to performance. This phenomenon is explored in the subsequent chapter.

The findings related to feedback processing show a double dissociation between two types of feedback evaluation and power. Compared to power-holders, subordinates showed a decrease in the FRN effect. FRN has been proposed to code a rather subjective reward prediction error (Bellebaum, Kobza, Thiele, & Daum, 2010). According to this interpretation, subordinates were less surprised when they received negative feedback, possibly reflecting a belief that they were indeed worse at this task. Feedback P3 indexes another aspect of feedback, where it has been shown to be sensitive to reward magnitude, regardless of valence (Yeung & Sanfey, 2004). Feedback P3 is interpreted as a top-down controlled process of outcome evaluation, into which allocation of attentional and motivational significance may come into play (Wu & Zhou, 2009). Compared to subordinates, power-holders showed smaller feedback P3. Thus, the same feedback was interpreted as having larger subjective magnitude, or importance, in subordinates. Power-holders, on the contrary, did not 'care' as much. This is an avenue that deserves further research. It is possible that subordinates attribute negative feedback to the self, whereas, in the power-holders' case, feedback draws attention to the task only. These two types of attribution have important effects on performance, as errors that draw attention to the self rather than the task have been shown to impair performance (Kluger & DeNisi, 1996). Notably, the FRN results are opposite to the study of status on performance evaluation (Boksem et al., 2011), which found heightened medial frontal negativities in low-status individuals. The authors interpreted this finding as indicative of an individual's concern over making mistakes in social contexts. Power is not the same construct as status, however, because status does not entail a situational monopoly over shared resources. Low status individuals probably have self-presentation anxieties for feedback that is seen by others, eliciting larger MFNs (Boksem et al, 2011).

As for the oFRN, power-holders showed more negative potentials than subordinates for the other's feedback, who hardly showed a clear oFRN. This result has to be interpreted with caution, however, because it does not reflect change across session. However, along the interpretations provided by past studies (Itagaki & Katayama, 2008) , it is possible that power-holders processed subordinates' negative feedback more as 'losses' than the inverse relationship. This may reflect the fact that the resource that they are both building towards is their own to split, making each negative feedback an indication of a depletion of resources. Another explanation is that they are more 'empathic' to subordinates, although it stands against the literature so far on power and empathy (Galinsky et al., 2006).

The questionnaire results suggest no pre-existing dispositions in power, approach/inhibition motivation, and empathy may have confounded the effect of the power manipulation.

4.3 Experiment 4.2

A second experiment was conducted, with the identical task parameters, except that there was no power manipulation involved.

This was done, in the first instance, to have a better idea of the differences in the neural and behavioural profile of competitors and cooperators, in a non-hierarchical state. These results could be placed beside the results of the first experiment, to compare the changes in the variables of interests according to the different manipulations. In the first experiment, there are three main reasons why one cannot easily separate the effects of competition/cooperation from the hierarchical nature of the participants.

Firstly, the competition was aimed towards achieving power in the second session, which has not been explored as much as a zero-sum scenario reflecting a tangible reward (Stanne, Johnson, & Johnson, 1999). Secondly, one cannot assume that the hierarchy allowed for a balanced cooperation, for each of the power-holders and subordinates had different levels of control over the communal sum. Thirdly, the cooperation session always occurred after the competition session. Practice effects are quite important to predict performance, and although speed and accuracy were generally higher in the hierarchical cooperative session, it is entirely possible that this effect can be attributed to the fact that they had more time to practice.

The second reason for conducting this experiment was to use a subset of the participants in this study, who completed the competition session first followed by cooperation, to investigate whether the differences between power-holders and subordinates in the first experiment were driven by power or subordination. This aim is elaborated subsequently in this chapter.

It is not straightforward to specify the relative merits of competition and cooperation on task performance. These constructs are complex and can be operationally defined in many ways. In a comprehensive meta-analysis (Stanne et al., 1999), it was found that, in general, cooperation resulted in higher achievement than competition. However, the authors do note than, when means interdependence is absent, competition may be more effective than cooperation, especially for relatively simple motor tasks. *Means interdependence* exists when a task is structured so two or more individuals are required to complete it, while *means independence* exists when a task is structured so that one person can complete it without the other. In the Flankers paradigm used here, although participants could ‘observe’ each other, or thought they did, the task was means-independent. In a different study, it was suggested that competition led to faster reaction times than cooperation (Bekkering et al., 2009)

There have been a few studies that have investigated the neural underpinnings of performance monitoring in competitive and cooperative contexts. As the setup of these experiments is generally quite diverse, it is difficult to generalize their results. Some of these studies, relevant here, have been concerned with how competition or cooperation affect the way own, but especially others', feedback is processed. For example, it was shown that the FRN is elicited in a similar fashion for own losses regardless of whether the agent was competing or cooperating; however, when observing opponents' errors, the FRN was elicited for gains and not losses (Itagaki & Katayama, 2008). The authors interpreted this finding to indicate that the FRN evaluates whether an outcome is good or bad for the self. Consistently, another study showed higher oFRNs for gains of others that translated to a loss for the self, which could be considered competitors (Marco-Pallarés et al., 2010). Both of these tasks involved gambling, which is a good paradigm to elicit FRNs. Also, in the second study, oFRN was not measured.

In this study, there was an interest in how individuals performed and evaluated their own performance in the light of ambiguous feedback, as a function of task directions to compete or cooperate.

4.3.1 Methods

4.3.1.1 Participants

The sample consisted of 24 healthy, right-handed males, aged 18-21. Each experimental session included a pair of participants who were previously unacquainted. The experiment was approved by the University of Oxford's Central University Research Ethics Committee (CUREC), and participants provided written consent.

4.3.1.2 The Task

The same Flankers task, with identical parameters and feedback probabilities, was employed as in Experiment 4.1.

4.3.1.3 Manipulation of competition/cooperation

Participants were required to compete on one session and cooperate on the second. In the competition session, the better player received 5 GBP. In the cooperation session, their joint winnings would be split in half (8-14 GBP). Six pairs did competition first followed by cooperation, and the remaining pairs did the reverse order. Importantly, the scores reflected actual performance but were only announced at the end of the experimental session to avoid a power manipulation.

4.3.1.4 ERP recording, pre-processing, and analysis

The same parameters were used for recording and pre-processing as the ones used in experiment 1. The analysis was conducted in the same fashion for Accuracy, RT, target N2, target P3, feedback P3, FRN, and oFRN. What differed from Experiment 1 was that the within-subject variable of *session* consisted of competition and cooperation, and the between-subject variable of group consisted of the participants who did competition first followed by cooperation (compthencoop) and those who did the reverse order (coopthencomp).

4.3.2 Results

4.3.2.1 Behavioural results

The question of interest was whether performance (RT or accuracy) was affected by whether participants were competing or cooperating, which would emerge as a main effect of session *type*.

This was found for RT, $F(1,22) = 8.50$, $p < .001$, revealing slower responses for cooperation (M=508.05 msec, SE=7.18) compared to competition (M=487.91 msec, SE=7.92) trials. There was also, as expected, a significant main effect of *congruency*, $F(1,22) = 107.24$, $p < .0001$, revealing slower responses for incongruent (M=515.43 msec, SE=7.47) compared with congruent (M=480.53 msec, SE=6.36) trials. There was a significant interaction between session *type* and *congruency,* $F(1,22)=4.76$, $p<0.05$. Adjusted pairwise comparisons showed that the difference in RT between competition and cooperation was probably driven by incongruent trials (M competition=503.42, SE=8.72; M cooperation=527.445, SE=7.86, $p<0.01$) than for congruent trials (M competition=472.42, SE=7.56; M cooperation=488.66, SE=6.93, $p<0.01$) (Figure 4.6).

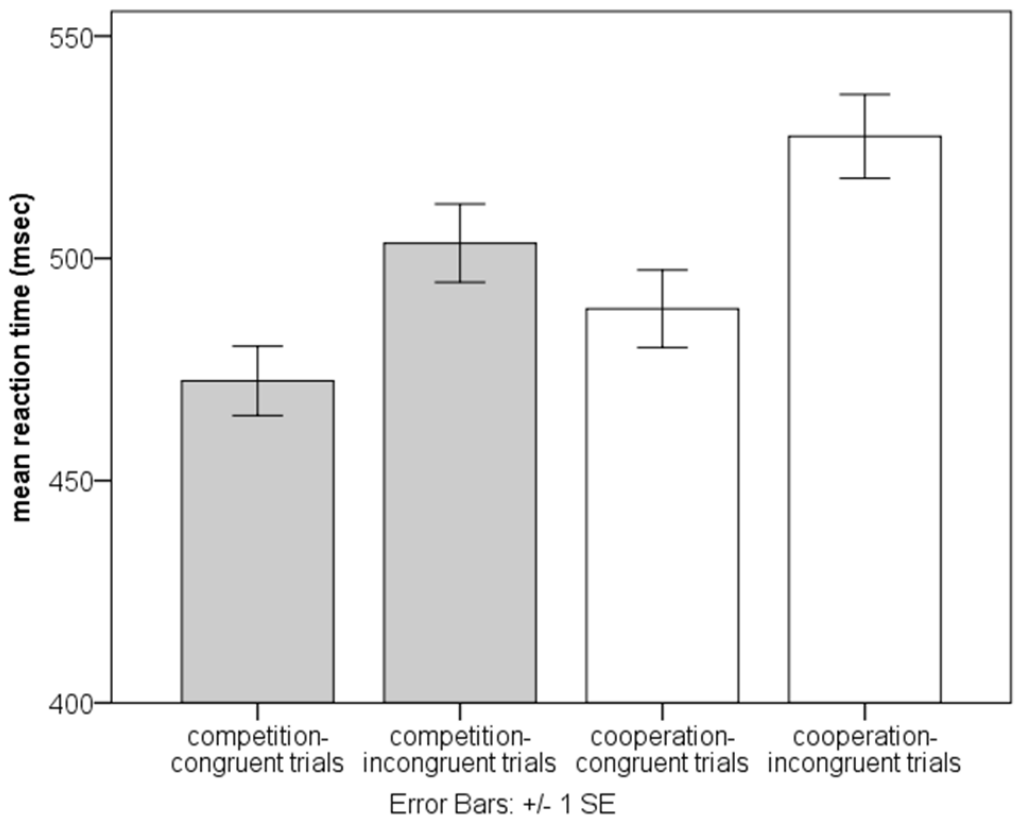

Figure 4.6: Graph displaying mean reaction time in Experiment 4.2, showing the interaction between congruency of targets (congruent on left and incongruent on right) and session type (competition in dark grey and cooperation in white). Error bars represent +/-1 SE.

For *accuracy*, there was no main effect of session type. There was only a main effect of congruency (flanker effect), $F(1,22) = 26.15$, $p < .0001$, revealing lower accuracy for incongruent (M=0.89, SE=0.02) compared with congruent (M=0.98 errors, SE=0.007) trials.

4.3.2.2 Target-related potential results

N2: The typical effect of congruency on N2, where incongruent trials have more negative N2s than congruent trials, was visible for all participants, for both own and other's targets, and was statistically reliable, $F(1,23)=8.36$, $p<0.01$. The question of interest was whether competition or cooperation had an impact on the N2, which would be characterised by an interaction between *type* and *congruency*. As the reaction time data revealed faster responses for competitors on incongruent compared to congruent trials, there was an apriori hypothesis that the cooperators would have a smaller N2 effect. The results showed that one-tailed probability was significant, $F(1,22)=2.83$, $p=0.10$. Due to the apriori hypothesis, and the small number of participants, the one tailed probability was accepted and the interaction was further explored. The N2 effect (N2incongruent-N2congruent) was calculated to simplify the analysis, and it was revealed that the N2effect in the cooperation condition was larger (more negative) than in the cooperation condition (Figure 4.7).

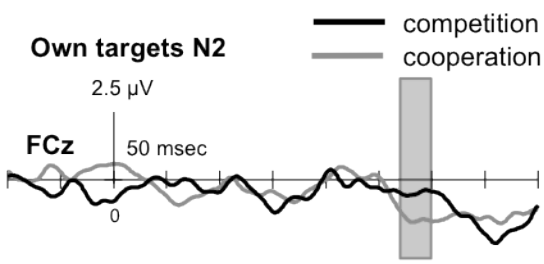

Figure 4.7: Own target N2 potentials in Experiment 4.2: Difference of grand-averaged waveforms elicited by targets at FCz (incongruent trials minus congruent trials). Grey curve represents cooperation, and the black curve competition. The rectangle represents the time window in which target N2 was analyzed.

Target P3bs: The main question of interest was whether competition or cooperation differed with respect to target processing, which would result in a main effect of *session* on target P3bs. This effect was found, $F(1,22) = 6.41$, $p < .05$, revealing lower target P3b amplitudes for cooperation compared with competition trials (Figure 4.8). There was a significant main effect of *ownership*, $F(1, 22)= 11.41$, $p<0.001$, revealing higher P3bs for own targets than for the other's targets. There was no interaction between *session* and *ownership*, meaning that competition was characterized by higher target P3bs for both own and other's targets.

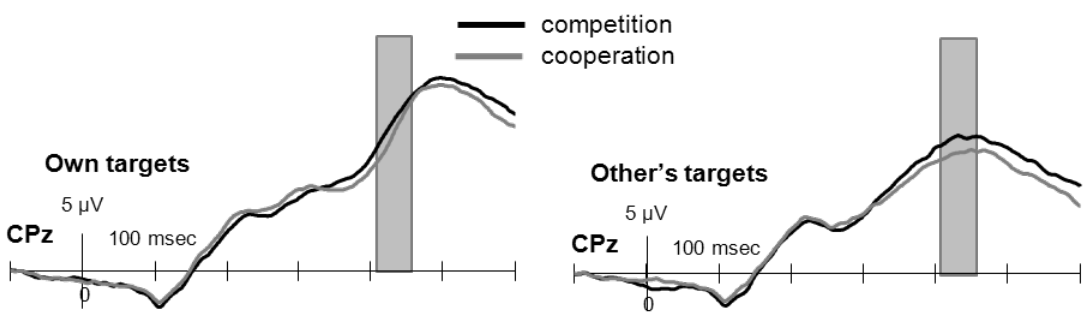

Figure 4.8: Target P3b potentials in Experiment 4.2. Grand-averaged waveforms for own targets (left) and other's targets (right) at the CPz electrode. The grey curve represents the cooperation session, and the black curve represents the competition session. The rectangle represents the time window in which target P3b was analyzed.

4.3.2.3 Feedback-related potential results

FRN: The main effect of *feedback valence* was significant, and the FRN was found for all participants $F(1,22)=77.66$, $p<0.001$. There was no significant interaction between *type* and *valence*, revealing that FRNs did not change as a function of competition or cooperation.

Feedback P3: The question of interest was whether competition or cooperation would be characterized by different feedback P3 amplitudes, which would result in a main effect of session type, or whether negative and positive feedback would be processed differently by the groups, which would result in an interaction between feedback *valence* and session *type*. There was a significant interaction between feedback *valence* and *type*, $F(1,22)=4.51$, $p<0.05$. Pairwise corrected comparisons showed that, while positive feedback amplitude did not differ between competition and cooperation; negative feedback amplitude was marginally significantly higher for cooperation than for competition (Figure 4.9). There was also a main effect of *valence* of feedback $F(1,22)=40.88$, $p<0.001$, showing higher amplitudes for negative feedback than for positive feedback.

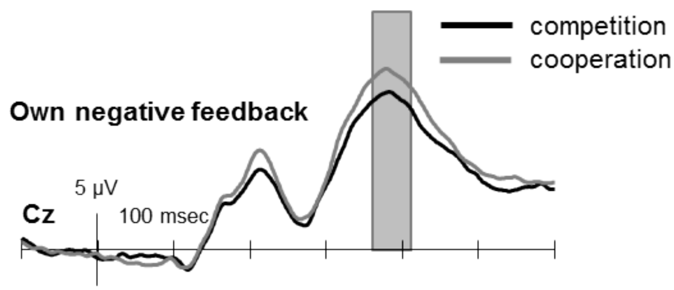

Figure 4.9: Own negative feedback P3 potentials in Experiment 4.2. Grand-averaged waveforms for own negative feedback at the Cz electrode. The grey curve represents the cooperation session, and the black curve represents the competition session. The shaded window represents the time window in which feedback P3 was analyzed.

oFRN: The main effect of feedback *valence* was significant, and the oFRN effect was found for all participants $F(1,22)=14.06$, $p=0.001$. There was no significant interaction between *type* and *valence*, revealing that oFRNs did not change as a function of competition or cooperation.

4.3.3 Discussion

Competition resulted in faster responses than cooperation, which was especially reflected on incongruent trials that require conflict monitoring. It is possible that, in this case, competition elicited a stronger motivation to perform well. This finding appears in contrast to meta-analytic results showing better performance for cooperation versus competition (Stanne et al., 1999). However, in this specific task, cooperation was means-independent, meaning that each participant was playing independently, although they could ‘observe’ each other. Stanne et al (1999) suggest that cooperation is strongest for a means-dependent task.

The neural data seem consistent with behavioural data. The task directions to compete or cooperate had an effect on the way targets and feedback signals were processed. Competitors showed a superior ability, compared to cooperators, to override conflict induced by the distracting flankers, as indexed by the N2. They also showed higher P3s both for their own and other’s targets, suggesting that they allocated more motivational and attention resources to all targets (Nieuwenhuis et al., 2005).

On the other hand, cooperation showed higher P3s for negative feedback, suggesting a larger subjective importance assigned to losses. It is possible that this reflects self-consciousness to errors that are thought to be seen by the other player, thereby affecting the joint score. Competition and cooperation had no effect on the FRN. This is compatible with the theory that FRN codes subjective reward prediction errors (Bellebaum, Polezzi, & Daum, 2010): participant’s expectations did not differ systematically between the two sessions, as no scores were announced. However, in contrast to previous studies (e.g. Itagaki & Katayama, 2008), cooperation and competition had no effect on the way other’s feedback was processed. Perhaps the FRN can also code a subjective reward prediction for the other’s performance, without a necessary implication of how it reflects on the self, as suggested in other variations of competition and cooperation paradigms (Marco-Pallarés et al., 2010) . Another study (Leng & Zhou, 2010) did not find a difference between the oFRN responses to the losses of friends versus strangers, which was attributed to the fact that this component is too early to “distinguish” friends and strangers. The findings related to oFRN are likely to vary as a function of the exact testing paradigm, and would benefit from further studies.

4.4 Cross-experiment analysis: Adding a neutral baseline

Using the subset of participants in Experiment 2 who did competition first, followed by cooperation, it was possible to add a neutral baseline to the results of the first experiment.

4.4.1 Data preparation

When the data from both experiments were combined, the initial sample consisted of 10 power-holders, 9 subordinates, and 12 neutrals. This combination of participants elicited two outliers on the measure of accuracy in the first session in the neutral group, and one outlier in the power-holder group. The final sample consisted of 9 power-holders, 9 subordinates, and 10 neutrals.

The change in the variables of interest was calculated by subtracting their value in session 1 from session 2, and compared the change with a one-way ANOVA with the between-subject variable of group (power-holder, subordinate, and neutral). Where a main effect of group emerged, this was followed up by post hoc analyses, and corrected for multiple comparisons. No change across session was calculated for oFRN, because it was only analyzed for the second session in the first experiment.

4.4.2 Results

Changes were not easily attributed exclusively to either subordinates or power-holders in the power-manipulation experiment.

4.4.2.1 Behavioural results

The change in accuracy (AcChange) across sessions by subtracting accuracy in session 1 from accuracy in session 2. AcChange for congruent and incongruent trials separately was considered separately, due to the results of Experiment 4.1, and submitted them to a separate one-way ANOVA with a between-subject variable of *group*. For AcChange on congruent trials, *group* did not emerge as significant (p=0.35), indicating that the manipulation had no effect on performance on the congruent trials (which was almost at ceiling). For AcChange on incongruent trials, however, *group* emerged as significant, $F(2,25)=4.45$, $p<0.05$. Post-hoc analyses (corrected for multiple comparisons) showed that power-holders differed significantly from subordinates ($p<0.001$), and marginally significantly from neutrals ($p=0.08$) (Figure 4.10). Subordinates and neutrals did not differ. Power-holders showed a significantly greater decrease in accuracy across session ($M=-0.41$, $SE=0.14$), than did either subordinates ($M=0.015$, $SE=0.14$, $p<0.05$) or neutrals ($M=-0.008$, $SE=0.13$, $p<0.05$). RTchange did not show a main effect of group (p=*ns*).

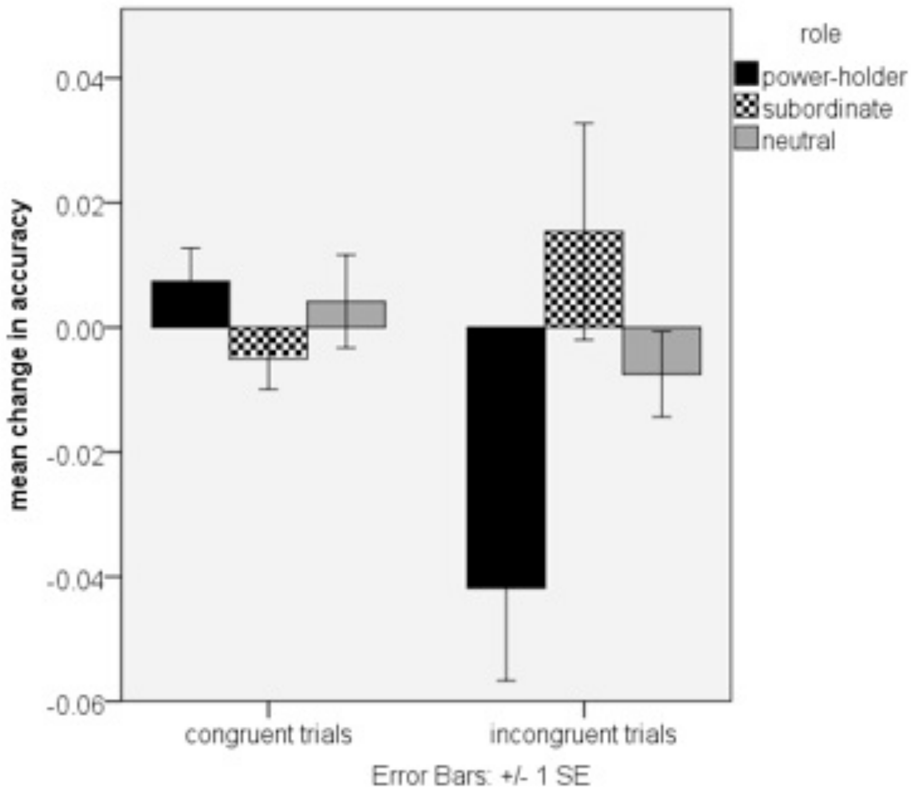

Figure 4.10: Graph displaying change in the mean proportion of accurate trials across sessions in cross-experiment analyses, plotted separately for congruent trials (left) and incongruent trials (right). Power-holders (black) show significant decrease in accuracy for incongruent trials compared to subordinates (shaded).

4.4.2.2 Target-related potential results

The N2effect (N2 of incongruent trials minus N2 of congruent trials) change did not show a variation according to group, consistent with the results of Experiment 4.1.

P3bchange was averaged across electrodes (Cz and CPz) and congruency to simplify the analysis, and was calculated separately for own and other's targets. Values were submitted to separate one-way ANOVAs with a between-subject variable of group. For own targets, there was a main effect of group, $F(2,25)=39.70$, $p<0.05$. Post-hoc analyses revealed that subordinates

(*M*=4.40 μV, *SE*=3.15) and neutrals (*M*=4.39 μV, *SE*=3.37) showed significantly higher P3change than power-holders (*M*=0.78 μV, *SE*=3.59, *p*<0.05 for both), while neutrals and subordinates did not differ. For other's targets, there was a marginally significant main effect of *group, F*(2,25)=2.69, *p*=0.08. Post-hoc analyses revealed that, for other's targets, subordinates (*M*=3.30 μV, *SE*=4.13) showed significantly higher P3change than power-holders (*M*=-0.45 μV, *SE*=2.8, *p*<0.05), and marginally significantly higher than neutrals (*M*=0.24 μV, *SE*=3.81, *p*=0.08), while neutrals and power-holders did not differ (Figure 4.11).

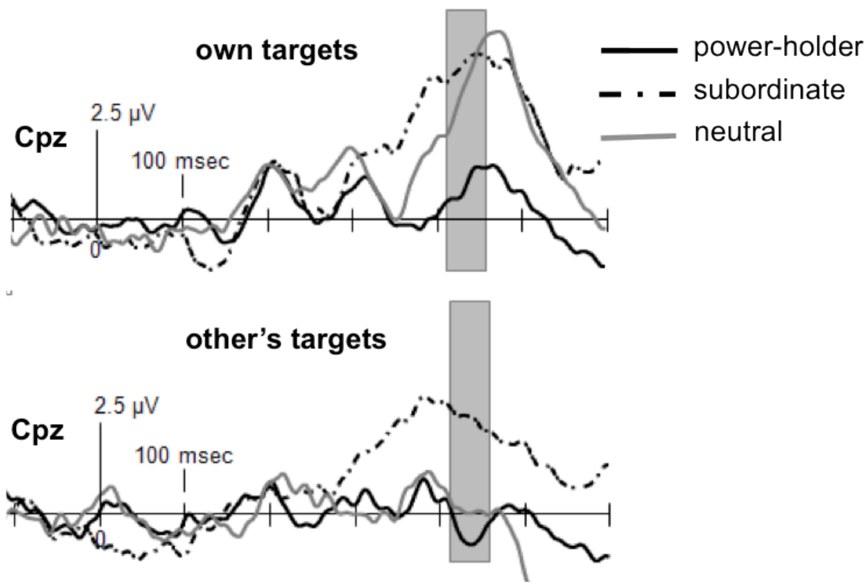

Figure 4.11: Target P3b potentials in cross-experiment analyses: Difference of grand-average waveforms across session for own targets (upper) and other's targets (lower) at CPz. Shaded rectangle represents time window where target P3b was analyzed.

4.4.2.3 Feedback-related potential results

This analysis was simplified by calculating a metric for the FRN effect by subtracting the positive feedback potentials from the negative feedback potentials (FRNe), allowing us to look at group differences on FRNeChange

(FRNeSession2-FRNeSession1). For FRNechange, a main effect of group emerged *F*(2,27)=3.74, *p*<0.05. Post-hoc analyses revealed that power-holders had significantly larger FRNechange (more negative) (*M*=-2.6 μV, *SE*=4.2) than subordinates (*M*=2.21 μV, *SE*=4.4, *p*<0.05). The mean of the neutrals (*M*=-0.55 μV, *SE*=1.67) did not differ significantly from either the power-holders or the subordinates (Figure 4.12).

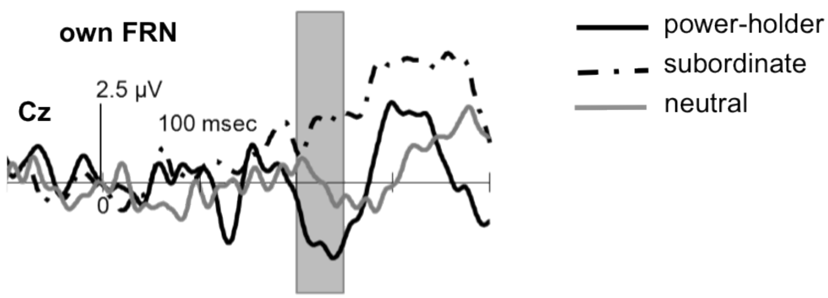

Figure 4.12: Own FRN potentials in cross-experiment analyses. Difference of grand-average waveforms across session for FRN (negative feedback minus positive feedback) potentials at Cz. Shaded rectangle represents time window where FRN was analyzed.

oFRN (analyzed in session 2) also showed a main effect of group, *F*(2,25)=6.11, *p*<0.01. Post-hoc analyses revealed that power-holders had significantly more negative oFRNs (*p*<0.05) than subordinates and neutrals. Subordinates and neutrals did not differ (*p*=*ns*).

Feedback P3 change was also averaged across electrodes (FCz and Cz), and calculated separately for negative and positive feedback. For negative feedback, *group* emerged as significant, *F*(2,25)=8.50, *p*<0.01. Post-hoc analyses showed that subordinates (*M*=5.17 μV, *SE*=1.54) had significantly higher P3change than power-holders (*M*=-3.76 μV, *SE*=1.54, *p*<0.05) and neutrals (M=0.88 μV, SE=1.46, p<0.05), and the difference between neutrals and power-holders was also significant (p<0.05). In other words, power led to a decrease in negative feedback P3, while subordination led to an increase in negative feedback P3, compared to neutrals (Figure 4.13).

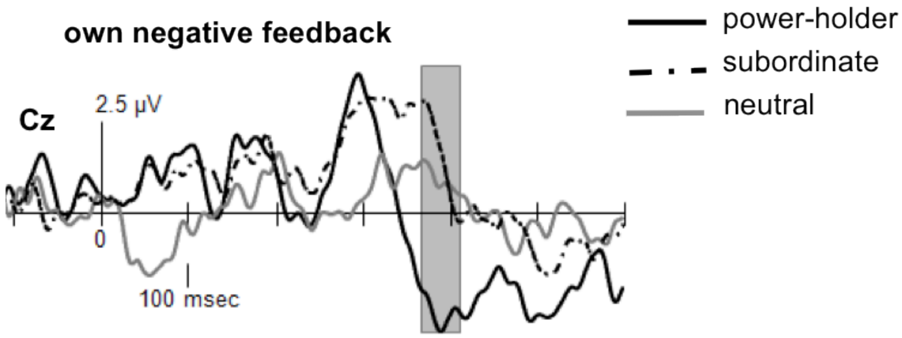

Figure 4.13: Own negative feedback P3 potentials in cross-experiment analyses. Difference of grand-average waveforms across session for own negative feedback at Cz. Shaded rectangle represents time window where feedback P3 was analyzed.

4.5 General Discussion

This chapter has revealed several interesting insights into the way power affects the way individuals deploy their resources and interact with the surrounding environment. Both power and subordination exerted their influences on the way cognitive and motivational processes unfold. Behaviourally, power-holders had lower accuracy than subordinates on a task that requires executive control. The ERP results showed that, while power-holders did not differ at the level of early processes related to detecting conflict, they devoted less top-down motivational resources to their task compared to subordinates or neutrals. Subordinates, on the other hand, were asymmetrically sensitive to the power-holders' targets, although attention to the other was not instructed. In terms of how they perceived feedback, power-holders expected more gains, as indexed by more pronounced reward prediction errors. On the other hand, power-holders attached less significance to their losses. Subordinates showed the opposite effect: expecting less, but caring more. It seems that holding power reduces the motivation to cooperate diligently with less powerful others.

The study suggests that power asymmetries leads to asymmetries in cooperation, which is not inconsistent to the social psychological literature on the corruptive effects of power (Galinsky et al., 2006; Kipnis, 1972). It is necessary, however, to divert from explanations of “metamorphic” or magical properties of power, and to lead to an explanation of how different affordances and constraints shape the deployment of cognitive resources.

One of the strengths of this study was the information provided by the combination of both experiments, which allowed two types of comparison. In the first instance, it provided an account of how behavioural and neural profiles of cooperators differed from those of competitors, in a non-hierarchical state, while taking into account order effects. These results could be placed beside the results of the first experiment, to compare how the variables of interest changed according to the different manipulations and task instructions. This analysis can be considered descriptive in the first instance.

In the first experiment, subordinates showed more accurate performance, which was not explained by the better inhibition, and executive control processes, at an early stage, as indexed by N2. While this result may diverge from some studies which associated power with superior ability to inhibit unwanted stimuli (e.g. Smith et al., 2008), it is important to keep in mind that it is quite likely that different inhibition paradigms may tap into different processes. For example, it remains controversial whether different tasks, like the Flanker paradigm, the Stroop task, or other variations, isolate processes of response inhibition, as opposed to related control processes such as conflict resolution, response selection, attention, and working memory (Chambers et al., 2009). Attention and working memory are also susceptible to power (e.g. Smith et al., 2008). It is therefore important to treat these results with caution and keep in mind that different cognitive processes might be at play. Given that the Flanker paradigm is, nevertheless, a classical paradigm that investigates inhibition in the context of executive control, one would have expected to observe an effect here.

A more likely explanation for the results of this study, suggested by the P3b findings, is relatively greater motivational importance devoted to these targets, which improved response preparations (Nieuwenhuis et al., 2005). The second experiment showed faster performance for competitors compared to cooperators on incongruent trials, without a speed/accuracy tradeoff. The N2 data, consistently, showed a superior ability for competitors to override conflict at an early stage of information processing. The second experiment shows that it is possible, within the current task and paradigm, for a social manipulation, like competition, to influence executive attention indexed by the N2. The fact that this result was not present in the first experiment adds evidence that power probably does not affect these early types of executive attention processes. The second experiment also showed higher P3bs for competitors, which may also explain their better performance. The two studies are consistent in linking higher P3bs to better performance, although was manifested in accuracy and speed respectively.

With regard to feedback, cooperators showed an increased P3 to their own negative feedback, demonstrating larger subjective value attributed to these errors than the competitors (Wu & Zhou, 2009). This pattern resembled that of the subordinates', who showed an increase in feedback P3 compared to power-holders. Looking at the two studies in this manner, one can tentatively suggest that subordinates receive feedback like cooperators, attaching a large value to communal losses that are seen by others. Competitors and cooperators did not show different FRNs, or oFRN, revealing that they did not differ in the extent to which they expected to get negative feedback (Bellebaum et al., 2010). The power manipulation, however, made the power-holders relatively more confident about their abilities, under Bellebaum et al.'s (2010) interpretation of FRN.

By taking the participants that performed the second experiment as competition followed by cooperation, and including them in one analysis with the first participants, a second very useful comparison was possible. It became clearer to observe whether it was power or subordination that provoked the changes in cognition and behavior in the first experiment. Behavioural data showed that it was power-holders who under-performed on the difficult trials, compared to subordinates and neutrals. The neural data show that this is likely attributed to lower significance attached to, and top-down resources devoted to, the stimuli/task, as indexed by P3b, rather than changes affecting early target selection or conflict detection processes. Subordinates also devoted greater resources to the other's targets, compared to power-holders and neutrals. Feedback locked potentials showed that both power and subordination had an effect on how individuals evaluated their own performance. Power increased and subordination decreased the feedback related negativity, which was interpreted here as a subjective reward prediction error, indicating that both power and subordination changed confidence in one's abilities. Feedback P3s showed that subordination increased, while power-holders decreased, the subjective magnitude attributed to losses. These results need to be treated with caution due to the small sample size; nevertheless, it is undeniable that the distinct effects of power and subordination are accentuated with the presence of the control group.

To summarize, it seems that power-holders become lazier information processors (Fiske & Depret, 1996) during a communal task compared to subordinates and neutrals. They devote less processing resources to targets, which allows for more errors. It is quite possible that they can underperform on tasks which they feel are not too worthy for their effort (DeWall, Baumeister, Mead, & Vohs, 2011). They have also been reported to act in a disinhibited fashion (Hirsh, Galinsky, & Zhong, 2011), which may have had the paradoxical effect of allowing incorrect responses primed by the distractors to emerge. Subordinates, on the other hand, devote more resources to environmental stimuli, which are task irrelevant, compared to power-holders and neutrals. Like good cooperators, subordinates attribute more value to negative feedback stimuli that reflect communal losses. Power-holders, on the other hand, expect fewer errors, as indexed by higher reward prediction errors, but are relatively less bothered when they make them. They do process subordinates' errors more like their own errors, which is likely due to the impact of their errors on their own resources (Marco-Pallarés et al., 2010).This shows that power-holders are not the best cooperators, which is somehow consistent with the literature describing power-holders as disruptive of harmonious social interactions (Galinsky et al., 2006; Kipnis, 1972).

The neural underpinnings of power are starting to receive some attention and speculation. In the previous study showing the effect of status on performance monitoring (Boksem et al., 2011), the authors suggest that high-status individuals may rely more on the proactive dorsal control system, stimulating approach and goal-directed behaviour, while the behaviour of low-status individuals may rely on the reactive ventral system, which down-regulates approach and is sensitive to salient external events (such as negative performance feedback) (Corbetta & Shulman, 2002). The same authors suggested a similar explanation in an earlier study (Boksem, Smolders, & De Cremer, 2009) where they measured EEG activity while subjects engaged in a task priming either high or low social power. Priming high social power was associated with greater left-frontal brain activity compared to low social power, which was interpreted as neural evidence for the theory that high power is associated with approach-related motivation.

These hypotheses are speculative and require more data and clarification, but they provide several ideas that can be followed up. For example, one can base an explanation on the Posner (1990) model and suggest that subordinates have high levels of endogenous vigilance or alertness (Keltner et al., 2003). This may coincide with larger presence of norepinephrine which regulates the alerting system (Fan & Posner, 2004). Interestingly, P3 is proposed to reflect phasic activity of the neuro-modulatory locus coeruleus-norepinephrine (LC-NE) system (Nieuwenhuis et al., 2005). One may speculate that these two phenomena are connected, where NE levels may explain the large P3 amplitudes of subordinates.

It is to be noted P3b amplitude is also affected by arousal level (Kok, 2001). An alternative explanation is that subordinates' higher arousal levels, due to the impending decision regarding their winnings, elicited all the changes in P3b amplitude, without any effect of resource allocation. However, as the results show that the both power-holders and subordinates showed different P3b effects, depending on who the target belongs to, suggests that a global arousal might not explain everything. It is recognized, however, that P3b is a multi-faceted potential. Better assays of attention, using stimuli in peripheral vision, are important to further explore how power-holders and subordinates differ in target processing.

These findings have interesting implications for work settings where power hierarchies exist, and may seem consistent with the classic social psychological literature that tends to cast power as corruptive for harmonious social interactions (Kipnis, 1972). The findings do not, however, imply that power has magical or transformative effects. The short-term manipulation suggests that situational affordance and constraints can affect cognition in remarkable ways. While one may assume that people reach positions of power because of underlying abilities and personality traits, the data suggest that power and subordination allow for cognitive and affective changes that may reinforce these roles (Smith et al., 2008). Moreover, both power-holders and subordinates become convinced by their assigned status in the hierarchy, and subsequently interpret feedback in quite different ways.

5 Chapter 5-Power and Memory

5.1 Introduction

We are not surprised when secretaries can accurately describe their boss's mood as a function of the time of day, or when employees knows what shoes their employer wore the day before. The opposite scenarios, however, tend to occur less frequently. Several lines of research have shown that interpersonal power can predict how much information people seek about others in their social relationships (Chen et al., 2001; Fiske, 1993; Fiske & Dépret, 1996; Goodwin et al., 2000; Overbeck & Park, 2006). It has been suggested that lack of power, or subordination, adaptively leads to a vigilant type of information-processing (Pittman & Agostino, 1989). In other worlds, subordinates adaptively start attending to cues around them, and especially to power-holders, to gain some information about when the monopolized resource will become available (Berscheid et al., 1976). One consequence is that subordinates may try to process available information rather indiscriminately (Guinote, 2007a), taxing their processing capacities and even leading to impairment in executive functions (Smith et al., 2008). How 'mindlessly' do subordinates attend to power-holders and recall information about them? Are they sensitive to the situational relevance of forming such memories, and to the type of information available? This study suggests that subordinates may seek information which is not relevant to the current task or goal. However, the information has to be diagnostic of the power-holder, as revealed by voluntary choices.

Humans are quite restricted by the amount of information that they recall, and it is attention that determines what items will leave a lasting impression (Chun & Turk-Browne, 2007). Thus, given equal demands, we can say that if one person asymmetrically remembers the actions or choices of another, it is likely that they also devoted more attentional resources to the other during encoding (Ballesteros, Reales, García, & Carrasco, 2006). In general, the attention we pay to any one person varies depending on how much we *need* them to obtain certain outcomes, how much we *want* to learn about them (motivation), and how *able* we are to devote resources to them (Fiske, 1993; Berdahl & Fiske, 2010). This becomes relevant in the context of power, where the default state is that attention travels up the power hierarchy (Fiske, 1993). Consider a boss and employee. The employee has to rely on the boss for access to a desired resource or outcome, like promotion, for example. The employee thus needs the boss to obtain their desired outcome, and is motivated to attend to the boss for cues as to when the resource will become available. More often than not, the employee is also more able than the boss to attend to the other, because the boss is likely to have other priorities and responsibilities. Consequently, in the default state, we can predict that subordinates are more likely to remember information related to the power-holders.

While power-holders default to attentional disregard, it has also been shown that when they are sufficiently motivated to do so, they are quite adept at attending to subordinates. Overbeck and Park (2001, 2006) conducted a series of experiments which showed that when people-oriented goals were emphasized, power-holders attended to individuating information about subordinates. Thus, it is conceivable that the processing asymmetry may disappear when it becomes relevant for power-holders to attend to subordinates. Another possibility is that, as long as a power hierarchy exists, subordinates will be relatively more motivated to attend to power-holders, regardless of the surrounding relevance and circumstances, and remember things about them. This, in part, also depends on whether, in the given context, it is power-holders who under-attend, subordinates who over-attend, or a mixture of both. This is an issue that is explored in this study.

Another interesting question is what type of information subordinates are interested in. One possibility is that subordinates are not selective in what information they retain about power-holders. Because it is adaptive to learn about the power-holder, this amplification of attentional focus may extend to include any item that is remotely associated with them. There is some indication in the literature that subordinates are rather indiscriminate information processors, failing to distinguish between relevant and peripheral information (Guinote, 2007a). Another possibility is that subordinates are outright interested in potentially diagnostic information. For example, it has been shown that behaviour which is perceived as voluntary provides more diagnostic information about the actor than behaviour which is perceived as forced or circumstantial (Jones & Davis, 1965). Thus, a free choice is more telling than an imposed one, making it more useful to remember for the subordinate. Another issue we explore in this study is how discriminating subordinates are about the information they process about power-holders.

In the first of three experiments, I tested whether the attentional asymmetry between power-holders and subordinates could be reduced by manipulating the task-relevance of remembering information associated with the other. In short, one group were told that they would be tested for memory at the end of the study, while the other group were not told anything. I hypothesized that giving power-holders incentive to attend to subordinates would eliminate at least some of their default attentional disregard (Goodwin et al., 2000). This study also included a control group to ascertain whether power reduces attention or whether subordination increases it. In the second experiment, I ruled out an explanation of the results of the first experiment in terms of an effect of power on the self-reference bias in memory. In the third experiment, I tested whether the type of information that was presented mattered, by investigating memory for imposed items. We hypothesized that subordinates are interested in diagnostic information. In the end, they, too, are “motivated tacticians” (Fiske, 2004), and should only attend to items which provided some information about the power-holders.

5.2 Experiment 5.1

5.2.1 Methods

5.2.1.1 Participants and design

The sample consisted of 84 participants, aged 18-21, who performed the experiment in same-sex pairs. Participants were recruited from Oxford’s student and non-student populations. There were 28 hierarchical pairs (14 male pairs), each consisting of a power-holder and a subordinate. There were 14 non-hierarchical (neutral) pairs (6 male pairs). Half the pairs were in the task-relevant condition, and half the pairs were in the spontaneous condition. Thus, the groupings were as following: 14 power-holders (task-relevant),14 subordinates (task-relevant),14 neutrals (task-relevant),14 power-holders (spontaneous),14 subordinates (spontaneous),14 neutrals (spontaneous). All participants provided written consent. The experiment was approved by the University of Oxford's Central University Research Ethics Committee (CUREC).

5.2.1.2 Procedure

Power manipulation: Pairs of participants first performed a 20-minute session of a cognitive task, which was an adaptation of the Eriksen flankers paradigm for this experiment (Eriksen & Eriksen, 1974). The purpose of this task was simply to induce a power manipulation. They were told that a good score on this task reflects greater cognitive control, and were instructed to compete for better performance on the first session. In the hierarchical pairs, this was the hierarchy-inducing session. One participant, randomly chosen, was told that he/she was the better performer. In a second session of the same task, their joint performance was translated into a sum in pounds, which was split by the winner of the first session. Thus, a power hierarchy was created after the first round, based on control over a desired resource (money), which was randomly assigned yet perceived as legitimate. In the non-hierarchical pairs, the scores were not announced after the first competitive session, and the joint winnings on the second round were automatically split in half.

Task: After a power hierarchy was created (or not, in the neutral groups), participants were seated together in front of a computer screen and performed the “choice session”. This consisted in taking turns in making preferential choices from a series of four-picture arrays. Twenty different arrays, each containing four pictures from the same visual category, were presented consecutively. Participants were given 5 seconds to make their choices after every array by button press on a common keyboard. Each of the four pictures was labelled “A”, “B”, “C”, or “D”. Participants chose a picture by pressing the corresponding key on the keyboard and then pressing Enter. Afterwards, both choices appeared on the screen for 1.2 sec. Before this time, participants did not know what choice the other participant made (Figure 5.1). At the end of the second session of the cognitive task, participants performed the “memory session” while seated separately in their booths. They were shown each array again and asked to remember their own choices, and the choices of the other participant. Written instructions appeared on the screen, in the middle of the array, instructing participants to press the letter corresponding to the picture that they chose, followed by the picture that the other chose. The order of the array categories was randomized, and so were the locations of the pictures within each array. All 20 arrays were tested, and there were no time limitations.

Presentation v10 (Neurobehavioural Systems, Albany, NY) was used for stimulus presentation and recording of behavioural responses. All statistical analysis was conducted with PASW Statistics 18.

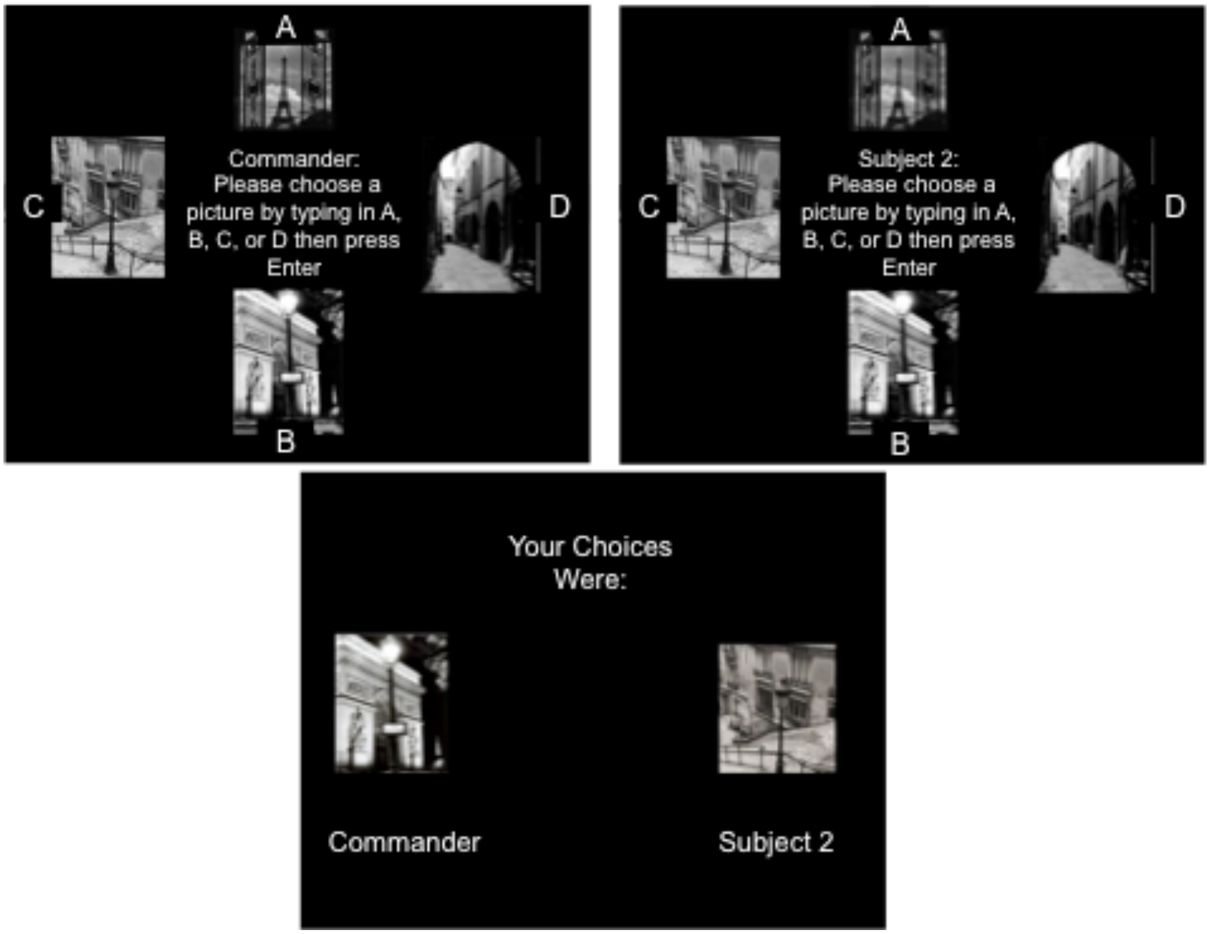

Figure 5.1: Schematic depiction of stimuli in the choice session, with one example of the presented picture arrays. The power-holder “Commander” was prompted to choose first (top left), followed by the subordinate “Subject 2” (top right), and their choices appeared on the screen for 1.2 seconds (below). The pair were seated together facing the same screen. In the memory test, the arrays were presented in a similar fashion, separately to each participant sitting in their own booth. The text was replaced with “Which picture did YOU choose” and “Which picture did the OTHER choose”. Array order and location on screen were randomized for the memory test.

Manipulation of task-relevance: Participants performed in one of two conditions. Half the participants were instructed to pay attention to the choices made by the self and the other, because they would be tested for memory of at the end of the experiment. This was the “task-relevant” condition: the task demanded that they attend and remember the choices. The second half of participants were not informed about the subsequent memory task during the choice session. It was the “spontaneous” condition, as there was no explicit instruction to attend and remember the choices. For the second group of participants, the memory test was not expected.

Analysis: When the pairs of choices from each array were recalled, there were different types of errors participants could make. An *egocentric* error was committed when a participant remembered their choice and failed to remember the other’s choice. An *allocentric* error was an error where participants failed to remember their own choice and remembered the other’s choice. Pure errors were errors where participants failed to remember either choice.

5.2.2 Results and discussion

To check whether the power or task-relevance manipulation had an effect on the ability to recall in general, a univariate analysis of variance (ANOVA) was conducted with accuracy (correct items/ all items) as the dependent variable, and with two fixed factors: *role* (power-holder, subordinate, or neutral), and *task-relevance* (relevant or spontaneous).

There was, as expected, a main effect of task-relevance, $F(2,78)=7.33$, $p<0.01$, revealing a higher proportion accuracy ($M=0.75$, $SE=0.023$) when it was relevant to the task to remember, compared to when they encoded spontaneously ($M=0.66$, $SE=0.023$). There was no main effect of role, or interaction of role with task-relevance, indicating that the manipulation had no effect on accuracy (Mpowerholder=0.68, $SE=0.028$; Msuboordinate=0.68, $SE=0.028$; Mneutral=0.74, $SE=0.028$; p=ns) (Figure 5.2).

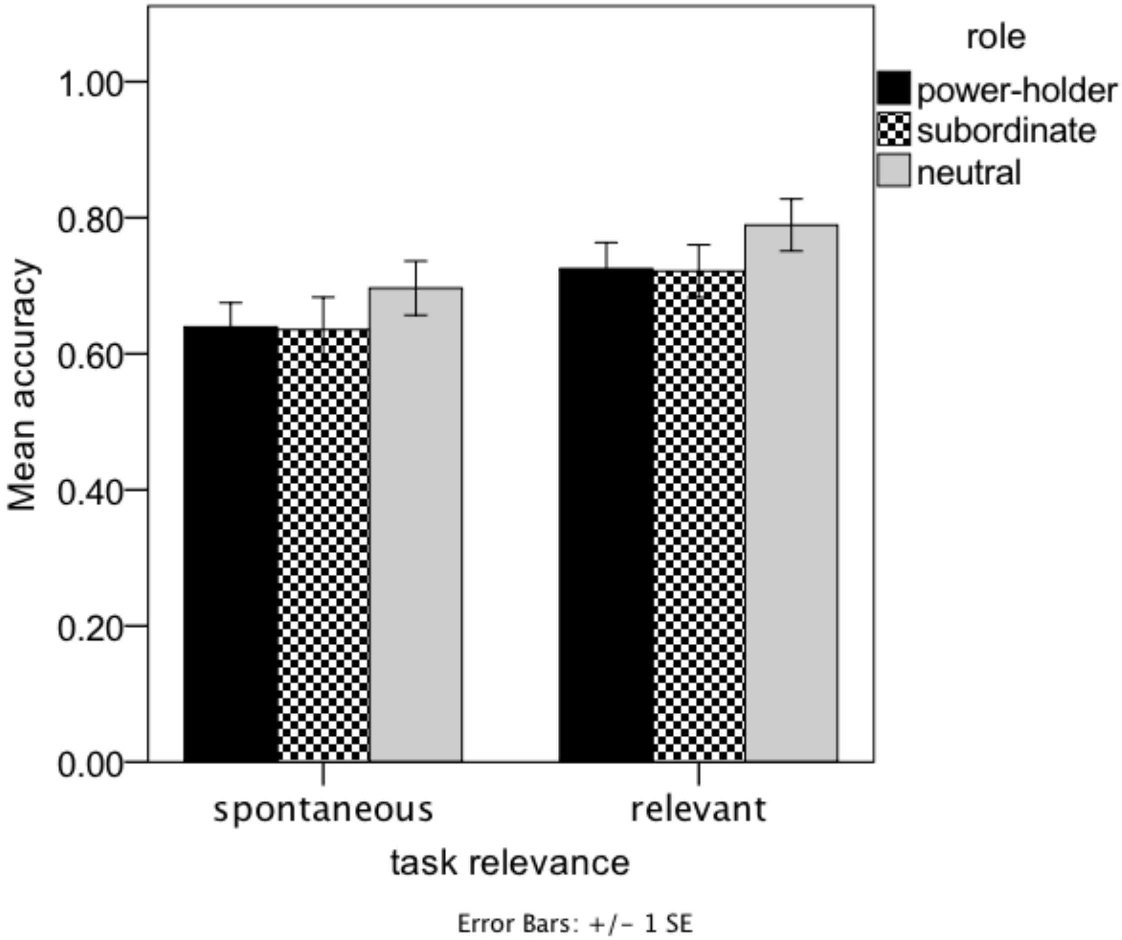

Figure 5.2: Graph dsiplaying the mean accuracy, separately for power-holders, subordinates, and neutrals, in recalling items chosen from each of the twenty arrays in Experiment 5.1. The left panel represents the spontaneous (uninstructed) condition, and the right panel represents the task-relevant (instructed) condition.

role	Task relevance	Error type	Mean number of errors	Std. Error
power-holder	spontaneous	egocentric	4.79	.49
		allocentric	.64	.26
		pure	1.71	.48
	task-relevant	egocentric	3.50	.49
		allocentric	.64	.26
		pure	1.45	.48
subordinate	spontaneous	egocentric	3.07	.49
		allocentric	1.07	.26
		pure	3.14	.48
	task-relevant	egocentric	2.93	.49
		allocentric	1.14	.26
		pure	1.50	.48
neutral	spontaneous	egocentric	3.50	.49
		allocentric	.93	.26
		pure	1.64	.48
	task-relevant	egocentric	2.93	.49
		allocentric	.43	.26
		pure	.93	.48

Table 5.1: Table displaying mean number of errors and standard errors of the means in Experiment 5.1 across role (power-holders, subordinates, or neutrals), task-relevance of remembering the items (spontaneous or task-relevant), and type of error (egocentric, allocentric, or pure).

To investigate whether the power manipulation had an effect on the type of error committed, a mixed-effects ANOVA was conducted with *role* and *task-relevance* as the between-subject variable and error *type* (egocentric or allocentric) as the within-subject variable. Error types were calculated as a proportion, by dividing the number of errors of that type by all possible errors.

First, there was a main effect of error type, $F(1,78)=176.86$, $p<0.001$, revealing, as expected, larger proportion of egocentric errors ($M=0.61$, $SE=0.025$) than allocentric errors ($M=0.14$, $SE=0.018$, $p<0.01$) for all participants.

There was a significant *role* by error *type* interaction, $F(2,78)=4.46$, $p<0.05$. To investigate the two-way interaction, each type of error was analyzed separately. For egocentric errors, there was a main effect of *role,* $F(2,78)=4.14$, $p<0.05$. Post-hoc analyses (corrected for multiple comparisons) revealed that subordinates ($M=0.52$, $SE=0.043$) made significantly fewer egocentric errors than power-holders ($M=0.69$, $SE=0.043$, $p<0.05$), and marginally significantly more than neutrals ($M=0.63$, $SE=0.043$, $p=0.07$) (Figure 5.3). Power-holders and neutrals did not differ significantly. For allocentric errors, the effect of role did not emerge as significant ($p=0.13$). There was no interaction with task-relevance, indicating that power's effect on type of error persisted regardless of whether it was relevant or irrelevant for the task to remember the choices.

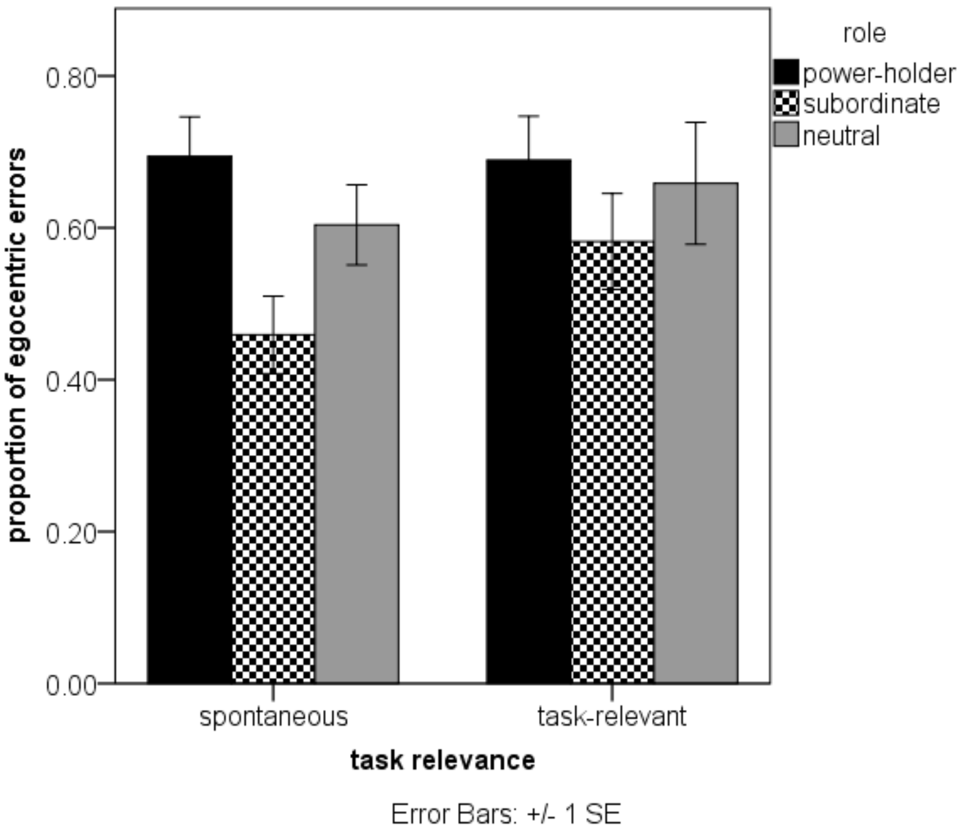

Figure 5.3: Graph displaying the mean proportion of egocentric errors, separately for power-holders, subordinates, and neutrals, in recalling items chosen from each array in Experiment 5.1. The left panel represents the spontaneous (uninstructed) condition, and the right panel represents the task-relevant (instructed) condition.

For allocentric errors, the effect of role did not emerge as significant (p=0.13), neither the effect of task-relevance (p=ns) [2].

In this first experiment, it was confirmed that the attention asymmetry between power-holders and subordinates (Fiske, 1993) extended to an asymmetry in remembering items associated with the other.

[2] There was a concern that the proportion of egocentric and proportion of allocentric errors are not completely independent variables, which may not be optimal to include as a within-subject variable in a repeated measures ANOVA. Wherever relevant, additional analyses were made for each type of error independently. In this particular analysis, the investigation of the two-way interaction necessitated an analysis of each type of error independently, which addressed this concern. In subsequent experiments, extra analyses are included in a footnote.

Subordinates made fewer egocentric errors in remembering array choices than did power-holders and neutrals. These findings suggest a mechanism whereby subordinates prioritize information related to power-holders, rather than power-holders disregarding subordinates.

It has been suggested that when circumstances motivate power-holders to attend, they do so effectively (Overbeck & Park, 2001; 2006). I sought to eliminate the attentional asymmetry between power-holders and subordinates by making it task-relevant for both parties to attend to the other. Moreover, in this experimental setup, it was not the case that the power-holder had more responsibilities than the subordinate, hence they were both equally able to attend to the other. These two factors have been proposed to reduce the tendency of power-holders to resort to attentional neglect (Russel & Fiske, 2010).

However, the results showed that subordinates were still less likely to make egocentric errors compared to power-holders and neutrals, regardless of the task instructions. Explicit directions to remember the choices made all participants less likely to commit errors, indicating that they were following the task instructions and paying attention to the choices that were being made. However, the proportion of egocentric errors did not change significantly in the three groups as a function of task instruction (Figure 5.3).

There is, however, a consideration to be made. Egocentric errors are quite common, because the act of choosing an item endows the item with a memorial advantage (Cunningham, Brady-Van Den Bos, & Turk, 2011) which is linked to self-referential encoding processes (Rogers, Kuiper, & Kirker, 1977). Because the other’s items were not *chosen* explains why egocentric errors were so high in proportion, across all participants. Due to the way the first experiment was set up, and the errors coded, it is also possible for the results to be explained by self-oriented, rather than other-oriented processes. Power may affect the memorial advantage of items related to the self. This is an issue we explored in the second experiment.

5.3 Experiment 5.2

A robust finding in the literature is the self-reference bias in memory: materials are remembered better if they have been encoded in a self-relevant way than if they have not (Rogers et al., 1977). A widely-accepted explanation is that the self, as a concept in memory, has elaborative properties and is frequently accessed (Symons & Johnson, 1997). The self-reference effect has been expanded to include a bias for remembering items one chooses and owns, due to their association with the self (Cunningham et al., 2011).

The literature offers some interesting perspectives on how power may affect the self-reference bias. Powerful individuals present themselves in ways which more consistent with their interests and dispositions than powerless individuals (Guinote, Judd, & Brauer, 2002). This could mean that their self-concepts are relatively conscious and accessible, which might enhance self-referencing during encoding (Markus, 1977). Power-holders also tend to perceive themselves as agentic subjects (James, 1890); whereas subordinates see themselves and are seen as objects (Galinsky et al., 2003), which may affect self-construals and subsequently the self-reference bias.

In the second experiment, I investigated this matter by allowing power-holders and subordinates to choose items for themselves, and for the other. This way, the attention processes related to making choices were equated, and it could be seen whether power created a bias in remembering self-related items.

5.3.1 Methods

5.3.1.1 Participants

Thirty-two participants (14 males) made up the sample, 16 power-holders and 16 subordinates, participating in same-sex pairs, aged 18-21. The participants were recruited from Oxford's student and non-student populations. All participants provided written consent. The experiment was approved by the University of Oxford's Central University Research Ethics Committee (CUREC).

5.3.1.2 Procedure

The same design, power-manipulation, and stimulus arrays were used as in Experiment 5.1. In the choice session, participants sat in separate booths and were told to choose one picture 'for themselves' and another 'for the other person'. They were told that the experiment was looking at how well their intuitive choices for themselves and the other person would match up. There was no instruction to try to remember any of the choices made. In the memory sessions, participants were told to make the same choices they made in the choice session all over again, both for themselves and the other person; again in separate booths.

5.3.1.3 Analysis

A consistent type of coding with that of the first two experiments was implemented. An *egocentric* error was committed when a participant remembered the picture that they chose for themselves, but failed to remember the picture they chose for the other. An *allocentric* error was an error where participants failed to remember the picture that they chose for themselves, but remembered the picture that they chose for the other. Pure errors were errors where participants failed to remember either choice.

5.3.2 Results and discussion

First, a t-test was conducted with dependent variable of accuracy, and independent variable of *role*. There was no effect of role, (Mpower-holder=0.76, SD=0.13; Msubordinate=0.79, SD=0.15, p=ns), indicating that the manipulation had no effect on the overall accuracy committed.

A mixed-effects ANOVA was conducted with *role* as a between-subject variable, and error *type* (egocentric or allocentric) as a within-subject variable. Two subordinates made zero errors overall, making the proportion of egocentric or allocentric errors difficult to interpret. Thus, in this analysis, there were 16 power-holders and 14 subordinates. There was, as expected, a main effect of error type $F(1,28)=14.46$, $p<0.01$, es=0.34; showing a larger proportion of egocentric errors (M=0.52, SE=0.062) than allocentric errors (M=0.18, SE=0.0137). There was no main effect, or interaction, with *role*, indicating that the power manipulation had no effect when each participant had to make both choices (Figure 5.4)[3].

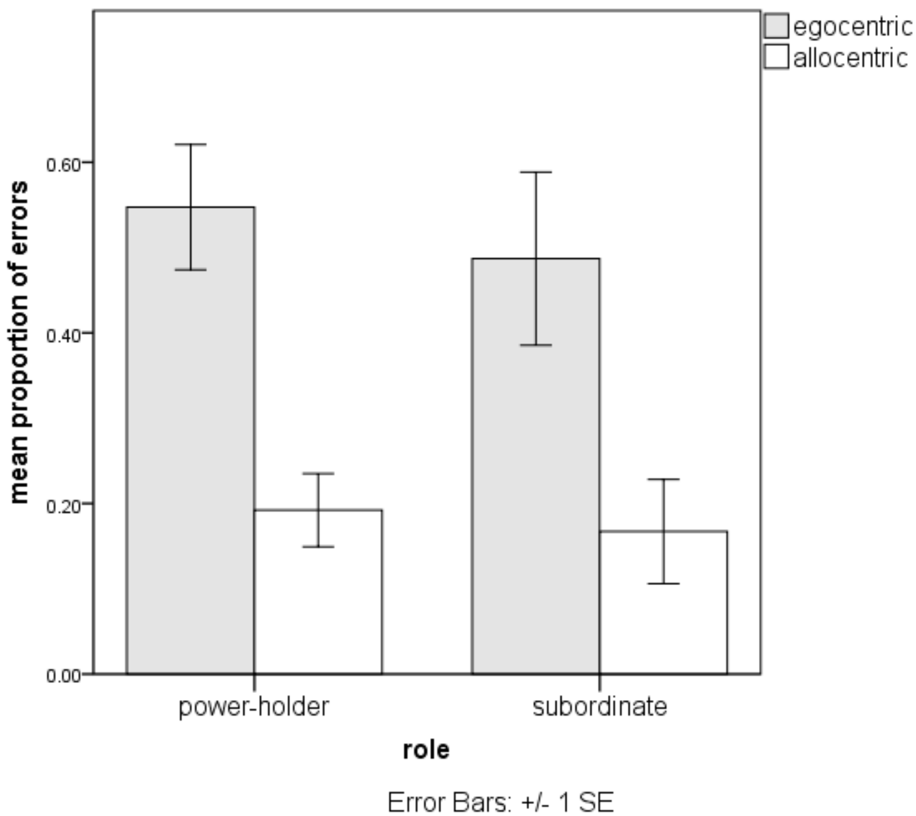

Figure 5.4: Graph displaying the mean proportion of egocentric and allocentric errors committed by power-holders and subordinates in recalling items they chose in each of the twenty arrays in Experiment 5.2.

No differences were found between power-holders and subordinates in the proportion of egocentric or allocentric errors, indicating no evidence that power affects self-referent processes in memory encoding. This allows to attribute the results of the first experiment to differences in other-oriented processes. The third issue I explored was the importance of choice in the items

[3] Separate analyses for error type: A t-test was conducted with dependent variable of proportion of egocentric errors, and independent variable of role. There was no effect of role, (*M*power-holder=0.54, *SD*=0.084; *M*subordinate=0.49, *SD*=0.0.09, *p*=ns), indicating that the manipulation had no effect on this measure. The same t-test was conducted where the dependent variable was proportion of allocentric errors. Similarly, there was no effect of role, (*M*power-holder=0.19, *SD*=0.17; *M*subordinate=0.17, *SD*=0.22, *p*=ns).

remembered, or whether subordinates were interested in the simple association of items with the power-holder.

5.4 Experiment 5.3

It was established that subordinates remain more interested in power-holders even when both parties were given an incentive to attend to the other. This could not be explained by a memory effect in general, or by differences in self-oriented processes. Power-holders and subordinates differed in the way they prioritized information about the other.

The next step was to see whether the type of information mattered at all. One possibility is that, because it is generally adaptive to do so, subordinates are more likely to encode any type of information related to the power-holder. Another possibility is that the type of information matters. Items chosen by the power-holder might be seen as reflecting preferences or dispositions, which might be useful to retain. In a similar manner, actions that are freely chosen are seen as more reflective of an individual's disposition than actions that were enforced by the situation (Jones & Davis, 1965). In the third experiment, I tested whether I could find the same attentional asymmetry with items associated with power-holders and subordinates but that the participants did not choose themselves.

5.4.1 Methods

5.4.1.1 Participants

The sample consisted of 30 participants, aged 18-21, who performed the experiment in same-sex pairs (8 male pairs). There were 15 power-holders and 15 subordinates. All participants provided written consent. All participants provided written consent. The experiment was approved by the University of Oxford's Central University Research Ethics Committee (CUREC).

5.4.1.2 Procedure

Power manipulation and task description: The same power manipulation was implemented as in Experiment 1, although a Posner-type attention task was used (Brignani et al., 2009). Both participants sat in front of the same screen as the same four-picture arrays as in experiment 1 appeared one after the other. For each array, a blue frame and a green frame bordered two different (or the same) picture, randomly chosen, and remained for 5 seconds. Each participant was instructed in advance to remember either the picture surrounded by the blue frame or the green frame for all 20 arrays (i.e. the power-holder was trying to remember the pictures surrounded by one coloured frame while the subordinate was trying to remember the pictures surrounded by the other coloured frame). Participants were not told that they would be tested for memory for the other's choices. At the end of the second session, participants sat in separate booths, and were told to try to remember the picture that was framed in their assigned colour in the choice session, and additionally to try to remember the picture assigned to the other participant.

Analysis: A consistent type of coding with that of Experiment 5.1 was implemented, to allow for comparison across experiments. An *egocentric* error was committed when a participant remembered the picture that was chosen for them and failed to remember the picture chosen for the other. This was a very common type of error, due to the instructions of the task. An *allocentric* error was an error where participants remembered the picture that was chosen for the other and failed to remember the picture that was chosen for them. Pure errors were errors where participants failed to remember each of the two choices.

5.4.2 Results and discussion

First, a t-test was conducted with an independent variable of *role* and a dependent variable of accuracy. There was no effect of *role*, (*M*power-holder=0.42, *SD*=0.13; *M*subordinate=0.44, *SD*=0.14, *p*=ns).

Then, a mixed-effects ANOVA was conducted with *role* as a between-subject variable, and error *type* (egocentric or allocentric) as a within-subject variable. There was, as expected, a main effect of error type $F(1,28)=304.04$, $p<0.001$; showing a larger proportion of egocentric errors ($M=0.79$, $SE=0.039$) than allocentric errors ($M=0.033$, $SE=0.011$). There was no main effect of, or interaction involving, role either, indicating that the power manipulation had no effect in this experiment (Figure 5.5). [4]

[4] Separate analyses for error type: A t-test was conducted with dependent variable of proportion of egocentric errors, and independent variable of role. There was no effect of role, (*M*power-holder=0.76, *SD*=0.24; *M*subordinate=0.81, *SD*=0.18, *p*=ns), indicating that the manipulation had no effect on this measure. The same t-test was conducted where the dependent variable was proportion of allocentric errors. Similarly, there was no effect of role, (*M*power-holder=0.021, *SD*=0.62; *M*subordinate=0.045, *SD*=0.054, *p*=ns).

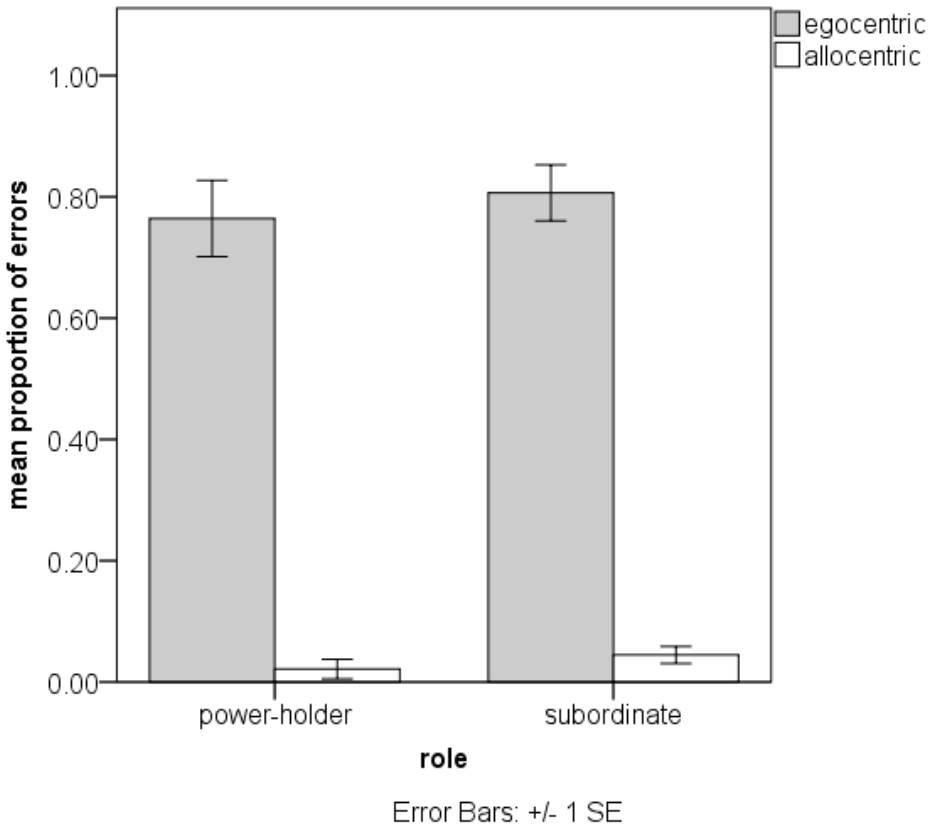

Figure 5.5: Graph displaying the mean proportion of egocentric and allocentric errors committed by power-holders and subordinates in recalling items in each of the twenty arrays in Experiment 5.3.

Similarly to the first two experiments, I found no effect of power on memory performance in general. However, unlike Experiment 5.1, I found no asymmetries in attention to items associated with the other. This indicates that although subordinates may be motivated to attend to power-holders and their choices in both relevant and irrelevant situations, this is a mechanism that does not apply for information that is not diagnostic of the power-holders.

5.5 General Discussion

This study shed some light on how power affects the extent to which we care to notice and remember things about other people. Across three experiments, it became obvious that power did not affect memory performance in general, which might have been inferred in light of recent literature on the effect of power on executive functions (Smith et al., 2008). Instead, it was found that, within similar memory capacities, power affected the way information regarding others was prioritized. In Experiment 5.1, I showed that subordination increased memory for power-holder's choices, regardless of whether it was relevant to the task directions to do so. Experiment 5.2 showed that these effects could not be explained by a self-reference bias in memory. Experiment 5.3 qualified the results of Experiment 5.1 by showing that subordinates are not interested in information which is not diagnostic of the power-holders.

In Experiment 5.1, after the power manipulation, participants were requested to make preferential choices from arrays of pictures, and were able to observe what the other chose as well. When subjected to a memory test afterwards, it was found that subordinates made fewer egocentric errors than power-holders. This suggests that subordinates were significantly more motivated to process the other's choice than power-holders. This is consistent with the finding that power-holders tend to stereotype subordinates, due to relatively less interest in gaining individuating information about them (Goodwin et al., 2000). The addition of the control group allowed us to deduce that it was the subordinates who over-attended, rather than power-holders under-attending.

Subordinates' better memory for power-holders' choices persisted even when the participants were given explicit directions that they would be required to remember the choices they make later. I sought to reduce or eliminate the attentional asymmetry between power-holders and subordinates by making it task-relevant to attend to the subordinates' choices. It has been proposed that power-holders, when motivated to do so, can be as attentive as subordinates (Overbeck & Park, 2006). There was no significant change in the relative proportions of egocentric errors: subordinates still made fewer egocentric errors than power-holders and neutrals. We only found that participants made fewer errors when instructed to remember, which simply indicated that they were better at remembering with explicit instructions. This can possibly be explained by the fact that the effects were driven by the subordinates. Had the effects been driven by the power-holders under-attending, giving them a motivation to attend to subordinates might have indeed reduced the attentional asymmetry. Of course, these dyadic processes occur in complementary fashion, in both directions (Russel & Fiske, 2010). However, this study shows that in a relatively easy task where processing resources are available, subordinates are the ones driving the attentional asymmetry, and this may persist even when it is not directly relevant for the task to remember information at all. This situation is similar to the example of the secretary who can describe a boss's shoes. Is it likely that this would ever prove relevant? The chances are slim, but they exist.

In the second experiment, it was confirmed that the results of the first experiment could not be explained by an effect of power on the self-reference bias in memory. Egocentric errors, where one remembers one's own choice and forgets the other's, were the most frequent errors for all participants. This comes as no surprise because the act of choosing a picture entails deeper processing of the item than just seeing the other's choice, thereby making it easier to recall (Cunningham et al., 2011; Demb et al., 1995). This is especially true when participants do not expect to be tested for memory. Asymmetrical proportions of egocentric errors in subordinates can also be explained by less attention to the self, rather than more attention to the power-holders. By asking participants to make both choices, for the self and for the other, I made the processing depth of both pictures more similar. There were no differences in egocentric errors between power-holders and subordinates, confirming that the result of the first experiment are more likely attributed to more attention on the subordinates directed towards power-holders.

In Experiment 5.3, I tested whether I could find attentional asymmetry for items which were chosen for the pair, rather than being chosen by them. This was done because the results of the first experiment may suggest that subordinates may automatically encode any bit of information related to the subordinates, rather than choosing to do so on the basis of utility. It may be an adaptive and efficient mechanism, as a decision regarding the importance of an item may also require processing resources. Participants were instructed to remember pictures that were chosen for them by a blue or green frame enclosing one of the four pictures in every array. They did this task together, and saw which items the other had to remember. No differences were found between power-holders and subordinates in the proportion of egocentric errors. This indicates that subordinates are only interested in information that is somehow telling of the power-holders. The preferential choice of power-holders may have been interesting to the subordinate, to find out what "sort of person" they are, perhaps to predict how they would split the money. Items chosen for them do not provide any diagnostic information, thereby not provoking the subordinate's interest.

There are some limitations to be addressed in this study. The first is that, in the power manipulation we used, it may be different to disentangle power and status. This is because the person who was in control of the resource, the power-holder, was also the person who was proclaimed as the better performer. Ranking people on performance has been used in the past as a status manipulation (Boksem et al., 2011). However, in defense of the manipulation used, we considered that a) power and status often occur hand in hand; and b) random allocation to the power-holder and subordinate role may have been perceived as illegitimate. Illegitimacy has been shown to moderate the effects of power (Lammers et al., 2008).

Another limitation is that Experiments 2 and 3 could have been included in one experiment, to allow for a comparison between choosing and being chosen for. However, I wanted to avoid a task-switching scenario where power-holders and subordinates switched between making choices and trying to remember. Due to subordination's proposed effect on executive functions, of which one was task-switching, such a confounding variable was undesirable. A between-subject comparison is not feasible because the task requirements to remember in

Experiments 2 and 3 are not equated: in the first, participants are told to remember the picture surrounded by their frame; whereas in the second, they are not told that they have to remember. This study, as it is, provides several further avenues of exploration.

In conclusion, this study sheds some light on the way knowledge flows in social hierarchies. The subordinate is still interested in learning about the power-holder, even if the acquired knowledge is not really important for the immediate task at hand. It makes one wonder whether they find information about their bosses' preferences useful to some extent, and whether they are not better off using their resources to focus on their tasks and jobs. However, the third study shows that they are only interested in diagnostic information, as provided by freely chosen items. While they might end up with stores of wisdom that are not immediately relevant, they might still end up learning something useful about the power-holder. The observant employee might know what gift to buy for her boss on her birthday, thereby increasing her chances of promotion. Subordinates, in the end, are also motivated tacticians (Fiske, 2004), trying to make the best use of their resources in a rather unfair and uncertain world.

6 Chapter 6-General Discussion

The story of how power affects cognitive processing is not a simple one. Power provokes a unique constellation of cognitive effects (Guinote, 2013), and we are still at the beginning of an exploration of how these effects occur. Power and subordination can shape an individual's mental world in very different ways, and lead to observable differences in behaviour. The study of power requires an integration of knowledge from the perspective of brains, individuals, dyads, groups, and societies.

Modern studies of power are moving away from a purely descriptive type of research that associates the occurrence of power with broad characteristics, like trying to determine *whether* power leads to kindness or to corruption. We cannot simply ascribe magical or transformative effects to power, like stating, for example, that the possession of power transforms an otherwise amiable individual into a corrupt dictator (e.g., Kipnis, 1972). There will always be research showing quite the opposite, where leaders take on benevolent roles and act in pro-social ways (e.g., Chen et al., 2001). Rather, we should be concerned with identifying *when* power manifests itself pro-socially, or self-servingly, and the mechanisms which allow these properties to emerge (Guinote, 2013).

Indeed, this is no trivial task. Central to the definition of power is the control of outcomes, where control is a basic need that is fundamental to survival and well-being (e.g., White, 1959). Exploring power's effects on cognitive function requires a continuous realization that cognition does not operate in a void, but is modulated in a moment-by moment way according to the motivational states and needs of the individual (Smith & Semin, 2004). The study of power emphasizes that research on cognition cannot proceed if social and motivational variables are considered as unwanted ‘noise’ in the analysis.

The studies described in this thesis provide a multi-layered account of power’s effects, ranging from basic cognitive processes to broader processes that appear at the level of social behaviour. It becomes apparent that both power and subordination change the way individuals react to their environment. The changes that occur with power and subordination serve adaptive functions, to optimize human beings’ survival in worlds that are perceived in different ways.

6.1 Summary of findings

Across all experiments, a consistent power manipulation was employed in pairs of participants. Control over joint monetary outcomes was conferred randomly to one participant, the power-holder, but was perceived to be allocated on the basis of superior task performance in a preliminary session of a cognitive task. Three main themes of research were explored in this thesis, which will be referred to as basic attention function, other-oriented processes, and reactivity to feedback. These themes were approached across different experimental chapters, and the findings associated with them will be elaborated briefly in this section.

Basic attention function was explored in Chapters 3 and 4, inspired by recent findings which suggest that power has distinct effects on the attentional systems of the brain, at a basic level of analysis (Guinote, 2007b; Willis et al., 2011). In Chapter 3, the effect of power on orienting spatial attention was explored. It was initially hypothesized that power would facilitate the discrimination of targets when flexible focus on specific spatial locations was required, whereas subordination would facilitate discrimination when distributed attention to multiple sites was required. In other words, it was of interest to explore whether subordinates operate under divided attention, whereas power-holders are at an advantage when flexible and focused attention is required. A Posner-type attention task was employed to test these hypotheses (Posner, 1980), with pairs of participants performing before and after a power allocation. The task also varied the amount of distractors surrounding the target location. The results cast some doubt as to whether power affected the orienting function specifically. Rather, the results demonstrated that the type of environment, and the amount of distractors present in it, dictated the pattern of results. Subordinates surpassed power-holders in performance when there were no distractors to compete with the targets, regardless of whether the task necessitated divided or flexibly focused attention. On the distractor-heavy version, subordinates surpassed power-holders when attention to one location was required, whereas power-holders surpassed subordinates when divided attention to two locations was required. This counter-intuitive result could be attributed to the fact that in the divided version, there were even more distractors to deal with, which was detrimental for subordinates' performance. This study supported the notion that subordination, and its associated increase of vigilance and alertness (Keltner et al., 2003), can be beneficial for the discrimination of stimuli. However, in environments where abundant competing information is present, subordinates might under-perform.

The results of Chapter 3 suggested that subordinates inhibited peripheral information to a lesser degree than power-holders, which was consistent with the studies presented by Guinote (2007b) and Smith et al. (2008). Inhibition, however, is a complex function. It was then of interest to explore whether subordinates were impaired in the ability to filter out, or inhibit, distracting stimuli at an early level of cognitive processing, in the context of executive control (Posner & Petersem, 1990). Additionally, it was of interest to investigate whether any effects would be driven by power or by subordination. The next study, described in Chapter 4, addressed these questions.

In Chapter 4, simultaneous EEG recordings were employed with a Flanker task (Eriksen & Eriksen, 1974). In this paradigm, target arrows that prime one response tendency are surrounded by distractor arrows that point either in a congruent or in an incongruent direction. In the latter case, responses are slower or incorrect. This paradigm was employed to explore whether, at an early level of cognitive processing, power would affect the extent to which participants experienced response conflict due to the presence of distractors (Yeung et al., 2004). The use of EEG allowed the exploration of events that may not be manifested at the level of behaviour. Behavioural results showed that, contrary to what was expected, power-holders were less accurate on the trials with incongruent distractors, compared with subordinates and the neutral control group. Interestingly, ERP analysis showed that the groups did not differ at the level of early conflict detection, or inhibition of unwanted stimuli, as indexed by the N2 potential (Folstein & van Petten, 2008). Rather, the results showed that the groups differed in the extent of motivational resources devoted to the targets, as indexed by the later P3b potential (Nieuwenhuis et al., 2005). The addition of the neutral control group revealed that it was power-holders who devoted decreased motivational resources to the targets, compared to subordinates or neutrals. It has been quite common to show power-holders as lazy information processors (Fiske, 1993), and it is quite possible that they can underperform on tasks which they perceive are not worthy of their effort (DeWall et al., 2011). Importantly, however, this task raised some doubts as to whether basic inhibitory processes are impaired in subordinates. Rather, the results reinforced the idea that subordinates become relatively more sensitive to environmental stimuli.

Even if a task requires inhibition, subordinates may out-perform power-holders, who may not feel the need to devote much significance to the task. It is possible that this task was not as demanding as the ones explored in the Smith et al. (2008) studies, which claimed that subordination impairs executive functions, of which inhibition is an important example. Also, as discussed in Chapter 4, it is important to keep in mind that different paradigms that investigate inhibitory mechanisms may not measure comparable processes. For example, it remains controversial whether different tasks, like the Flanker paradigm, the Stroop task, or other variations, isolate processes of response inhibition, as opposed to related control processes such as conflict resolution, response selection, attention, and working memory (Chambers et al., 2009). Power is an undoubtedly complex mechanism, with multi-layered effects on cognition. It is therefore not surprising that different paradigms, which may invoke different cognitive processes, may produce such divergent effects of power on cognition. Nevertheless, the Flanker paradigm is a well-established task for investigating inhibitory executive processes, and it was expected that such a prominent claim in the literature, linking subordination to impaired inhibition, would also be visible here. Therefore, it may be pertinent to conduct more studies to identify which tasks, and contexts, are sensitive to the presence and lack of power.

To conclude, the investigation at the level of attention raised doubts as to whether subordination impaired the ability to orient attention across space, or inhibit peripheral information. Rather, the results are consistent with the idea that subordinates become relatively vigilant and sensitive to their environments, up-regulating the use of their cognitive functions in general. Power-holders, on the other hand, can afford to relax and use their resources more efficiently. The effects of such abilities vary according to what type of environment they are operating in.

Another theme of research explored in this thesis was concerned with other-oriented processes, which encompass attention to the other, attention to stimuli associated with another, and memory for actions performed by the other. This theme was explored in Chapters 4 and 5. In Chapter 4, I showed that power-holders were asymmetrically sensitive to targets that ‘belonged to’ the power holder, although these targets were not relevant to task-performance. This sensitivity was indexed by a relatively late ERP, the P3b, which is thought to index motivational significance attributed to stimuli. This finding neatly demonstrates support for a conjunction of two hypotheses: subordinates' sensitivity to multiple environmental stimuli, and subordinates' asymmetrical attention to power-holders (Fiske, 1993). I showed that subordinates devoted resources to stimuli associated with power-holders in an asymmetrical fashion. Adding a control group showed that it was the subordinates driving the effects, and not the power-holders. These findings are again consistent with the vigilance hypothesis (Keltner et al., 2003).

In Chapter 5, I moved away from basic cognitive processes and investigated the effect of power on memory for visual stimuli chosen by another individual. Consistently, I showed that subordinates were asymmetrically competent at remembering items associated with the other (power-holder), compared to power-holders remembering subordinates' choices. This line of research was based on the theory that power predicts information-seeking in social relationships, where subordinates are relatively attentive to power-holders, whereas power-holders default to neglecting subordinates (Fiske, 1993). In the experiments described in Chapter 5, I also showed that the task-relevance of remembering the other's items had no effect on the memory asymmetry. The addition of a control group revealed that subordination was driving the effects, rather than power. It was also confirmed that the results could not be explained by differences in self-reference bias in memory. Interestingly, I did not find memory asymmetries when the items were chosen for the participants by the computer program, indicating that subordinates are interested in diagnostic information provided by voluntary choices, not merely any information associated with power-holders.

The third theme of research dealt with the way individuals evaluated their own performance through feedback processing, which taps into variables like confidence, affect, and motivation. The task employed in Chapter 4 allowed an investigation of ERPs elicited by feedback indicating monetary gains and losses after every trial. The use of EEG was particularly useful for this purpose, due to its ability to reveal cognitive processes that may not emerge at the level of behaviour. The feedback ERP results showed that both power and subordination elicited changes in feedback-processing relative to the control group. The results showed higher expectation of rewards in power-holders, as indexed by the FRN, but reduced subjective magnitude attributed to losses, as indexed by the feedback P3. Subordinates, on the other hand, expected fewer rewards, but attributed greater significance to losses. It was not the case that subordinates attributed more motivational significance to all types of feedback, because power-holders and subordinates did not differ in the way they processed positive feedback.

6.2 General conclusions

To conclude, this thesis employed a well-controlled paradigm and made use of multi-disciplinary approaches to investigate the effect of power on cognitive processes. The following conclusions can be made:

- The vigilance and up-regulation of cognitive function that adaptively occurs with subordination is a major determinant of the observed effects of power on cognition.

- There is insufficient evidence that subordination impairs the ability to a) orient attention across space or b) inhibit peripheral information at a basic attentional level.
- Both power and subordination change the way individuals evaluate their own performance, as indexed by neural measures of feedback processing. Subordinates attach more significance to negative feedback, although they are less surprised by its occurrence. The converse occurs for power-holders.
- The employment of neural measures is a useful tool for investigating the subtleties of the effects of power on cognitive processing.

6.3 Integration with the major theories of power

It is useful to try to place the results of the studies described in this thesis in context of the major modern theories that have framed the study of power. Although one should not be confined by existing paradigms, it is undeniable that integrating the current state of knowledge is a useful activity, rather than branching off on completely independent avenues.

The results of this thesis are broadly consistent with Fiske's (1993) 'Power as Control' theory, which proposes that, in the default state, attention travels up the power hierarchy, where subordinates attend to power-holders in an unreciprocated manner. This thesis extended the implications of this theory to display an asymmetry in processing items *associated with, or relevant to* power-holders, as revealed by studies of both brain and behaviour. Chapter 4 showed an enhanced response in the brain potentials of subordinates to power-holders' targets, at a relatively late stage that represents motivational resources attributed to targets. Chapter 5 showed that subordinates were more competent at remembering items chosen by power-holders. However, this effect did not persist when the items were not chosen by power-holders, but simply assigned to them, revealing that subordinates are interested in potentially diagnostic information.

Keltner et al.'s (2003) theory of approach and inhibition proposes that power is associated with an approach tendency, whereas subordination is associated with an inhibition tendency. This theory also gained some support from the findings of Chapter 4, which revealed that subordinates were asymmetrically sensitive to negative feedback, which implies a sensitivity to environmental threats. Keltner et al. (2003) also integrate past research programmes in what they propose as the power-vigilance hypothesis (e.g., Chance, 1967; Ellison & Dovidio, 1985), which indicates that subordinates are asymmetrically vigilant to environmental stimuli due to threatening environments. As elaborated in previous sections, the results of the current experiments are broadly consistent with this theory.

The Situated Focus Theory of Power (Guinote, 2007a, 2010) proposes that power affects motivation and information processing in ways that lead to more situated responses in power-holders compared to subordinates. It proposes that power-holders process information more selectively in line with the primary constructs activated on a moment-to-moment basis, whether they are goals, subjective experiences, or needs. The results described in this thesis are consistent with what this theory proposes. One of the implications of the theory is that subordinates, compared to power-holders, are relatively less prone to filter out information that is not relevant to their goals. Chapter 3 provided evidence for this pattern at the level of attention selection, where subordinates were shown to under-perform when the environment provided large amounts of distracting information. In Chapter 5, it was shown that subordinates remembered items associated with the power-holders even if the task did not particularly require them to do so. However, it is to be noted that Chapter 4 showed no differences between the groups at the level of basic attention inhibition, as indexed by ERPs. It is more likely that power-holders are more parsimonious in the top-down resources they choose to devote to their environmental stimuli, which is also consistent with the Situated Focus Theory of Power.

Of course, it is important to note that these theories themselves are not inconsistent with each other. Rather, they approach the complexity of power from different angles. All the theories recognize that humans adaptively try to make the best out of the world they inhabit, with the constraint that their cognitive resources are largely insufficient to process the wealth of information that surrounds them. Subordinates up-regulate their cognitive function, and become hyper-vigilant (Keltner et al., 2003), paying attention to multiple sources of information (Guinote, 2007a), and especially the power-holder (Fiske, 1993).

6.4 Limitations

Every programme of study has its limitations, and the series of experiments described in this thesis are no exception. This section deals with broad conceptual and methodological limitations that apply to the experiments in general, and attempts to suggest ways in which they can be addressed. The particular limitations of each experiment have already been addressed at the end of the corresponding experimental chapter.

The first set of limitations deals with the power manipulation that has been employed across the experiments described in this thesis. It is possible that, as power was allocated, other variables were manipulated simultaneously, creating confounds in the interpretation of data. Such confounds may be status, anxiety, mood, incentive, among others.

Because individuals were ranked according to performance, where the power-holder was allegedly the better performer in the first round of the task, there is a possibility that status, or competence, was manipulated alongside power. Whereas power is defined as a situational asymmetric control over a desired resource, status can be defined as power that is already crystallized, a valued social position, usually associated with a group (Spears et al., 2010). Status and power may have dissociable influences on cognition, which should be kept in mind as the results of this thesis are interpreted.

On the one hand, it may be difficult to determine whether the results reported here can generalize to other studies which manipulated power as outcome control without a possible status confound, which is arguably the case for priming manipulations or studies that allocated outcome control randomly (i.e., Guinote, 2007b). It is always possible that the surprising and counter-intuitive results reported in Chapter 3 could have risen due to the fact that status, and not purely power, was manipulated. Due to the young nature of the field, there has not been a systematic comparison between the differential effects of status and power on cognition, which should be a compelling research programme for the future.

If one attempts to dissociate power and status, one can envisage a scenario where control over resources is assigned randomly. That would be a power manipulation without a clear invocation of status. It is to be kept in mind that such a manipulation runs the risk of being perceived as illegitimate, which has been proposed to modulate the effects of power on cognition (Lammers et al., 2008). Nevertheless, the same study can be conducted with one group of participants having power assigned randomly, and the second with power assigned in the way reported in this thesis. Such an investigation may be useful to shed some light on the results. If the results are similar under the two conditions (random assignment and the current form), it would imply that it is, in fact, outcome control which guides the pattern of results. However, it would put to doubt whether legitimacy has any effect on power, which has been reported.

Thus, an additional control experiment would be useful. Monetary outcome control could be removed from the second session, allowing participants to perform the task again after one is told that they performed better. This would allow us to investigate whether a simple assignment to a higher status group has comparable effect on task performance and cognition. If participants perform similarly under no differences in monetary outcome control, it would be difficult to attribute the results of the experiment to power, rather than status.

The constructs being dealt with are undoubtedly complex, which would make it difficult to definitely dissociate the independent effects of each on cognition. When it comes to power and status, it is rather hard, to begin with, to identify where strict boundaries between these two constructs lie. Indeed, in some of the literature, power and status are used interchangeably (Boksem et al., 2011). Several other power manipulations used in the literature, like the leadership questionnaire for example (as discussed in Chapter 1), could also be manipulating status alongside power. By declaring that one participant is fit to be a manager, and the other a worker, it is very possible that status is manipulated as well. Another point is that, in a real life setting, it is often the case that power and status occur together.

Another possible confound is a different degree of performance incentive between power-holders and subordinates. By assuring the power-holder that he/she would be able to split the money in whichever way they preferred, one can argue that power-holders are more incentivized to perform well. On the other hand, one may argue that it is subordinates who are incentivized to perform well, due to the need to prove that they deserve a share of the communal resource. It is difficult to pinpoint the difference in incentive between the power-holder and the subordinate. It is noticeable, however, that subordinates, with a few exceptions, are generally the better performers in the tasks reported in this thesis. This was found, for example, in faster reaction times for the non-distractor version of the task in Chapter 3, in accuracy for incongruent trials in Chapter 4, and in memory for others' items in Chapter 5. Although this performance difference can be explained by the cognitive changes induced by power and subordination, it is important to identify boundary conditions in which one may expect that power-holders may perform better in the same tasks described.

It is conceivable that the way the task was set up did not emphasize the benefit of communal goals. Rather, it individualistically glorified the power-holder as a 'winner'. In an important study where the classically-reported disruptive effects of power were questioned, Chen et al. (2001) demonstrated that individuals with a communal orientation are more likely to behave in socially responsible ways when primed with power, whereas those with an exchange orientation behave in self-serving manners following the same manipulation (Chen et al., 2001). In a complementary fashion, priming people-oriented goals allowed power-holders to individuate subordinates (Overbeck & Park, 2006), as opposed to their default tendency to stereotype them. Thus, it is possible that a scenario where the experimenter emphasized the communal goals would have prompted more motivation in power-holders to perform better and increase the communal monetary gains in Chapters 3 and 4, and would have promoted fewer egocentric errors in Chapter 5.

On a related note, a scenario in which the power-holder would not be so certain of their monopoly over any communal sum would have possibly motivated more accurate performance in power-holders. This could have been warranted through a different power manipulation, where the goal that the pair is acting towards is independent of the resource that creates the power manipulation. It is important to note, however, that these proposed boundary conditions are only legitimate under the assumption that power provokes ‘laziness’ and using others as a means to an end, rather than a general disruption in the ability to perform well. This assumption, however, is warranted from previous literature (e.g., Fiske, 1993; Galinsky et al., 2006).

One must also mention a possible confound with mood, which also has demonstrable effects on cognition (Schwarz & Clore, 2007). Positive mood can occur with power, and negative mood can occur subordination (Keltner et al., 2003). This confound specifically, however, applies to all power manipulations. Also, power is a multi-faceted phenomenon, where mood is an important aspect of its presence and manifestation. In the real world, power inevitably occurs associated with different levels of mood. Dissociating the different effects of mood and outcome control may be desirable, but not absolutely necessary, to explore the effects of power on cognition.

Similarly to the incentive argument, but perhaps stated differently, one may argue that the differences in performance simply arise out of the consequences of ‘winning’ and ‘losing’ in the first round. As mentioned, however, a power manipulation without the staged loss may be deemed illegitimate. It would be interesting, for future studies, to follow identical paradigms, where participants simply perform the task after winning versus losing, without having different levels of control over resources. The results can then be compared to the current findings. It is to be noted, however, that the results described in this thesis are broadly consistent with findings from other experiments which employed different power manipulations.

Generally speaking, an important limitation of laboratory investigations of power is the problem that the employed manipulations convey a depiction of power that is quite static. They generally fail to convey the notion that power is a context-dependent dynamic force, driven by self- and group-serving needs (Guinote & Vescio, 2010). Power emerges from a negotiated reality between groups and the environment, in an attempt to secure outcomes. If power is conceived as a zero-sum variable, there is a risk of overlooking effects that may emerge due to its dynamic, nuanced, and multi-layered characteristics. The only way to address this limitation is to do more experiments, with well-controlled paradigms and creative methods that investigate power at its different levels. Importantly, the results should be integrated at successive stages, rather than allowing the research programmes to proceed on irreconcilable avenues.

Another set of limitations is inherent in the use of neuroscience methodologies to explore questions of a social nature. The difficulty associated with setting up a paired EEG experimental setup necessitates a smaller number of participants than would be ideal to draw conclusions at the level of social behaviour. Another obvious issue is that, if laboratory setups are known to obstruct the ecological validity of a study, adding neuroscience equipment compounds that problem. A boss does not walk around the company with an EEG helmet, and is not forced to stare for an hour at a subordinate in a closed room. Nevertheless, the precision conferred by these methodologies, and the window they provide into mental function, somewhat balances out these limitations. The neuroscientific findings need to be integrated with findings that emerge from studies that observe power in more naturalistic environments.

6.5 Future directions

The study of power opens numerous exciting avenues of exploration, which are only enhanced with the advance of neuroscience methodologies.
It is possible to explore power with fMRI hyperscanning (Montague et al., 2002), which would allow the investigation of diverse hypotheses related to power and cognition. FMRI hyperscanning would combine the benefits of excellent spatial resolution for the localization of brain function with the ability to utilize truly interactional paradigms, to locate brain activity and function as it emerges in real time. For example, fMRI offers exciting possibilities to explore power and reward processing in the brain, due to prior work having established that the ventral striatum, medial prefrontal cortex, and the broader meso-cortico-limbic dopamine system mediate aspects of reward processing from expectation of reward, to the positive feeling experienced upon reward attainment (e.g., Carlson, Foti, Mujica-Parodi, Harmon-Jones, & Hajcak, 2011). Using a task similar to the one employed in Chapter 4, it is possible to investigate how “rewarding” participants find the other’s wins, or whether they experience the negative affect that occurs when the other commits an error, as a function of their social group (e.g., Newman-Norlund, Ganesh, van Schie, De Bruijn, & Bekkering, 2009). In the study described in Chapter 4, EEG did not offer the full potential of exploring

participants' responses to the other's feedback, as there was an attenuated other-P3b potential that prevented a robust analysis. Thus, higher-level affective and motivational responses to the other's performance could not be explored. The ability of fMRI to confer such analysis opens the way for research into variables like empathy, like example. Power holders have been shown to be bad perspective-takers, whereas subordinates tend to show increased empathy (Galinsky et al., 2006). Therefore, one can predict that power-holders will not react affectively to a subordinate's loss. However, given that a subordinate's loss in the current paradigm entails a loss to the communal resource, it would be interesting to explore participants' affective reactions to the other's performance as a function of their position in the hierarchy.

Neuro-imaging methods are a useful method for exploring the conscious experience of an individual, at the level of perceptual awareness (e.g., Haynes & Rees, 2005). By using innovative fMRI acquisition and analysis techniques, like retinotopic mapping and multivariate pattern analysis, it is possible to determine which features of an environment are being perceived by an individual. The combination of this methodology with a power manipulation makes it possible to explore whether the presence or lack of power changes an individual's conscious experience of the same environment. In this way, it will be possible to explore whether power-holders and subordinates inhabit different universes. Indeed, the study of how power shapes consciousness is an exciting avenue that deserves further follow-up.

Structural brain imaging can also be conducted to reveal differences at the level of brain structure between individuals high in positions of high power and individuals in positions of low power, or between individuals with different levels of ‘power motive’, or the propensity to attain positions of power (Winter, 2011). Structural brain imaging has been used in the past in the study of individual differences (Kanai & Rees, 2011). While such a research paradigm would necessitate careful control over a host of other variables that occur with power, it would undoubtedly be interesting to find how a lifetime of power has shaped people’s brains. Of course, there is always the possibility that different brains predispose different levels of power. It would be fascinating to implement this kind of study in the corporate world. Leading firms might scan the brains of newly selected entrants to their graduate schemes, and then continue this process as they move up along, or down, the power hierarchy in the firm.

Although it is undoubtedly complex, the joint aim of multidisciplinary efforts from social psychology and neuroscience is to show how cognition is modulated in a continuous manner according to different needs, motivation, and environmental constraints (Guinote & Vescio, 2010). We are still far from this state of knowledge, when it comes to power. Regardless of the advancement in the field, we are still gleaning the end results of complex processes, and attempting to attribute their occurence to causal relationships. With the development of precise yet unobstrusive acquisition devices that capture multi-layered brain data, from electric signals to neurostransmitters, it may be reasonable to hope that we can study complex human interactions in real time, in ecological settings as they occur unobstructed by the limitations of a laboratory setting.

Aside from the research possibilities conferred by innovative technologies, interesting questions at the behavioural level can be explored by different experimental designs. For example, it would be possible to explore the effects of restoring power after a period of subordination, or of imposing subordination after a period of power. Are the cognitive changes that occur with power flexible, and can they be restored and reduced? From a more socially interesting perspective, it would be possible to explore how communal resources are allocated by new power-holders after spending some time in a period of subordination. This is only one example of the many types of questions that can be investigated with creative experimental designs.

6.6 Final word

I hope that the experiments described in this thesis have enriched our knowledge about the complex ways in which power affects cognitive processing. I also hope that this thesis provides a convincing demonstration that interdisciplinary efforts are useful and informative in increasing our understanding of how social variables modulate cognition. In particular, it is hoped that the described experiments further motivate the use of neuroscience methodologies in the investigation of power.

At the same time, it is important to keep in mind that behavioural data can be extremely rich and informative. There is no scope in employing neuroscientific methods if they cannot provide data that go beyond what can be gleaned through behaviour. However, as this thesis demonstrates, careful employment of neuroscience methods can inform us of processes that occur too early to be manifested clearly, or that individuals do not choose to manifest. This can be especially interesting in the context of affect and motivation, which are closely linked to power.

It is unlikely that humanity will lose interest in power anytime soon. Our aim as scientists is to quantify, measure, and understand it in a parsimonious way, without losing fascination for its ‘power’.

7 References

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