DOES PERCEIVED POWER INFLUENCE RELATIONAL PROCESSING IN THE LATIN SQUARE TASK?

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ABSTRACT

Previous research suggests that the experience of low power places an additional cognitive burden on individuals because they must monitor the environment more closely than individuals with higher power. Consequently, poorer cognitive performance has been observed in individuals in situations of low power (Smith, Jostmann, Galinsky, & van Dijk, 2008). The current research examined the effects of perceived power on relational processing. The 63 female participants were randomly assigned to one of three conditions (high-power, control, low-power). A writing procedure (Galinsky, Gruenfeld & Magee, 2003) was used to prime experiences of high- and low-power. Perceptions of high and low power, and positive and negative affect were assessed at three time points during the procedure. Changes in these variables across time points confirmed that perceptions of high power were manipulated independently of positive affect, but perceptions of low power were not manipulated independently of negative affect. Following the power manipulation, relational processing was assessed using the Latin Square Task (LST; Birney, Halford & Andrews, 2006). The LST items varied in complexity (binary-, ternary-, quaternary-relational) and the number of steps (one, two). The standard effects of complexity and number of steps on the LST were observed, however perceived power had no effect on LST performance (accuracy, response times). A number of possible explanations are discussed and suggestions for future research are put forward.
INTRODUCTION

Society is structured by social hierarchies and some individuals achieve positions of power and influence over others. The capacity to influence others is a key idea in many conceptualisations of power. In this chapter, power is defined as the ability to exert influence over others, emerging from control over resources and the ability to administer rewards and punishments (Galinsky, Gruenfeld, & Magee, 2003). Power is important to our status and our social position (Boksem, Smolders & De Cremer, 2009) and it confers many advantages to the holder. Those with high levels of power tend to exert political influence, enjoy protection, wealth, access to high-quality housing, plentiful food, health care, leisure and education, whereas those with lower levels of power endure substandard housing, disease, underemployment, dangerous work, punishment and stigmatisation (Pratto, Sidanius & Levin, 2006). Powerful individuals obtain valued outcomes, are higher achievers and obtain better social positions (Guinote, 2007a), while powerless individuals achieve less, and as such do not fill powerful positions (Smith, Jostmann, Galinsky, & van Dijk, 2008). The research reported in this chapter focuses on the effect of perceived power on cognitive task performance.

Findings that individuals with low levels of power achieve less were initially interpreted in terms of their lower levels of cognitive capacity or motivation (Smith et al., 2008). Smith et al. challenged this assumption, by proposing that powerless people achieve less because lacking power fundamentally alters cognitive functioning. Low power situations increase cognitive demands because in such situations individuals are obliged to attend to and monitor the environment more closely than they would in high power situations. For example, in work situations subordinates might need to monitor their supervisors’ goals as well as perform their own set tasks. Individuals with low power perform less well because these extra monitoring
demands draw cognitive resources away from the task at hand, and make them more likely to experience cognitive overload.

Smith et al.’s (2008) proposal is based primarily on studies employing experimental manipulations of perceived power. Participants are randomly assigned to either a high-power condition or a low-power condition. Perceived power is then manipulated using one of a number of priming or role manipulation procedures, which will be described further below. Immediately after the power manipulation, all participants complete a cognitive task. The high-power and low-power conditions are compared in terms of their performance on the cognitive task. Some studies also include a neutral-power control condition, which provides a useful baseline, against which the other conditions can be compared. This assists interpretation by allowing researchers to determine whether high-power facilitates cognitive performance or whether low-power impairs performance on the cognitive task. Priming procedures are based on the assumption that the psychological properties of power can be activated by exposure to power-related cues or by recalling power-related experiences from the past (Galinsky, Magee, Inesi & Gruenfeld, 2006). The experiences of power (or lack thereof) produced by such priming procedures are assumed to be functionally equivalent to those produced by actual power-related situations (Smith & Trope, 2006).

Two power-priming techniques are the scrambled-sentence task and the writing task. In the scrambled-sentence task (Smith & Trope, 2006) sets of five words are presented on each trial. Participants are required to use four of the words to construct a grammatically correct sentence. In the low-power condition, some trials contain a word relating to lack of power. In the high-power condition some trials contain a word related to having power. In the control condition, all trials contain power-irrelevant words.
When power is primed using writing tasks (Galinsky et al., 2003), participants in the high-power condition are asked to recall and write about a time when they had control over another individual. Participants in the low-power condition are asked to recall and write about a time when another individual had control over them. Participants in a control condition are asked to recall and write about a power-irrelevant topic such as what they did yesterday.

Some studies incorporate ways to assess the effectiveness of the power manipulation. In the writing task, this has been done by asking participants about the level of power they had experienced during the recalled event. These ratings refer to the original event but they are obtained following the priming procedure. To the extent that the manipulation is successful, ratings of perceived power should be greater in the high-power condition than the low-power condition. In the scrambled-sentence task, a manipulation check is not usually included.

Another way to investigate the effects of power involves role-based manipulations (Galinsky et al., 2003; Galinsky et al., 2006; Smith et al., 2008). Participants are assigned to either a superior or a subordinate role. The superior directs the subordinate and evaluates their performance, and this evaluation supposedly determines the subordinate’s payment for the experiment (Smith et al.). After the task, participants report the level of perceived control they felt during the task. If the manipulation is successful, participants in the high-power condition report feeling higher levels of perceived control than participants in the low-power condition.

Research employing these procedures supports the proposition that perceived power influences cognitive functioning. Smith and Trope (2006) demonstrated in six experiments that participants in the high-power conditions displayed more abstract thinking than those in the low-power conditions. In Experiments 1, 4, and 6 the writing task was used, while in Experiments 2, 3 and 5 the scrambled-sentences task was used to prime power-related experiences. In Experiment 1, abstract thinking was inferred from the degree to which participants included
atypical stimuli in a given category. Participants indicated the extent to which an atypical
exemplar (e.g., purse) was a good member of a given category (e.g., clothing). Participants in
the low-power condition were less inclusive than participants in both the control and high-power
conditions, while the control and high-power conditions did not differ.

In Experiment 2 (Smith & Trope, 2006), abstract thinking was inferred from the level at
which participants categorised verbal stimuli. For example, action words such as voting can be
categorised at lower (e.g., marking a ballot) or higher (e.g., changing the government) levels of
categorisation. Categorisation at higher levels was observed more frequently in the high-power
condition than the control condition.

In Experiment 3 (Smith & Trope, 2006), abstract thinking was inferred from participants’
judgments of the semantic coherence of sets of three words. A set was coherent if each of the
three words could be associated with a common fourth word that was not presented. For
example, the triad salt, deep and foam was considered coherent because all three words could be
associated with the word sea, but the triad deep, nose, and wood was considered incoherent.
Accuracy in the high-power condition was significantly higher than in the low-power condition.
No control group was included in this experiment.

In Experiment 4 (Smith & Trope, 2006), abstract thinking was assessed using a false
recognition paradigm. Participants were presented with lists of words (e.g., door, glass, pane,
shade, ledge) that are highly associated with a non-presented critical lure (e.g., window). On
subsequent memory tests, participants tend to falsely recognise the lures. False recognition of
lures is interpreted as indicating that participants extracted the gist of the word set, rather than
relying on a verbatim memory of the individual words. Higher rates of false recognition were
observed in the high-power condition, implying a greater reliance on gist. As such, participants
in the high-power condition displayed more abstract thinking, leading to higher false recognition rates.

In Experiment 5 (Smith & Trope, 2006), abstract thinking was inferred from performance on a visual detection task. Twenty-five random fragmented pictures were presented within a larger visual detection task. Participants primed with low-power made guesses about these “random” pictures that were less plausible than guesses made by participants in the high-power or control conditions, while the latter two groups did not differ.

In Experiment 6 (Smith & Trope, 2006), abstract processing was inferred from participants’ ability to find a simple figure within a complex geometric pattern. Ordinarily, the small figure would be considered a secondary aspect of the larger pattern, however in this task the smaller figure is more task-relevant and as such becomes primary. Participants in the high-power condition were better able to find the simple figures within geometric patterns than participants in the low-power and control conditions. Accuracy of the latter two groups did not differ. This series of six experiments demonstrates higher levels of abstract thinking in high-power conditions than low-power conditions. The findings are more mixed regarding whether differences between power conditions reflect the facilitative effects of high-power or the detrimental effects of low-power.

Guinote (2007b) used the writing task to manipulate power. The cognitive task involved attending to or ignoring contextual information according to whether it was relevant or irrelevant to the task at hand. Compared to participants with lower perceived power, individuals with higher perceived power were better able to inhibit contextual information when it was not relevant to the task, and better able to attend to contextual information when it was relevant to the task. Thus individuals with high perceived power focused attention on the task at hand, and showed greater attentional flexibility than individuals with low perceived power. Perceived
power has also been shown to affect the pursuit and attainment of goals. Guinote (2007a) showed that participants in a low-power condition needed more time and information in making decisions about which goal to pursue and their preferred course of action than participants in a high-power condition. Guinote’s studies did not include neutral control conditions therefore they do not inform the issue of whether high power facilitates or low power impairs cognitive performance.

It is also proposed that perceived power is linked to the extent to which people attend to punishment and threat, and the extent to which they interpret ambiguous social events as threatening (Keltner, Gruenfeld & Anderson, 2003). Social threat might interfere with the cognitive performance of individuals with low levels of perceived power, by virtue of their membership of a minority. Lord and Saenz (1985) used a role-based manipulation to examine the effects of membership in a numerical minority versus numerical majority on a memory retrieval task. Participants discussed everyday topics with three confederates who were either all of the same sex as the participant or all of the opposite sex. Students in the minorities remembered less of their group’s discussion, suggesting that subordinate status might interfere with memory processes.

Research on stereotype threat also suggests that the experience of low perceived power impairs performance on difficult cognitive tasks. Stereotype threat occurs when a negative stereotype about a relevant social group is made salient. For women, stereotype threat was activated by highlighting gender differences (favouring males) in quantitative ability. For Latino participants, stereotype threat was activated by stressing ethnic group differences. Women showed lower working memory scores compared to men (Beilock, Rydell, & McConnell, 2007; Schmader & Johns, 2003), and Latinos displayed lower working memory scores than their White
counterparts (Schmader & Johns). Thus individuals under stereotype threat performed more poorly on a working memory task than individuals not targeted by the stereotype.

Working memory is involved to a greater or lesser extent in a broad range of cognitive tasks (Schmader & Johns, 2003). If the experience of low-power occupies working memory resources, there is potential for performance on cognitive tasks to be impaired (Beilock et al., 2007). However, the potential for impairment is likely to increase with the working memory demand of the task. Beilock et al. found that low demand problems were not impacted by the introduction of a performance stereotype, however performance on high demand problems was significantly impaired compared to baseline conditions. Schmader, Johns and Forbes (2008) proposed that stereotype threat disrupts performance via a physiological stress mechanism that directly impairs cognitive processes that rely on the prefrontal cortex. These include working memory and executive functions such as active monitoring of one’s performance and the effortful suppression of negative thoughts and emotions. Thus stereotype threat creates an extra situational burden which interferes with task performance.

The previously discussed research (Guinote, 2007b; Smith & Trope, 2006) indicates some effects of high compared to low power on cognitive functions (e.g., increased attentional flexibility, more abstract thinking, working memory), it is less clear whether the observed effects are due to facilitative effects of high-power or to detrimental effects of low-power.

A recent study by Smith et al. (2008) appears to show that performance differences on cognitive tasks are indeed due to the detrimental effects of low-power. The effects of perceived power on executive functioning tasks were examined. Executive function is an umbrella term for the group of skills that control our cognitive activity, emotional responses and overt behaviours. Executive functions depend on the integrity of the prefrontal cortex of the brain (Banich et al., 2000). They are central, self-regulatory functions that are used to coordinate basic and domain-
specific cognitive processes (Isquith, Crawford, Espy & Gioia, 2005). Executive function includes a wide variety of processes including the ability to create a plan or goal, to monitor progress toward that goal, to oversee the organisation of action and to override stereotypical responses (Banich, et al.). Other researchers also include inhibitory control processes, updating information in working memory, switching between tasks (Miyake et al., 2000). Relational processing (Halford, Wilson & Phillips, 1998) also shares many properties with executive functions.

Smith et al. (2008) demonstrated in four experiments using four different executive function tasks that participants in low-power conditions performed worse than participants in high-power conditions. Moreover, in Experiments 2, 3 and 4 each of which included a control condition, the experience of low-power was detrimental to executive functioning, but high-power had no facilitative effects.

In Experiment 1 (Smith et al., 2008), the effect of power on the executive function of updating in working memory was investigated. A role-based manipulation of power was employed, in which participants were assigned to either a superior role or a subordinate role in a computer-based task. The superior’s role was to direct and evaluate the subordinate’s performance and to determine the subordinate’s payment. This procedure was effective in inducing experiences of high or low power. Post experiment ratings showed that participants in the low-power condition perceived they had less power than participants in the high-power condition. The two-back task was used to assess updating in working memory. In this task, participants are exposed to a stream of stimuli, presented one at a time. Their task is to judge whether or not the current stimulus matches the stimulus presented two places back in the stimulus stream. Participants in the low-power condition performed worse than those in the high-power condition. A control group was not included in this experiment therefore the researchers
could not exclude the possibility that the high-power role improved participants’ executive function.

Control groups were included in subsequent experiments (Smith et al., 2008). In Experiment 2 (Smith et al., 2008), a 17-trial scrambled-sentence task was used to prime experiences of high, low, or neutral power. In the low-power condition, nine of the 17 trials contained one word related to lack of power. In the high-power condition, nine of the 17 trials contained one word related to having power. In the control condition, all 17 trials contained power-irrelevant words. Inhibition was assessed using the Stroop Colour-naming task. A robust Stroop effect was evident, in that performance accuracy on incongruent trials in which the colour words were printed in inconsistent font colours (e.g., the word red printed in blue font) was poorer than on neutral trials in which the stimuli were rows of four Xs (i.e., XXXX) rather than colour words. The Stroop effect (Stroop, 1935), has been replicated by many researchers (see review by MacLeod, 1991). This research showed that neutral trials are easier than incongruent trials, resulting in greater accuracy and faster response times. Smith et al. found that power affected performance on the more difficult incongruent trials but not the simpler neutral trials. On the incongruent trials, participants in the low-power condition made more errors than participants in the high-power or control conditions, while the latter two groups did not differ. Thus the experience of low-power impaired executive function as assessed using the Stroop task.

In Experiment 3 (Smith et al., 2008), perceived power was manipulated using the writing task (Galinsky et al., 2003). Participants in the high-power condition wrote about a time they had control over others, participants in the low-power condition wrote about a time when others had control over them, and participants in the control condition wrote about what they did yesterday. The effect of power on the executive function of planning was examined. Planning was assessed using a computer-administered version of the Tower of Hanoi task. In the original version of the experiment...
task, the apparatus consists of a set of three vertical wooden pegs attached to a wooden base and three different sized disks. Each disk has a hole in its centre. The disks can be placed on the pegs. At the outset of the game, the three disks are arranged in a pyramid formation on the left-most peg (i.e., the largest disk at the bottom and the smallest on the top). Participants’ task is to construct a pyramid on the right-most peg in as few moves as possible and without violating the rules. The rules are that only one disk can be moved at a time, and larger disks cannot be placed on top of smaller disks.

There have been many modifications of the original Tower of Hanoi task. In the computer-administered version used by Smith et al. (2008) participants saw two different configurations of disks on pegs, the goal configuration was shown at the top of the screen and the other configuration at the bottom. The aim was to transform the configuration at the bottom of the screen into the goal configuration in as few moves as possible. In no-conflict trials, movement of the first disk was in the direction of its final position in the goal configuration, so this subgoal was congruent with the overall goal of the task. In conflict trials, however, the best strategy was to move the first disk in the opposite direction to its final position, and as such this subgoal conflicted with the final goal. Conflict trials are more difficult than the no-conflict trials. On the critical conflict trials, participants in the low-power condition required more moves above the minimum than participants in both the control and high-power conditions, while the latter two groups did not differ. Contrary to expectation, power also affected performance on the no-conflict trials. This effect was driven, however, by participants in the control condition who required more moves above the minimum than participants in both the high-power and low-power conditions. Critically, participants in the high-power and low-power conditions performed equally well on the no-conflict trials. These results further demonstrate that the effect of low-
power is detrimental to the executive function of planning, especially when task difficulty is high.

In Experiment 4 (Smith et al., 2008) an adaptation of the Stroop paradigm was used to test the hypothesis that lack of power impairs executive function because of goal neglect. The scrambled-sentences task was used to prime the experience of power. Participants completed one of two Stroop versions: no-congruent or majority-congruent. In the no-congruent version, participants received only neutral and incongruent trials. In the majority-congruent version, participants received mostly congruent trials, some neutral trials and some incongruent trials. Congruent trials are those in which there is no conflict between the meaning of the colour word and the font colour in which it is presented (e.g., the word red printed in red font colour). Goal maintenance demands would be higher on the incongruent trials in the majority-congruent condition, because incongruent trials were less frequent. Consistent with this, a significant effect of power condition was found in the majority-congruent version. Power did not affect performance on neutral trials, but it did affect performance on incongruent trials, where participants in the low-power condition made more errors than participants in both the control and high-power conditions, and the latter two groups did not differ. This suggests further that low-power is detrimental to performance accuracy. No significant effect of power condition was observed on the no-congruent version of the Stroop task.

Smith et al.’s (2008) findings showed that low power impaired performance on executive functioning tasks. Their results for the neutral and incongruent trials of the Stroop task and conflict and no-conflict trials of the Tower of Hanoi task suggest that the effects might be restricted to the more difficult items in the tasks, and that performance on simpler items might be relatively unaffected by variations in perceived power.

Limitations of power priming procedures

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Although the writing task priming procedure has been used successfully in several recent studies (e.g., Guinote, 2007a, 2007b; Magee, Galinsky & Gruenfeld, 2007; Smith et al., 2008; Smith & Trope, 2006), two potential issues have been identified which may impede its efficacy. The first relates to the adequacy of the manipulation checks that are used in conjunction with the writing task procedure. Participants are typically asked to report the extent to which they experienced feelings of power in the situation or event they described in the writing task. For example, Smith et al. (2008) asked participants how powerless and in control they had felt during the situation they described. Similarly, Guinote (2007a, 2007b) asked participants to indicate on a 9-point scale how “in charge of the situation” they had felt. The implicit assumption is that there is a close correspondence between level of power reported as being experienced during the incident described in the writing task and the participant’s current feelings of power. The veracity of this assumption was tested in the current research.

The second issue with the writing task and other priming procedures is the extent to which the effects of high- and low-power can be distinguished from those of positive and negative affect, respectively. Power and affect are closely linked. Based on a comprehensive review, Keltner et al. (2003) proposed that high power increases the experience and the expression of positive affect, and low power increases the experience and expression of negative affect. Watson and Clark (1997, as cited in Keltner et al.) demonstrated that self-reports of power-related traits of dominance, assertiveness, social potency and assumed leadership roles all correlated with a self-reported experience of positive mood. In addition, a sense of power was correlated with the increased experience of positive emotions such as amusement, desire, enthusiasm, happiness and love (Anderson, Langner & Keltner, 2001, as cited in Keltner et al.). Similarly, higher sociometric status (degree to which a person is liked or disliked by their peers) is associated with more positive affect and less negative mood during childhood (La Freniere &
Stroufe, 1985). Social status is linked to power in that having and being able to exercise power is an important component of status and social position (Boksem et al., 2009; Flynn, Reagans, Amanatullah & Ames, 2006).

These correlational findings are supported by an experimental study (Gruenfeld, 1993, as cited in Keltner et al., 2003), in which participants were assigned to either a unanimous or a non-unanimous group in which they belonged to a majority or a minority. After a group decision task, minority members reported more negative affect than majority members and members of unanimous groups. In addition, subjective power has been found to correlate with self-reports of negative emotions such as embarrassment, fear, guilt, sadness and shame. In a study that manipulated status, low-status individuals reported more guilt and sadness in response to negative events, whereas high-status individuals reported anger (Tiedens, Ellsworth & Mesquita, 2000). As this brief review demonstrates, affect may differ substantially according to the power an individual holds.

Since Keltner et al.’s (2003) review, further studies have supported the notion that power and affect are closely linked. Berdahl and Mortorana (2006) manipulated social power in three-person groups whose members engaged in a meaningful discussion that produced disagreements and strong emotions. One participant was assigned to the role of leader and participants were told that leaders would be in control over how to allocate $300 to the group members. Leaders reported experiencing more positive than negative emotions, whereas subordinates reported experiencing more negative than positive emotions. Lücken & Simon (2005) found in four experiments that minority members of groups experienced less positive affect, and that this difference could be ascribed to a power disadvantage. Langner and Keltner (2008) examined the effects of social power in romantic relationships. Participants’ self-rated power predicted their
own positive emotion. For participants in the low-power role, self-rated power also predicted negative emotion.

The influence of affect on performance of cognitive tasks is well documented (e.g., Bartolic, Basso, Scheff, Glauser & Titanic-Scheff, 1999; Blanchette & Richards, 2009; Brand, Reimer & Opwis, 2003; Phillips, Bull, Adams & Fraser, 2002; Spering, Wagener & Funke, 2005). Given the demonstrated link between power and affect, it is essential to differentiate the effects of power on task performance from those of affect. Smith et al. (2008) claimed that affect did not explain the effect of power on executive function in any of their experiments. The researchers attempted to distinguish the effects of power from positive or negative affect in all four experiments. Different measures of affect were employed. These were the Positive Affect Negative Affect Schedule (PANAS; Watson, Tellegen & Clark, 1988) in Experiment 1, and 12 items assessing positive and negative approach- and avoidance-related affect in Experiment 4. In Experiments 2 and 3, affect was assessed using a single item, the nature of which was not specified. Reliance on single-item measures in Experiments 2 and 3 weakens the interpretation that power was manipulated independently of affect.

The current study will employ a more comprehensive measure of affect in order to dissociate the effects of power from those of affect. Perceptions of high power, perceptions of low power, positive affect and negative affect will each be measured three times within the experimental session, that is, before and after the power induction (writing task) and again after the cognitive task. If the writing task produces different patterns of change on perceptions of high and low power versus ratings of positive and negative affect, this would suggest that power has been manipulated independently of affect.

The observed links between power and affect combined with findings that men and women might experience emotions differently (e.g., Madden, Barrett, & Pietromonaco, 2000)
and that females may be more susceptible to mood induction procedures (Robins, 1988), it seems possible that gender differences might be observed in power manipulation studies. Smith et al. (2008) found no effects of gender in any of the three experiments where the number of males per cell was sufficient for analysis. It must be noted, however, that these experiments contained lower relative numbers of males than females. In order to avoid any potential gender differences in the power priming procedure, the current study will be restricted to females.

**Relational Processing**

The executive functions investigated by Smith et al. (2008) are known to depend on prefrontal cortical regions of the brain. These were the executive functions of inhibition (Bench, et al., 1993; Harrison, et al., 2005; Stuss, et al., 2001; Vendrell, et al., 1995), updating (Braver, et al., 2001; Ye, et al., 1998), planning (Goel & Grafman, 1995; Morris, et al., 1997) and goal neglect (Duncan, Emslie, Williams, Johnson, & Freer, 1996). Given the well-documented involvement of the prefrontal cortex in these processes, other processes involving the prefrontal cortex might also be sensitive to manipulations of power.

One function that relies on the prefrontal cortex is relational processing (Christoff et al., 2001; Waltz, et al., 1999), which can be described by reference to a relational match-to-sample task (Smith, Keramatian & Christoff, 2007). Participants are presented with a pair of objects (e.g., banana-apple), and two (or more) choice pairs of objects (e.g., orange-pear; melon-melon). Their task is to select the choice pair that has the same relation as the sample pair. In this example, the correct choice would be orange-pear because like the sample pair it is an example of the relation, *different*. The relational match-to-sample task depends on relational processing. It cannot be performed by matching the objects.

Relational complexity theory (Halford, et al., 1998) proposes that many higher cognitive processes can be conceptualised in terms of complex relational processing.
complexity refers to the number of arguments that are related. Each argument corresponds to a
dimension. The number of dimensions corresponds to the number of interacting variables that
constrain responses. Binary relations involve two entities, as in larger-than (elephant, mouse).
Ternary relations such as arithmetic addition involve three entities, arithmetic-addition (2, 3, 5),
and are more complex than binary relations. Quaternary relations such as proportion involve four
entities, proportion (2, 3, 4, 6) and are more complex than ternary relations.

The cognitive load imposed by tasks increases with the complexity of the relational
information being processed (Andrews, Birney & Halford, 2006; Halford, Baker, McCudden &
Bain, 2005). Normative data suggests that binary relations can be processed at a median age of 2
years, ternary relations at a median age of 5 years (Andrews & Halford, 2002; Andrews, Halford,
Bunch, Bowden & Jones, 2003; Bunch, Andrews & Halford, 2007; Halford, Andrews, Dalton,
Boag & Zielinski, 2002; Halford, Andrews & Jensen, 2002) and quaternary relations at a median
age of 11 years (Halford et al., 1998). Higher complexity produces decrements in performance as
reflected in increased errors and response times (Birney, Halford & Andrews, 2006; Zhang, Xin,
Lin & Li, 2009). Integration of four variables in one representation appears to be the limit for
most adults. This corresponds to processing at the quaternary-relational level of complexity.
Processing of five variables is possible only under optimal conditions (Halford et al., 2005).

One relational processing task that includes problems at several levels of complexity is
the Latin Square Task (LST; Birney et al., 2006). Examples of LST problems are shown in
Figure 1. In each item an incomplete 4 × 4 matrix is presented. Some cells contain coloured
geometric objects, others are empty. Participants’ task is to determine which of four possible
objects should be placed in the target cell, which is marked with a question mark. Correct
responses conform to the rule that each object appears once and only once in each row and in
each column. The LST contains problems at binary-, ternary- and quaternary-relational levels of
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complexity (Birney et al.). Problems at each of the three complexity levels can be further classified according to whether one or two processing steps are required for solution.

![Problem Square Option](image)

Figure 1. Example items from the Latin Square task, with problem squares on the left and response options on the right. Binary-relational, ternary-relational, and quaternary-relational items are shown in parts A, B, and C, respectively.

This current project extends existing research on the effects of perceived power on cognitive performance. It examines the effects of perceived power on relational processing, which like the executive functions studied by Smith et al. (2008) involves the prefrontal cortex (Christoff et al., 2001; Smith et al., 2008; Waltz et al., 1999). Relational processing will be assessed using the LST (Birney et al., 2006). The LST includes 1-step and 2-step problems at each of three levels of complexity. This will allow evaluation of the potential interactive effects

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of perceived power and number of steps and/or complexity on LST performance. The writing task methodology will be used to manipulate perceptions of high and low power. The experiment will incorporate measures of perceived high and low power as experienced in the experimental session. These measures will be developed in the pilot study and will be used to check the effectiveness of the power manipulation in the main study. Positive affect and negative affect will be assessed using the PANAS (Watson et al., 1988). Examination of perceived high and low power, positive affect and negative affect at three time points in the session will show whether perceived high-power and low-power have been manipulated independently of positive and negative affect.

**Hypotheses**

With regards to manipulation checks, it is expected that perceptions of high power will increase after completion of the writing task in the high-power condition. Conversely, perceptions of low power will increase after completion of the writing task in the low-power condition. Perceptions of power should not change after the writing task in the control group. Following the writing, perceptions of high power should be stronger in the high-power condition than in the control and low-power conditions, whereas perceptions of low power should be stronger in the low-power condition than in the control and high-power conditions. If power is manipulated independently of affect, positive and negative affect should show either no change over time or different patterns of change over time to perceptions of high and low power.

In accordance with the standard observations on the LST (Birney et al., 2006; Zhang et al., 2009), response accuracy is expected to be higher for binary-relational problems than for ternary-relational problems, and higher for ternary-relational problems than quaternary-relational problems. In addition, response accuracy should be higher on one-step problems than two-step problems. Similarly, it is predicted that response latencies for problems solved correctly.
(henceforth, correct response latencies) should be shorter for binary-relational problems than for ternary-relational problems, and shorter for ternary-relational problems than for quaternary-relational problems. Correct response latencies should be shorter for one-step problems than for two-step problems.

Based on findings that the effects of perceived power vary with task difficulty (Beilock et al., 2007; Smith et al., 2008), it was hypothesised that there would be minimal differences between the low-power condition and the control and high-power conditions on response accuracy for the binary-relational LST problems. Since the cognitive demands of the task increase with complexity, performance decrements in the low-power condition should be more pronounced on ternary- and quaternary-relational LST problems. According to relational complexity theory, the two-back task used by Smith et al. (2008) is ternary-relational. Therefore based on Smith et al.’s findings, performance decrements in the low-power condition were expected on LST items at ternary-relational level of complexity and above. Accuracy should be lower and response times should be longer in the low-power condition than in the control and high-power conditions on the ternary- and quaternary-relational LST problems. Similarly, performance decrements in the low-power condition should be more pronounced for two-step problems than one-step problems, due to increased task demands. Differences in performance of the control group and the high-power group will also be examined. Previous studies have yielded conflicting findings regarding the facilitative effects of high power therefore, no predictions were made regarding this comparison.

**Pilot Study**

One purpose of the pilot study was to obtain power ratings for a pool of words that were potentially related to power. Based on these ratings, five high-power words and five low-power words were selected and used in the main study to check the effectiveness of the power

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manipulation. Another purpose was to obtain power ratings for positive affect and negative affect items from the PANAS (Watson et al., 1988). Power ratings for these words, combined with data from the main study, will help establish the extent to which participants differentiate perceptions of high and low power from positive and negative affect.

**Method**

Participants. The 35 female participants ranged from 17 to 27 years of age, with a mean age of 22.60 years (\(SE = 1.09\)).

Materials and Procedure. Institutional ethics approval was obtained for the pilot study and main study and all participants provided written informed consent.

Sixty-nine words were selected for inclusion in the pilot questionnaire. These were the 20 words from the short form of the PANAS (Watson et al., 1988). A further 39 words were selected based on the experimenters’ judgments of their relatedness to power. Power was defined as a feeling of control over another individual or individuals (Galinsky et al., 2003). These words were obtained from a number of sources, including power-priming procedures used in past research (e.g., Smith & Trope, 2006), a list of personality-trait words (Anderson, 1968) and literature, thesaurus and dictionary searches. This process produced 17 words initially judged as high-power (e.g., forceful, persuasive, executive) and 22 words initially judged as low-power (e.g., compliant, obedient, inept). The remaining ten words were selected from a list of personality-trait words (Anderson). They were judged as being neutral in terms of power (e.g., honest, suitable, superficial).

The words were included in a questionnaire booklet. The words were listed in a quasi-random order down the left side of the pages. To the right of each word was a 7-point response scale. Headers at the top of each page identified the meaning of each point on the scale. These headers were: 1 ‘very powerless’, 2 ‘powerless’, 3 ‘slightly powerless’, 4 ‘neutral’, 5 ‘slightly Email: g.andrews@griffith.edu.au
powerful’, 6 ‘powerful’, and 7 ‘very powerful’. The booklets included written instructions for respondents to indicate how powerful or powerless each word made them feel by circling the relevant number on the response scale. Power was explicitly defined as a feeling of control over another individual or individuals. Participants also provided demographic information (sex, age).

Results

All responses were entered into the statistical software program, Statistical Package for the Social Sciences (SPSS), with each word as the unit of analysis. Mean power ratings were computed for each word.

The first analysis examined the 39 power-related words and 10 neutral words. As expected, one-way ANOVA showed that power ratings of neutral words differed to ratings of high- and low-power words, $F(2, 46) = 95.98, p < .0001$. The words initially judged as high-power ($M = 5.34, SE = .13$) received higher power ratings than neutral words ($M = 4.48, SE = .25, p = .002$), which in turn received higher power ratings than the words initially judged as low-power ($M = 2.78, SE = .11, p < .0001$).

The following process was used to select the high-power and low-power words that would be retained for use in the main study. First, words with a mean score of 5.5 or higher were identified as high-power words; words with a mean score of 2.5 or lower were identified as low-power words. Any obvious synonyms were excluded. The lists of high-power and low-power words were equated for the number of syllables. It was decided that adjectives would be retained, rather than nouns, because most words identified as high- or low-power were adjectives. This also reflected the type of words presented in the PANAS. This process yielded five high-power words and five low-power words which were subsequently used in the manipulation check in the main study. The selected words and corresponding means and standard errors are presented in Table 1. As expected, an independent samples $t$-test showed that the selected high-power words

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\((M = 5.79, SE = .08)\) received higher power ratings than the selected low-power words \((M = 2.32, SE = .18)\), \(t(8) = 31.13, p < .0001\).

Table 1.

**High Power and Low Power Words Selected for Inclusion in Main Study with Mean (Standard Errors) Power Ratings.**

<table>
<thead>
<tr>
<th>High power words</th>
<th>Low power words</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M)</td>
</tr>
<tr>
<td>Commanding</td>
<td>6.03</td>
</tr>
<tr>
<td>Authoritative</td>
<td>5.91</td>
</tr>
<tr>
<td>Independent</td>
<td>5.71</td>
</tr>
<tr>
<td>Bossy</td>
<td>5.69</td>
</tr>
<tr>
<td>Dominating</td>
<td>5.60</td>
</tr>
</tbody>
</table>

The second analysis investigated the 20 PANAS (Watson et al., 1988) words. Independent-samples \(t\)-tests were conducted to examine differences in power ratings of positive affect words and negative affect words. Positive affect words \((M = 5.08, SE = 0.15)\) had significantly higher power ratings than the negative affect words \((M = 3.06, SE = 0.15), t(17) = -9.64, p < .0001\). However, the mean power ratings of the selected high-power words was significantly higher than positive affect words, \(t(12) = 3.28, p = .007\), and mean power ratings of the selected low-power words was significantly lower than negative affect words, \(t(13) = -3.39, p = .005\). This suggests that while positive affect words were rated higher on power than negative affect words, participants differentiated power from affect to some extent.

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MAIN STUDY

Method

Participants. Sixty-five female undergraduate university students were recruited for the main study. First-year psychology students received course credit in an introductory psychology course in return for their participation in the research. Second and third year students received a voucher entitling them to a small coffee from the university coffee shop. Two participants were excluded due to large amounts of missing data on the power and affect ratings, resulting in data from 63 participants being included in the analyses.

Participants ranged in age from 17 to 55 years, with a mean age of 23.5 years (SE = 1.09). The age of participants in each power condition did not differ significantly, $F(2, 60) = 0.44, p = .648$. The mean ages were 24.4 years (SE = 2.34) in the high-power condition, 24.1 years (SE = 1.93) in the control condition and 22.1 years (SE = 1.32) in the low-power condition.

Materials and Procedure. Students participated in groups of up to four. Those who participated in the same session were assigned to the same power condition. The overall procedure consisted of eight phases. In phase 1, an introduction to the Latin Square task (LST) was provided and students completed the practice trials. In phase 2, they completed a modified version of PANAS (Watson et al., 1988) to obtain affect and perceived power ratings. In phase 3, perceived power was manipulated using the writing task (Galinsky, et al., 2003). In phase 4, affect and perceived power ratings were obtained for the second time. In phase 5, the test items of the LST were completed. In phase 6, participants provided ratings of affect and perceived power for the third time. Phase 7 involved a debriefing. In phase 8, those participants in the low-power condition only, received a positive mood induction.

Perceptions of power and affect ratings. Ratings of positive and negative affect were obtained using the short form of the PANAS (Watson et al., 1988). It contains 20 words that

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describe different feelings or emotions, 10 reflecting positive affect and 10 reflecting negative affect. The words were listed down the left side of the page. Next to each word was a 5-point scale. The scale points were: 1 ‘very slightly or not at all’, 2 ‘a little’, 3 ‘moderately’, 4 ‘quite a bit’ and 5 ‘extremely’. Participants were given written instruction to read each item and circle the appropriate number next to each word. They were asked to indicate the extent to which they felt this way right now using the scale provided. The PANAS is a widely used measure of affect. Its short form has demonstrated high internal consistency (Cronbach’s alpha) for both the positive affect scale, ranging .85 to .92, and the negative affect scale, ranging .88 to .91 (Crawford & Henry, 2004; Mehrabian, 1997).

Embedded within the PANAS items were the five high-power and five low-power words identified in the pilot study. The power words were randomly inserted among the PANAS words, with the constraint that no more than two power-related items appeared consecutively. The power items were rated on the same 5-point scale as the PANAS items, ranging from 1 ‘not at all or slightly’ to 5 ‘extremely’. Given that this form was administered three times within a short experimental session, three versions were created by changing the order of the words presented. The first ten words of the first version became the last ten words of the second version, and the first ten words of the second version became the last ten words of the third version. These forms were administered in phases 2, 4 and 6.

Writing Task. The writing task (Galinsky, et al., 2003) was used to prime experiences of power in phase 3 of the procedure. Participants were asked to recall and write about an incident in their lives. The instructions for the high-power condition were as follows:

*Please recall a particular incident in which you had influence over another individual or individuals. By influence, I mean a situation in which you controlled the ability of another person or persons to get something they wanted, to direct*
their actions or behaviour, or were in a position to evaluate those individuals.

Please describe this situation in which you had control – what happened, how you felt, your thoughts, and so on. You have 5 minutes to complete this task.

The instructions for the low-power condition were as follows:

Please recall a particular incident in which another individual or individuals exerted influence over you. By influence, I mean a situation in which another person or persons had control over your ability to get something you wanted, to direct your actions or behaviour, or was in a position to evaluate you. Please describe this situation in which you did not have control – what happened, how you felt, your thoughts, and so on. You have 5 minutes to complete this task.

The instructions for the control condition were as follows:

Please recall your day yesterday. What did you do? Did you go out or stay at home? If you went out, where did you go? Who did you see and what did you talk about? What kind of mood were you in? Describe your experiences yesterday – what happened, how you felt, your thoughts, and so on. You have 5 minutes to complete this task.

These instructions used words ‘control’ and ‘influence’ rather than ‘power’, in order to reduce potential demand characteristics. In addition, instructions for the control condition were lengthened to be similar to the length of those used in the high-power and low-power conditions. The instructions were read aloud to participants, and were also presented on the top of the response sheets. The response sheet also contained 17 blank lines, on which participants wrote their responses. They were also asked to provide an “in charge” rating. The question “to what extent were you in charge of your life at that time?” and a 9-point response scale ranging from ‘not in charge at all’ to ‘completely in charge’ was presented at the bottom of the response sheet.

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This has been employed as a manipulation check measure in previous studies (Guinote, 2007a, 2007b). It was included in the current study in order to reference previous research. Participants were given 5 minutes to complete their written responses and to provide an “in charge” rating.

Latin Square Task. The LST was designed to assess relational processing in adults (Birney et al., 2006). Problems consist of incomplete 4 × 4 matrices. Participants’ goal is to determine which object fills the target cell, abiding by the rule that each shape can appear only once in each row and in each column. The relational complexity manipulation is based on an increasingly complex instantiation of this rule. In binary-relational problems correct responses require integration of elements in a single row or column (see Figure 1A). For ternary-relational problems, obtaining the solution requires integration of information from both a row and a column (Figure 1B). Quaternary problems require integration of elements across multiple rows and columns (Figure 1C). In addition to this complexity manipulation, the LST problems are further classified according to the number of processing steps required to solve the problem, either one-step or two-step problems (Birney et al.).

Participants completed the task on one of four computers, each of which was located in an individual booth. LST problems were displayed on a computer screen. Participants used the left mouse button to click on their chosen response option, and the space bar key to move through the problems. Instructions were part of the computer program. These instructions described the aim of the task, and provided an explanation of the rule.

The four practice problems of the LST were completed in phase 1 of the procedure. On each problem, a matrix was displayed on the left of screen, and the corresponding response options were displayed on the right. The target cell was highlighted with a question mark. The practice problems increased in complexity. The first was a 1 × 3 matrix with two of the three cells filled. The second was an incomplete 3 × 3 matrix. The third and fourth were 4 × 4 matrices.
matrices, with a ternary-relational problem followed by a quaternary-relational problem. The program provided feedback in the practice trials, with the accuracy of the response and a detailed explanation using row and column labels. If any of these problems were answered incorrectly participants repeated the item, and as such all participants successfully completed all practice trials.

The test problems were completed in phase 5 of the procedure. Due to a procedural error, the test phase consisted of 24 problems for 36 participants and 36 problems for 27 participants. The 24 item version was loaded onto two computers and the 36 item version was loaded onto the other two computers. All test problems involved $4 \times 4$ matrices. As in the practice trials, the incomplete problem matrix was presented on the left of screen and the four response options were displayed on the right of screen. Participants clicked on their chosen response option using the left mouse button. There were equal numbers of problems within each complexity level (i.e., either 8 or 12 of each). Each complexity level contained equal numbers of one-step and two-step problems. Problems were intermixed and presented in random order. No feedback was provided in the test phase.

Debriefing. A debriefing was conducted in phase 7 of the overall procedure. Participants provided written responses to three questions. The first open-ended question was, “what did you think the purpose of this experiment was?” The purpose of this question was to identify participants who realised that the experiment involved a power manipulation. The second question asked participants to indicate how motivated they were to do well on the LST using a 5-point scale ranging from 1 ‘not at all’ to 5 ‘very’. The third question asked how well participants thought they actually performed on the LST, by responding to a 5-point scale ranging from 1 ‘very badly’ to 5 ‘very well’. These questions were included to assess whether motivation or perceived performance explained the difference between power conditions on LST performance.

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Mood Induction. The participants in the low-power condition took part in a mood induction to ensure they did not leave the experimental session in a negative mood after recalling a potentially difficult situation in their lives. The induction procedure was adapted from Seibert and Ellis (1991). Five items were taken from the Neutral Mood Induction Scale, and ten were selected from the Happy Mood Induction Scale. Selection of the items was based on suitability for university-age participants. To preserve the structure as designed, the order of statements was maintained. Neutral items were presented first to ensure the sudden presentation of highly positive statements did not have the opposite effect than intended. The main aspects of the instructions were retained, however, were adapted slightly for brevity and in consideration that some items were neutral rather than happy.

Results

Preliminary analyses. Examination of responses to the debriefing question indicated that no participants identified that the experiment examined the effects of power, and further, that no participants realised that an induction of any kind (i.e., power or mood) had occurred. Consequently, data from all participants were retained in the following analyses (N = 63). Ratings of neither motivation, $F(2, 60) = 0.06, p = .946$, nor perceived performance, $F(2, 60) = 1.51, p = .229$, differed between power conditions.

To check whether participants had followed instructions on the writing task, the responses were read and checked for power-related content. All participants in the low-power and high-power conditions described a situation involving power. The most frequent themes were manager/supervisor-subordinate relationships (19%) and parent-child relationships (19%). Responses from participants in the control condition were not expected to contain power-related content, and a check of their responses confirmed this.
A procedural error meant that 27 participants received a 36-item version of the LST task whereas 36 participants received a 24-item version. However, the proportions of participants who completed the long versus short versions were comparable across the three power conditions. A Chi-square analysis confirmed this, $\chi^2 (2, N = 63) = 0.39, p = .823$. The frequencies are shown in Table 2.

Table 2

**Numbers of Participants in each Power Condition who Completed the Short and Long Versions of the Latin Square Task.**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Version</th>
<th>High-Power</th>
<th>Control</th>
<th>Low Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short (24 items)</td>
<td>11</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Long (36 items)</td>
<td>10</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Accuracy scores (percent correct) for one-step and two-step LST problems at binary-, ternary- and quaternary-relational levels of complexity were computed for each participant. Mean response latencies for one-step and two-step problems at each level of relational complexity were also computed for each participant, based on those problems that were answered correctly.

Perceptions of high power. The effectiveness of the writing task in priming perceptions of high power was examined. Ratings for the five high power items were summed to compute high power ratings for each participant at each time point. Higher scores indicated stronger perceptions of high power ($\text{max} = 25; \text{min} = 5$). Perceived high power ratings were subjected to a 3 (power condition: high-power, control, low-power) × 3 (time: 1, 2, 3) mixed ANOVA in which power condition was the between-groups variable and time was a repeated variable. The main
effect of power condition did not reach significance, $F(2, 60) = 2.79, p = .07$, partial $\eta^2 (\eta_p^2) = .07$. However, there was a significant main effect of time, $F(2,120) = 4.88, p = .009, \eta_p^2 = .075$ which was modified by a significant Power condition $\times$ Time interaction, $F(4,120) = 4.48, p = .002, \eta_p^2 = .13$. The interaction is shown in Figure 2.

Simple effects analyses showed that in the high-power condition, the increase in perceptions of high power from time 1 to time 2 approached but did not reach significance, $F(1, 20) = 3.76, p = .057, \eta_p^2 = .16$. There was a significant decline in perceptions of high power from time 2 to time 3, $F(1, 20) = 10.80, p = .004, \eta_p^2 = .35$. There were no significant changes in perceptions of high power across the three time points in the control condition, $F(2, 40) = 1.67, p = .20, \eta_p^2 = .08$, nor in the low-power condition, $F(2, 40) = 0.55, p = .58, \eta_p^2 = .03$.

![Figure 2. Perceived high power ratings at Times 1, 2 and 3 in the high-power, control, and low-power conditions.](image)

One way ANOVAs compared perceptions of high power in the three conditions at each time point. At time 2, there was a significant effect of condition, $F(2, 60) = 6.22, p = .004$. Post hoc Scheffe tests revealed that perceptions of high power were significantly stronger in the high-
power condition than in the control condition ($p = .005$) and also the low-power condition ($p = .046$). The control and low-power conditions did not differ significantly ($p = .71$). At times 1 and 3, there were no significant difference in perceptions of high power between the three conditions. These analyses suggest that writing about an episode in which the participants experienced high power increased their current perceptions of high power.

Perceptions of low power. The effectiveness of the writing task in priming perceptions of low power was examined. Ratings for the five low power items were summed to compute low power ratings for each participant at each time point. Higher scores indicated stronger perceptions of low power (max = 25; min = 5). Perceived low power ratings were subjected to a 3 (power condition: high-power, control, low-power) × 3 (time: 1, 2, 3) mixed ANOVA in which power condition was the between-groups variable and time was a repeated variable. The main effect of power condition was not significant, $F(2, 60) = 0.80, p = .46$, partial $\eta^2 = .03$. The main effect of time did not reach significance, $F(2,120) = 2.62, p = .077$, $\eta_p^2 = .042$. However, there was a significant Power condition × Time interaction, $F(4,120) = 4.40, p = .002$, $\eta_p^2 = .13$, which is shown in Figure 3.

Simple effects analyses showed that in the high-power condition, perceptions of low power did not change significantly from Time 1 to Time 2, $F(1, 20) = 0.96, p = .34$, $\eta_p^2 = .05$. There was a significant increase in perceptions of low power from Time 2 to Time 3, $F(1, 20) = 8.11, p = .01$, $\eta_p^2 = .29$, coinciding with the decline in perceptions of high power in this condition. In the control condition, there was no significant change in perceptions of low power across the three time points, $F(2, 40) = 0.16, p = .85$, $\eta_p^2 = .01$. However in the low-power condition, perceptions of low power increased significantly from time 1 to time 2, $F(2, 40) = 7.18, p = .014$, $\eta_p^2 = .26$, then decreased significantly from time 2 to time 3, $F(2, 40) = 4.52, p = .046$, $\eta_p^2 = .18$. Email: g.andrews@griffith.edu.au
One way ANOVAs compared perceptions of low power in the three conditions at each time point. At Time 2, there was a significant effect of condition, $F(2, 60) = 5.07, p = .009$. Post hoc Scheffe tests revealed that perceptions of low power were significantly stronger in the low-power condition than in the high-power condition ($p = .011$). Perceptions of low power in the control condition were at an intermediate which did not differ significantly from the high-power condition ($p = .647$) nor the low-power condition ($p = .10$). There were no significant differences in perceptions of low power between the three conditions at time 1 and time 3. These analyses suggest that writing about an episode in which the participants experienced low power increased their current perceptions of low power. The manipulation strengthened perceptions of low power (in the low-power condition) to a point where they exceeded those in the high-power condition, but not the control condition. The nonsignificant difference between the low-power condition and the control condition should be borne in mind when interpreting the findings.
“In charge” ratings. Participants’ ratings of being in charge of their life at the time of the incident described in the writing task were analysed. These ratings were obtained after completion of the writing task. One-way ANOVA revealed a significant effect of power condition, $F(2, 59) = 29.59, p < .0001, \eta^2_p = .50$. Bonferroni post-hoc tests established that participants in the high-power condition ($M = 7.05, SE = 0.39$) reported being significantly more in charge of their life than participants in the control condition ($M = 5.4, SE = 0.40, p = .016$), who reported being significantly more in charge than participants in the low-power condition ($M = 2.76, SE = 0.41, p < .0001$). Thus the pattern of group differences observed for “in-charge” ratings differs from the perceptions of high power and low power, where the difference between control and low-power conditions did not reach significance.

The “in charge” ratings were significantly positively correlated with perceptions of high power ratings at Time 2, $r = .30, p = .018$, and significantly negatively correlated with low power ratings at Time 2, $r = -.43, p = .008$, in the full sample. Participants in the control condition did not recount a power-related episode in the writing task, therefore the correlations were recomputed excluding these participants. In the reduced sample ($N = 42$), the “in charge” ratings were significantly positively correlated with perceptions of high power ratings at Time 2, $r = .33, p = .036$, and significantly negatively correlated with low power ratings at Time 2, $r = -.47, p = .002$. These findings suggest that feeling of power about the incident described in the writing task were related to the perceptions of high and low power experienced after the writing task.

Perceptions of high power, perceptions of low power, positive affect and negative affect. Positive affect and negative affect ratings were computed by summing responses to the ten positive affect items and the ten negative affect items, respectively (max = 50, min = 10). The associations between power and positive and negative affect at Times 1, 2 and 3 were examined using bivariate correlations, which are shown in Tables 3, 4 and 5. At each time point,
perceptions of high power were significantly positively correlated with positive affect whereas perceptions of low power were significantly positively correlated with negative affect. The pattern of significance and the magnitude of the correlations were substantially unchanged when the sample was restricted by excluding participants in the control condition.

The “in-charge ratings” obtained at Time 2 were also significantly negatively correlated with negative affect at Time 2, $r = -.40, p = .001$. The correlation with positive affect at Time 2 approached, but did not reach significance, $r = .23, p = .07$. When the sample was restricted by excluding the participants in the control condition, “in-charge ratings” were significantly negatively correlated with negative affect at Time 2, $r = -.44, p = .003$, while the correlation with positive affect at Time 2 approached, but did not reach significance, $r = .27, p = .08$. These correlations, along with the findings of pilot study, indicate that perceptions of high power are associated with positive affect, and perceptions of low power are associated with negative affect.
Table 3.

Zero-order Correlations among Perceptions of High Power, Perceptions of Low Power, Positive Affect, and Negative Affect at Time 1. (** p < .01; *** p < .001)

<table>
<thead>
<tr>
<th></th>
<th>High power</th>
<th>Low Power</th>
<th>Positive Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Power</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Affect</td>
<td>.57***</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Negative Affect</td>
<td>.12</td>
<td>.61***</td>
<td>-.07</td>
</tr>
</tbody>
</table>

Table 4.

Zero-order Correlations among Perceptions of High Power, Perceptions of Low Power, Positive Affect, and Negative Affect at Time 2. (** p < .01; *** p < .001)

<table>
<thead>
<tr>
<th></th>
<th>High power</th>
<th>Low Power</th>
<th>Positive Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Power</td>
<td>.14</td>
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<tr>
<td>Positive Affect</td>
<td>.40**</td>
<td>-.01</td>
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<tr>
<td>Negative Affect</td>
<td>.08</td>
<td>.64***</td>
<td>-.15</td>
</tr>
</tbody>
</table>

Table 5.

Zero-order Correlations among Perceptions of High Power, Perceptions of Low Power, Positive Affect, and Negative Affect at Time 3. *** p < .001

<table>
<thead>
<tr>
<th></th>
<th>High power</th>
<th>Low Power</th>
<th>Positive Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Power</td>
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<td></td>
</tr>
<tr>
<td>Positive Affect</td>
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<td>.06</td>
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<tr>
<td>Negative Affect</td>
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<td>.51***</td>
<td>-.17</td>
</tr>
</tbody>
</table>

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Effect of the Power Manipulation on Affect. Two 3 (Power condition) × 3 (Time) mixed-model ANOVAs were conducted with positive and negative affect as dependent variables. Power condition (high-power, control, low-power) was a between-groups variable and time (1, 2, 3) was a within-subjects variable. If the writing task primed the experience of power independent of affect, minimal differences would be expected in positive or negative affect across time.

The analysis of positive affect yielded a significant main effect of time, $F(2,120) = 9.38$, $p < .001$, $\eta_p^2 = .14$. The main effect of power condition was not significant, $F(2, 60) = 0.92$, $p = .406$, $\eta_p^2 = .03$. However there was a significant Power condition × Time interaction, $F(4,120) = 2.56$, $p = .042$, $\eta_p^2 = .08$, which is shown in Figure 4.

Simple effects analyses showed that positive affect in the high-power condition did not change significantly from time 1 to time 2, $F(1, 20) = 1.97$, $p = .18$, $\eta_p^2 = .09$, but it declined significantly from time 2 to time 3, $F(1, 20) = 6.15$, $p = .022$, $\eta_p^2 = .24$. A similar pattern was observed in the control condition. Positive affect did not change significantly from time 1 to time 2, $F(1, 20) = 0.20$, $p = .66$, $\eta_p^2 = .01$, but it declined significantly from time 2 to time 3, $F(1, 20) = 12.50$, $p = .002$, $\eta_p^2 = .39$. In the low power condition, positive affect declined significantly from time 1 to time 2, $F(1, 20) = 4.74$, $p = .042$, $\eta_p^2 = .19$, but there was no significant change from time 2 to time 3, $F(1, 20) = 0.66$, $p = .43$, $\eta_p^2 = .03$.

One way ANOVAs comparing positive affect in the three conditions revealed no significant differences between the three conditions at time 1, time 2 or time 3. A comparison of these findings (Figure 4) with those for perceptions of high power (Figure 2) indicates that perceptions of high power were manipulated independently of positive affect.
The analysis of negative affect yielded no significant main effects of time, $F(2, 120) = 2.50, p = .087, \eta_p^2 = .04$, nor of power condition, $F(2, 60) = 0.95, p = .391, \eta_p^2 = .03$. However, the Power condition × Time interaction was significant, $F(4, 120) = 3.86, p = .005, \eta_p^2 = .11$. This interaction is shown in Figure 5.
Simple effects analyses showed the significant interaction was driven by differences over time in the low-power condition only. Negative affect increased significantly from Time 1 to Time 2, $F(1, 20) = 5.21, p = .034$, $\eta^2_p = .21$, but then decreased from Time 2 to Time 3, $F(1, 20) = 7.69, p = .012$, $\eta^2_p = .28$. The simple effect of time was not significant in the control condition, $F(2, 40) = 0.06, p = .893$, $\eta^2_p = .003$, nor in the high-power condition, $F(2, 40) = 0.18, p = .836$, $\eta^2_p = .01$.

One way ANOVAs compared negative affect in the three conditions at each time point. The effect of power condition was significant at Time 2, $F(2, 60) = 4.17, p = .020$. Post-hoc Scheffe tests showed that participants in the low-power condition reported significantly more negative affect than participants in the high-power condition ($p = .022$). Participants in the control condition did not differ significantly from participants in the low-power condition ($p = .12$) nor participants in the high-power condition ($p = .80$). There were no significant differences
in negative affect between the three power conditions at Time 1, $F(2, 60) = 0.24, p = .790$, or
Time 3, $F(2, 60) = 0.86, p = .428$. A comparison of these findings (Figure 5) with those for
perceptions of low power (Figure 3) suggests that perceptions of low power were not
manipulated independently of negative affect.

Effects of Power on Latin Square Task Performance. The effects of the power
manipulation on LST performance were then investigated. Accuracy (% correct) on the LST was
subjected to a 3 (power: high-power, control, low-power) × 2 (LST version: short, long) × 3
(complexity: binary, ternary, quaternary) × 2 (steps: one-step, two-step) mixed-model ANOVA.
Power condition and LST version were between-subjects variables and complexity and step were
within-subjects variables. This analysis yielded no significant main effect of LST version and no
significant interactions involving LST version, therefore the analysis was re-run excluding this
variable. The assumption of sphericity was violated therefore the Huynh-Feldt correction was
applied.

The analysis yielded significant main effects of relational complexity, $F(1.5, 89.8) = 106.17, p < .0001, \eta_p^2 = .64$, and steps, $F(1, 60) = 118.95, p < .0001, \eta_p^2 = .67$. These main
effects were modified by a significant Complexity × Steps interaction, $F(1.7, 103.2) = 5.30, p =
.009, \eta_p^2 = .08$, which is shown in Figure 6. The simple effect of steps was significant at the
binary, $F(1, 60) = 39.63, p < .0001, \eta_p^2 = .40$, ternary, $F(1, 60) = 43.07, p < .0001, \eta_p^2 = .42$, and
quaternary levels of relational complexity, $F(1, 60) = 56.75, p < .0001, \eta_p^2 = .49$. At each
complexity level, one-step problems were answered more accurately than two-step problems.
The simple effect of complexity was significant for one-step problems, \( F(1.18, 71) = 43.57, p < .0001, \eta_p^2 = .42 \), and for the two-step problems, \( F(2, 120) = 82.38, p < .0001, \eta_p^2 = .58 \). The decline in accuracy as complexity increased from the ternary- to quaternary-relational level was greater for two-step problems, \( F(1, 60) = 106.30, p < .0001, \eta_p^2 = .64 \), than for one-step problems, \( F(1, 60) = 41.54, p < .0001, \eta_p^2 = .41 \). This was the main source of the interaction. The pattern shown in Figure 6 is consistent with previous findings for the LST. Figure 7 shows the Complexity \( \times \) Steps interaction in each power condition.

The main effect of power condition, \( F(2, 60) = 1.03, p = .365, \eta_p^2 = .03 \), the Complexity \( \times \) Power condition interaction, \( F(3, 89.8) = 0.32, p = .809, \eta_p^2 = .01 \), the Steps \( \times \) Power condition interaction, \( F(2, 60) = 0.10, p = .909, \eta_p^2 = .003 \), and the Complexity \( \times \) Steps \( \times \) Power condition interaction, \( F(3.4, 103.2) = 0.25, p = .911, \eta_p^2 = .01 \) on LST accuracy were all non-significant.
Figure 7. Accuracy for one-step and two-step Latin Square problems at binary-, ternary-, and quaternary-relational levels of complexity in the high-power (top panel), control (middle panel) and low-power (bottom panel) conditions.

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Response latencies for correct LST problems were subjected to a 3 (power: high-power, control, low-power) × 2 (LST version: short, long) × 3 (complexity: binary, ternary, quaternary) × 2 (steps: one-step, two-step) mixed-model ANOVA. The analysis yielded significant main effects of complexity, $F(2, 98) = 41.26, p < .0001, \eta^2_p = .46$, and steps, $F(1, 49) = 48.92, p < .0001, \eta^2_p = .50$. These main effects were modified by a significant Complexity × Steps interaction, $F(2, 98) = 18.68, p < .0001, \eta^2_p = .28$. Response latencies increased as complexity increased from the ternary- to quaternary-relational level, but this increase was greater for two-step problems than for one-step problems.

The Complexity × Steps × Power condition interaction approached significance, $F(4, 98) = 2.01, p = .098, \eta^2_p = .08$. The Complexity × Steps interaction was significant in the high power condition, $F(2, 34) = 7.70, p = .002, \eta^2_p = .30$, and in the low-power condition, $F(2, 34) = 10.26, p < .001, \eta^2_p = .38$, but it did not reach significance in the control condition, $F(2, 34) = 2.92, p = .071, \eta^2_p = .17$. The significant Complexity × Steps interactions stemmed mainly from the increase in response times as complexity increased from ternary- to quaternary-relational. This increase was significantly greater in the two-step problems than in the one-step problems in the high-power, $F(1, 18) = 7.76, p = .012, \eta^2_p = .30$, and in the low-power conditions, $F(1, 17) = 15.10, p = .001, \eta^2_p = .47$. The means and standard errors are shown in Figure 8.
Figure 8. Response times for correct one-step and two-step Latin Square problems at binary-, ternary-, and quaternary-relational levels of complexity in the high-power (top panel), control (middle panel) and low-power (bottom panel) conditions.
DISCUSSION

This study aimed to extend Smith et al.’s (2008) finding that the experience of low power impairs executive function to another cognitive process that depends on the prefrontal regions of the brain; namely relational processing. Relational processing was assessed using the Latin Square Task. The writing task (Galinsky et al., 2003) was used to prime experiences of high power and low power. The effectiveness of this procedure was examined using items assessing participants’ perceptions of high power and perceptions of low power, that were developed in the pilot study. The standard “in-charge” ratings used in previous research were also employed. The PANAS (Watson et al., 1988) was used to dissociate the effects of perceived high and low power from those of positive and negative affect.

The effectiveness of the writing task in priming perceptions of power was evaluated in several ways. The “in-charge” ratings differed significantly in the predicted directions across the three power conditions, consistent with previous studies on which this measure was used (Guinote, 2007a, 2007b). The “in-charge” ratings were also positively correlated with perceptions of high power and negatively correlated with perceptions of low power. Although the correlations were far from perfect, these findings support the assumption that the levels of power reported in relation to the incident described in the writing task are linked with current perceptions of power. By this criterion then, the writing task was effective. However, the significant correlations of “in-charge” ratings with positive affect and negative affect at time 2 suggest that power and affect were not fully dissociated.

The measures of perceptions of high power and perceptions of low power provide a more mixed interpretation. When the measure of perceptions of high power was used as the criterion, three findings suggest that the writing task procedure was successful in priming perceptions of high power, and that perceptions of high power were (to some extent) independent of positive affect.
affect. First, perceptions of high power tended to increase from time 1 to time 2 in the high-power condition, but did not change in the control or low-power conditions. Second, following the writing task, perceptions of high power were significantly stronger in the high-power condition than in the control and low-power conditions. Third, the analyses of perceptions of high power and positive affect revealed different patterns of change across the three time points. That is, writing about an experience of high-power increased perceptions of high power but did not increase positive affect.

When the measure of perceptions of low power was used as the criterion, the writing task procedure appears to have been less successful. As expected, perceptions of low power increased significantly from time 1 to time 2 in the low-power condition, and did not change in the control or low-power conditions. Also as expected, perceptions of low power following the writing task were significantly stronger in the low-power condition than in the high-power condition. However, perceptions of low power following the writing task did not differ between the low-power and the control conditions, suggesting that the manipulation was not sufficiently strong. Furthermore, the analyses of perceptions of low power and negative affect revealed similar patterns of change across time. That is, writing about an experience of low power increased perceptions of low power (as intended) but it also increased negative affect. It appears then that perceptions of low power were not manipulated independently of negative affect.

The standard effects were observed on LST performance. That is, accuracy declined and response latencies increased as complexity increased from binary- to ternary- to quaternary-relational levels. In addition, accuracy was lower and response latencies were longer for two-step problems than for one-step problems. These findings are consistent with previous research (Birney et al., 2006; Zhang et al., 2009).
The hypotheses related to the influence of perceived power on LST performance were not supported. Accuracy was expected to be lower in the low-power condition on ternary-relational and quaternary-relational problems. According to Smith et al. (2008), the processing loads imposed by complex problems should be further increased by the experience of low-power (e.g., monitoring contextual factors), with the result that participants in the low-power condition should be relatively more affected by increases in relational-complexity than participants in the control or high-power conditions. Similarly, performance on the two-step problems was expected to be more affected by the experience of low power than performance on the one-step problems. The accuracy data provided no evidence to support these hypotheses.

Response times for correctly solved problems provided the only evidence that LST performance differed as a function of power condition. Figure 8 and the associated analyses showed that the interaction of complexity and steps, which was significant in the high-power and low-power conditions, was not significant in the control condition. The different pattern of findings for the low-power condition versus control condition might be interpreted as support for the hypothesis that low power impairs performance to a greater effect as complexity and number of steps increases. However, the fact that similar patterns were observed in the high-power and low-power conditions does not support this interpretation. We conclude therefore that the experience of low-power did not affect LST performance, as evidenced by accuracy and response times.

Our findings are contrary to previous research (Smith et al., 2008) in which low-power resulted in impaired performance on tasks that recruit prefrontal regions of the brain. Some potential explanations for this null finding are considered next.

One possible explanation for the non-significant effect of power on LST performance relates to the strength of the power manipulation. As already noted, the writing task was
effective in changing participants’ perceptions of high power, this was less clearly the case for perceptions of low power, which did not differ in the low-power versus control conditions at time 2. However perceptions of low power at time 2 and “in-charge” ratings did differ in the low-power versus high-power conditions. On this basis, poorer LST performance would be expected in the low-power condition than in the high-power condition. That no such differences were observed suggests that weakness of the low-power manipulation is not an adequate explanation of the null findings.

Another explanation is that participants in the three conditions might have differed in ways that affected their LST performance. Even though participants were randomly assigned to conditions, it is possible (for example) that many people with higher fluid intelligence or higher working memory capacity were by chance assigned to the low-power condition and were able to perform well despite the power manipulation. Future research could control for fluid intelligence and working memory capacity, both of which are associated with LST performance (Andrews et al., 2006; Birney et al., 2006). The obtained sample size is at the lower end of sample sizes in previous studies (Smith et al., 2008), therefore use of larger samples in future research is recommended.

Another possible explanation relates to differences between the cognitive tasks used in previous research and the LST used here in terms of the relative involvement of the left and right cerebral hemispheres. The Stroop task and the two-back task used by Smith et al. (2008) contained verbal content. Tasks with verbal content are associated with increased left frontal activity (e.g., Reuter-Lorenz et al., 2000; Schlosser et al., 1998). The Tower of Hanoi and the closely related Tower of London tasks also recruit the left prefrontal cortex (Beauchamp, Dagher, Aston & Doyon, 2003; Cazalis, et al., 2003), although their content is not inherently verbal. The verbal nature of the writing task used to prime high-power and low-power means that
it is likely to involve the left hemisphere. The brain regions involved in the LST have not yet been investigated, but because it involves completion of non-verbal patterns, at least some right hemisphere involvement might be expected. These hemispheric differences might explain why LST performance was immune to the effect of power manipulation as induced using the writing task. This explanation could be checked in future research by using a more verbal test of relational processing, such as relative-clause sentence comprehension (Andrews et al., 2006) or transitive inference (Waltz et al., 1999).

The brain regions that underpin perceptions of high and low power is an area of emerging research. Boksem et al. (2009) demonstrated that following the writing task (Galinsky et al., 2003) higher left frontal EEG activation was observed in the high-power condition than in the low-power condition. Further imaging research identifying the brain regions activated by perceptions of high and low power and by cognitive tasks will increase our understanding of the impact of power on cognitive performance.

**CONCLUSION**

In conclusion, the current research did not support the hypothesis that low-power impairs cognitive performance and consequently it cannot inform the issue regarding the detrimental effects of low power versus the facilitative effects of high power. The research does provide a new measure of perceptions of high power and low power which can be used in conjunction with the writing task (Galinsky et al., 2003). This measure yielded a different pattern of change over time to the widely-used “in-charge” ratings. The study shows that while participants were able to differentiate perceived power from affect to some extent, it reaffirms the need to include measures of affect in order to distinguish the effects of high and low power from the effect of positive and negative affect respectively.
AUTHOR NOTES

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