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Mighty metaphors: Behavioral and ERP evidence that power shifts attention on a vertical dimension

Kiki Zanolie [a,*], Saskia van Dantzig [a,b], Inge Boot [a], Jasper Wijnen [c], Thomas W. Schubert [d], Steffen R. Giessner [a], Diane Pecher [a]

[a] Erasmus University Rotterdam, Institute for Psychology, The Netherlands
[b] Leiden University, Institute for Psychological Research, The Netherlands
[c] University of Amsterdam, Department of Psychology, The Netherlands
[d] Instituto Universitário de Lisboa (ISCTE-IUL), Centro de Investigação e Intervenção Social, Lisboa, Portugal

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ABSTRACT

Thinking about the abstract concept *power* may automatically activate the spatial up–down image schema (*powerful up*; *powerless down*) and consequently direct spatial attention to the image schema-congruent location. Participants indicated whether a word represented a powerful or powerless person (e.g. 'king' or 'servant'). Following each decision, they identified a target at the top or bottom of the visual field. In Experiment 1 participants identified the target faster when their spatial position was congruent with the perceived power of the preceding word than when it was incongruent. In Experiment 2 ERPs showed a higher N1 amplitude for congruent spatial positions. These results support the view that attention is driven to the image schema congruent location of a power word. Thus, *power* is partially understood in terms of vertical space, which demonstrates that abstract concepts are grounded in sensory-motor processing.

1. Introduction

A very important question within the domain of cognitive psychology is how we represent abstract concepts. In the grounded cognition framework, researchers have proposed that the mental representation of concepts involves the simulation of actual sensory-motor experiences (e.g., Barsalou, 1999, 2008a; Glenberg, 1997). On this account action, perception, and mental representation share processing mechanisms. When someone represents a concept, previously stored information of the sensory-motor experience is partially reactivated to form a simulation of this sensory-motor experience. There is ample evidence that concrete concepts are grounded in sensory-motor representations (Barsalou, 2008b). However, the question remains whether and how abstract concepts can be represented in a grounded fashion (Pecher, Boot, & Van Dantzig, 2011). For instance, how would abstract concepts such as *power* and *love*, that have far less direct reference in the physical world than concrete concepts such as *apple* or *hammer*, be grounded? A proposal is that metaphors play a role in the representation of abstract concepts.

The idea that abstract concepts are represented by metaphors was described by the Conceptual Metaphor Theory (Gibbs, 1994; Lakoff & Johnson, 1980, 1999). According to this theory, metaphors provide grounding for abstract concepts by connecting them to more concrete representations. Evidence for this idea originates from metaphorical expressions. For example, the concept *war* may be used as a metaphor for the abstract concept *argument*, as in the sentence *He attacked every weak point in my argument*. By means of this metaphorical connection, the structure inherently present in a concrete concept (the *source domain*) is mapped onto the abstract concept (the *target domain*). The concrete concepts in turn take their structure from image schemas (e.g. Hampe & Grady, 2005; Johnson, 1987), which are dynamic patterns of multi-modal activation that emerge from recurring perceptual and action experiences. Lakoff and Johnson (1980, 1999) argue that metaphors are not merely a linguistic phenomenon but also serve a representational goal.

Conceptual Metaphor Theory is not the only theory of how abstract concepts are grounded. Other accounts of abstract concepts have proposed that abstract concepts are represented by concrete situations and introspective experiences (Barsalou & Wiemer-Hastings, 2005) or by affective and linguistic information (Andrews, Vigliocco, & Vinson, 2009; Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011). Whereas Conceptual Metaphor Theory assumes only basic image schemas as a way of grounding,

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* Corresponding author. Address: Institute for Psychology, T13-08, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands. Fax: +31 10 4089009.

E-mail address: zanolie@fsw.eur.nl (K. Zanolie).

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these other accounts may provide richer sensory-motor representations (Pecher et al., 2011). In the present study we investigated the role of image schemas as proposed by the Conceptual Metaphor Theory. For a complete account of how abstract concepts are grounded, however, other accounts would also need to be considered.

There is now increasing evidence for the interplay between image schemas and abstract concepts (e.g., Casasanto & Boroditsky, 2008; Giessner & Schubert, 2007; Meier, Hauser, Robinson, Friesen, & Schjeldahl, 2007; Schubert, 2005). Schubert (2005) showed that power judgments can be affected by vertical dimensions. He presented pairs of related stimuli with a clear difference in power, such as *master-servant*, simultaneously, one above the other. The participants were instructed to detect the powerful or powerless member of the pair as quickly as possible. Participants were faster to identify the powerful member when it was presented at the top location and faster to identify the powerless member when presented at the bottom location. In another experiment, single words referring to powerful or powerless people were presented either at the top or at the bottom of the computer screen. Participants made a power-decision; they decided whether the word represented a powerful or powerless person. An interaction between stimulus position and power was found, such that participants were faster to respond to powerful targets when they appeared at the top position, whereas responses to powerless targets were faster when they were presented at the bottom position.

Although the results of Schubert (2005) and other similar results (e.g. Giessner & Schubert, 2007; Meier & Robinson, 2004) have been explained in terms of people understanding *power* metaphorically by activating the up–down (verticality) image schema, it still remains unclear whether this activation is an automatic process that is part of the concept's representation. An alternative explanation might be that the paradigm that was used, namely the manipulation of the vertical location of the power-words themselves, induced strategic use of spatial location. If participants noticed the relation between the concept of power and the spatial location, they might have had a bias to respond in an image schema-congruent way. For example, they may have had a bias to respond 'powerful' to stimuli at the top of the screen and 'powerless' to stimuli at the bottom of the screen. Such a bias or strategy does not necessarily show that the image schema is needed or used to represent the concept itself. Rather, the results could merely show that the concept *power* and spatial up–down schema were activated, and participants noticed the relation *power is up* only after both had been activated.

Spatial attention as an alternative dependent variable could be crucial to show that the activation of an image schema is independent of strategic concerns. More direct symbolic and social cues can orient attention to an implied spatial location. For instance, visual targets are identified faster when their spatial location is cued by a preceding arrow (e.g. Posner, Snyder, & Davidson, 1980; Tipples, 2002), direction words such as *left* or *right* (Hommel, Pratt, Colzato, & Godijn, 2001), a head facing toward a certain location (Langton, Watt, & Bruce, 2000) or gazing eyes (e.g. Driver et al., 1999; Friesen & Kingstone, 1998; Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003). Even the perception of numbers can induce a shift of attention (e.g. Fischer, Castel, Dodd, & Pratt, 2003; but see Pecher & Boot, 2011; Zanolie & Pecher, 2011). Fischer et al. found that numbers high in magnitude (e.g. 9) induced a shift of attention to the right visual field and low numbers (e.g. 1) induced a shift of attention to the left visual field. These types of directional cues do orient attention, even when targets are distributed equally across cued and uncued locations. Since the Conceptual Metaphor Theory predicts that the image schema is inherent to the concept's representation it should affect spatial attention in an automatic manner. Therefore, it might be possible that attention can be directed automatically to congruent spatial locations (e.g., up for a powerful word).

Meier and Robinson (2004) designed a paradigm that is particularly suited to investigate the automatic activation of image schemas because congruency effects in this task (e.g. faster reaction times for targets in an up position after a powerful or positive word and vice versa) cannot be explained by a response bias. Meier and Robinson studied the metaphor *good is up*, *bad is down*. In their paradigm participants were asked to evaluate positive and negative words presented at the center of the screen. After the evaluation, participants performed a spatial identification task where the target stimulus (a *p* or *q*) was presented either at the top or bottom of the screen. Congruent with the metaphorical mapping, discriminations at the top of the screen were faster after participants made a positive evaluation (*good* is *up*); in contrast, discriminations at the bottom of the screen were faster after participants made a negative evaluation (*bad* is *down*). It is unlikely that these results are caused by a response bias, because the identity of the target letter was completely unrelated to its position or evaluation of the valence of the word. Thus, even if participants noticed the metaphorical relation, it would not have made them more accurate in discriminating between a *p* or a *q*.

Could it be that thinking of power can induce a shift of attention to the upper or lower visual field? When the up–down image schema plays a central role in the representation of *power*, one would expect that attention is directed to the location that is congruent with this image schema. It is crucial to present a task in which the spatial information assumed to be embedded in the concept cannot be used strategically by the participant to improve performance.

Therefore, we adopted the paradigm used by Meier and Robinson (2004) to address two important questions, namely whether thinking about *power* automatically activates a spatial image schema and whether thinking about *power* directs spatial attention. Experiment 1 was a behavioral study in which participants made power decisions to words denoting powerful or powerless people (e.g. *king* or *servant*), presented centrally. Following each decision, a target letter was presented in the upper or lower visual field. Participants were required to identify the target letter as quickly and accurate as possible. If the up–down image schema is activated automatically, as Meier and Robinson found in the domain of valence, we should find an interaction between power and the spatial location of the visual target. Participants should be faster to identify a target presented at the top of the screen when it is preceded by a *powerful* word, whereas they should be faster to identify a target at the bottom of the screen when it is preceded by a *powerless* word. Importantly, such a result would show that thinking about the concept *power* automatically activates an underlying vertical spatial image schema, as Meier and Robinson found in a different target domain.

A spatial attention shift can be observed not just behaviorally by faster reaction times to targets presented in a spatial location congruent with the up–down image schema, but also by using electrophysiological measures, such as event-related potentials (ERPs). In Experiment 2 we measured ERPs time-locked to target presentation to investigate components that are typically modulated by spatial attention. By measuring ERPs we gain important insight in the allocation of visuospatial attention, allowing a detailed observation of the time course of cognitive processes after making a power decision. Mainly two components (P1 and N1) are modulated at target onset as a function of previous cueing. The first component, the P1 component, is a positive deflection occurring at 80–130 ms after target presentation over posterior, occipital scalp regions. This component is enhanced as a function of attention allocated to the visual target. Targets presented at attended locations elicit a larger P1 amplitude than targets at non-attended locations (Hillyard, Mangun, Woldorff, & Luck, 1995; Mangun, 1995; Mangun, Hopfinger, & Heinze, 1998), with no modulation in latencies or scalp distribution.

The second component known to be modulated by attention is the visual N1 component, a negative deflection occurring at 160–200 ms after target presentation and is considered to reflect the application of a discrimination mechanism to stimuli at the attended location (Vogel & Luck, 2000). Especially, the N1 attention effect reflects an enhancement of targets at the attended location (Doallo et al., 2004; Luck & Hillyard, 1995; Luck et al., 1994) and is particularly found when subjects are required to make a discrimination response (Mangun & Hillyard, 1991).

We hypothesized that, if thinking about *power* shifts attention in an image schema-congruent manner, this should modulate the P1 and/or N1 component, showing larger amplitudes for trials where the spatial location of the target is congruent with a *powerful* or *powerless* word compared to incongruent trials. Specifically, we would expect to find an N1 attention effect, considering that the target identification task requires a discrimination response (*p* or *q*), instead of mere detection of a target, drawing heavily on the nature of the N1 component.

2. Experiment 1

Experiment 1 was conducted to investigate whether a power decision automatically activates the *power is up* metaphor. In this experiment, a power decision task was used as a prime task, followed by a letter identification task in which the position of the target letter could either be consistent or inconsistent with the metaphor. To control for a possible confound of word valence, the items in the powerful and powerless groups were matched on valence, based on ratings provided in a pilot study.

2.1. Methods

2.1.1. Participants

Forty psychology undergraduates at the Erasmus University Rotterdam took part in the study in return for course credit. Two participants were excluded from the analysis because they made more than 15% errors in the power decision task, leaving a total of 38 participants.

2.1.2. Materials

Sixty-four words referring to types of people, professions, or social classes were selected as critical items for the experiment (see Appendix A). Thirty-two words referred to powerful people (e.g. *king*, *director*, *general*), whereas the other thirty-two words referred to powerless people (e.g. *baby*, *prisoner*, *slave*). Valence scores for these words were obtained in a pilot study, in which the words were rated on a seven-point scale, (1 = 'very negative', 7 = 'very positive'). We orthogonally manipulated the valence of the words in such a way that both powerful and powerless words could be associated with positive or negative affect. Powerful words were not rated significantly more positive ($M = 3.68$, SD = 1.19) than powerless words ($M = 3.36$, SD = 1.03), $t(62) = 1.15$, $p > .25$. In addition, word frequency norms were retrieved from the CELEX database (Baayen, Piepenbrock, & Van Rijn, 1993). Word frequencies, expressed as log frequency per million, did not differ significantly between the powerful ($M = .99$, SD = .64) and powerless group ($M = .83$, SD = .67), $t(62) = .93$, $p > .35$. In addition to the experimental items, ten powerful words and ten powerless words were selected to be used as practice items.

2.1.3. Procedure

The experiment was conducted with E-Prime software (Psychology Software Tools, Inc., Pittsburgh, USA; www.pstnet.com/eprime). Responses were recorded with a serial response-box with five horizontally aligned keys, of which all but the center key were used.

A trial started with a fixation (a '+' sign) of 500 ms followed by a centrally presented word reflecting a powerful or powerless person. The word remained on the screen until the participant decided whether the word reflected a powerful or powerless person. Participants were instructed to respond as quickly and accurately as possible by pressing one of two keys labeled *M* (*machtig* = powerful) or *O* (*onmachtig* = powerless) on the serial response-box. As soon as the participant responded the word disappeared from the screen. After a delay of 200 ms, a horizontally centered letter (*p* or *q*[1]) was presented at the top or bottom of the screen (at 75% and 25% of the screen height respectively). Participants were instructed to decide as quickly and accurately as possible whether a *p* or *q* was presented. They responded by pressing one of two serial response-box keys, labeled *P* and *Q*. The *P* and *Q* keys were on the opposite hand of the *M* and *O* keys. The *p* or *q* remained visible on the screen until the participant responded. Following an incorrect response to the target letter, feedback (*FOUT* = incorrect) was presented in red uppercase letters for 1500 ms. Following a correct response, a blank screen was presented for 500 ms, after which the next trial was initiated. The presentation of the letters *p* or *q* and the top vs. bottom location were equally distributed across trials. Thus, each word was followed once by a letter at the top position and once by a letter at the bottom position. The response mappings for the *M*, *O* and *P*, *Q* keys were counterbalanced across participants. However, the combination of *M*, *O* vs. *P*, *Q* keys remained always at the same side (hand).

The experiment started with two practice sessions to familiarize participants with the task. Participants first practiced with the words *Machtig* (=powerful) and *Onmachtig* (=powerless) as prime words. In the second practice session, ten powerful and ten powerless words were presented as prime words. The practice sessions were followed by two experimental blocks. All 64 critical words were presented once in each block, hence twice in total. Stimuli were counterbalanced across blocks, such that each word was presented once in a congruent trial and once in an incongruent trial.

2.1.4. Results and discussion

One powerful word (*slave driver*) was removed from the analysis because fewer than 60% of the participants categorized this item as powerful. Trials with incorrect responses to either the power word or to the target letter were excluded from the reaction time and ERP (Experiment 2) analyses. In addition, trials with reaction times longer than 3000 ms to the power word or longer than 2000 ms to the target letter were removed from the analysis. There was no pattern in the types of trials that were removed due to outlier reaction times. Of the remaining trials, those with reaction times being more than two standard deviations faster or slower than the subject's condition mean were discarded. In total, 7.9% of the trials were removed because of errors, and 5.1% were removed because of outlying reaction times. For the error analysis the percentages of incorrect responses on the target letter decision were calculated for each condition.

The reaction times and error scores on the target letter identification task were submitted to a two (Power: powerful vs. powerless) × two (Position: top vs. bottom) repeated measures ANOVA. In the reaction times there were no main effects of Power or Position (both *F*s < 1), but the predicted interaction between Power and Position was significant: $F(1,37) = 11.00$, $p = .002$. The significant interaction effect between power and position should be

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[1] Note that the letter *p* was unrelated to the Dutch words *machtig* (*powerful*) and *onmachtig* (*powerless*).

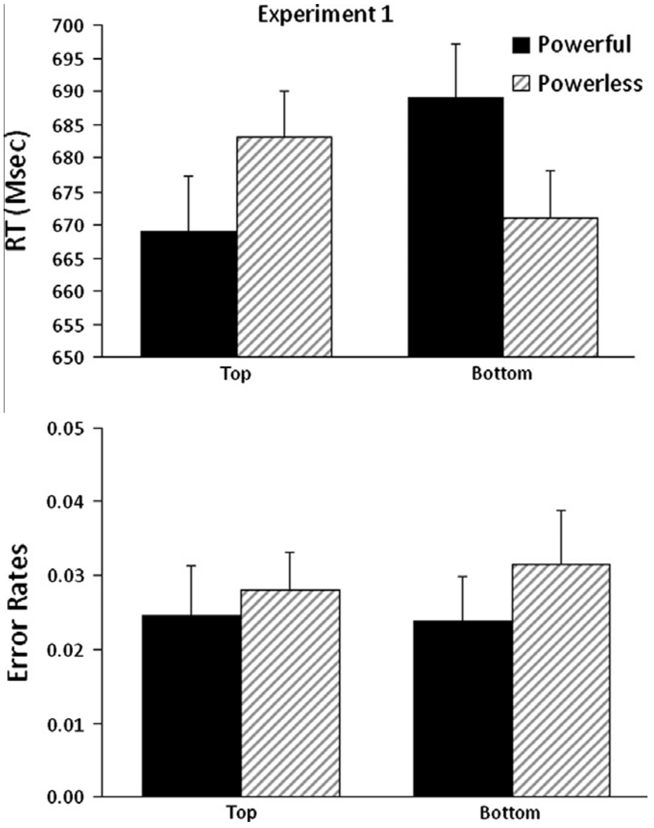

Fig. 1. Reaction times and error rates (in proportions) for the target letter identification task (*p*–*q* judgment) in Experiment 1. Error bars represent standard errors of the mean difference between adjacent bars.

considered our main result supporting the hypotheses that power shifts visual spatial attention on a vertical dimension. As shown in Fig. 1, letters in the top position were discriminated faster when they were preceded by a powerful word than when preceded by a powerless word, whereas letters in the bottom position were discriminated faster when they were preceded by a powerless word then when preceded by a powerful word. The analysis of the error scores revealed no significant main effects or interaction effect (all *F*s < 1). On the prime task, participants responded slightly faster to powerful words ($M = 942$ ms) than to powerless words ($M = 969$ ms). This difference showed a trend towards significance, $t(37) = 1.93$, $p = .06$.

The results of Experiment 1 show that thinking about the concept *power*[2] automatically activates an underlying vertical spatial image schema, suggesting that thinking about power affects spatial attention. As participants processed power-related words, their attention shifted in an image schema congruent direction (up or down), thereby facilitating identification of targets in the corresponding location. Thus, activating the metaphorical target domain (power) influences subsequent processing in the source domain (vertical orientation). The target domain draws upon the structure present in the source domain to organize abstract concepts into a coherent framework. In this manner abstract concepts may be grounded in sensory-motor experiences by means of metaphors.

3. Experiment 2

To further substantiate the claim that thinking about power directs spatial attention in an image schema-congruent way we adopted the same paradigm as in Experiment 1, while measuring ERPs time-locked to target presentation to investigate the P1 and N1 components. A shift of attention should modulate the P1 and/or N1 component, showing a larger amplitude for congruent trials where the spatial location of the target letter (up or down) is consistent with the image schema activated by a *powerful* or *powerless* word compared to incongruent trials. Considering that the target identification task required a discriminating response (*p* or *q*), we especially expected to find a modulation of the N1 component (e.g., Doallo et al., 2004; Luck & Hillyard, 1995; Luck et al., 1994; Vogel & Luck, 2000). However, we also investigated the P1 component, since the P1 also is associated with early visuospatial attention (Hillyard et al., 1995; Mangun, 1995; Mangun et al., 1998). Based on previous studies we expected the P1 and N1 attention effects at parietal–occipital scalp sites (e.g., Mangun, 1995; Mangun & Hillyard, 1991; Salillas, El Yagoubi, & Semenza, 2008; Vogel & Luck, 2000). A modulation of the amplitudes of the P1 and N1 components would support the hypothesis that attention is allocated according to the spatial up–down image schema. Importantly, a modulation of the P1 or N1 would show us that thinking of *power* affects an initial sensory process on the visual target.

Because most prior studies of the P1 and N1 components manipulated spatial attention on the horizontal axis (left–right), we also included a condition in which spatial attention was directed by arrows that pointed up or down. We expected that the arrow stimuli would direct spatial attention up or down. This allowed us to directly compare the effect of up and down arrows with the effect of powerful or powerless words.

3.1. Methods

3.1.1. Participants

Participants were 15 healthy right-handed undergraduate psychology students (10 female; mean age 19.7; age range 18–26). Five additional participants were excluded due to noise in the ERP data, excessive eye movements, and one participant was excluded due to an eye condition. The 15 included participants all had normal or corrected-to-normal vision and had no reported psychiatric or neurological disorders. All participants signed an informed consent and received course credits for their participation.

3.1.2. Materials

In the power condition the critical items consisted of the same 64 words as were used in Experiment 1 (see Appendix A). Furthermore, in the arrow condition, two pictures were used, depicting a light gray arrow pointing up or down on a black background.

3.1.3. Procedure

The main purpose of Experiment 2 was to look at ERPs related to spatial attention; therefore we adjusted the procedure in a way to best measure ERPs. The procedure was the same as in Experiment 1 with the following differences. To introduce jitter, the delay between the response and the presentation of the letter *p* or *q* varied between 500 and 700 ms, with increments of 50 ms. In ERP experiments it is necessary to introduce jitter in order to

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[2] In order further support the valence scores, that did not show differences in valence between powerful and powerless words, and to show that only power and not valence drives the effect we calculated the average reaction times per condition for the 16 (most) negative and 16 (most) positive words of the powerful and powerless words. We then performed a two (Valence: positive vs. Negative) × two (Position: Up vs. Down) × two (Power: Powerful vs. Powerless) repeated measures ANOVA on the reaction time data. If Valence drove the effect, instead of power, we would expect to find a three-way and two-way interaction. However, we did not find any effects of Valence, neither the three-way interaction, Valence × Position × Power ($F(1,38) = .57$, $p = .46$), nor the two-way interaction, Valence × Position ($F(1,38) = 1.05$), $p = .31$) or the main effect of Valence ($F(1,38) = 1.02$, $p = .32$) reached significance. The two-way interaction Power × Position, however, was still significant when valence was added as a factor, $F(1,38) = 11.45$, $p = .002$).

prevent the brain from habituating to the trial sequence and an upcoming stimulus. In Experiment 1 the delay was 200 ms. Increasing the delay from 200 ms to 500–700 ms was necessary in order to weaken the signature of potential ongoing motor related processes from the power or arrow decision task. This, however, introduces the risk of not finding behavioral results, because the time between the response and the target presentation is lengthened. Furthermore, no feedback was given after an incorrect response. Finally, the fixation at the start of a trial (a '+' sign) was increased to 600 ms. All stimuli were light gray on a black background. The power condition consisted of 16 blocks in which all 64 words were presented once per block in random order resulting in 1024 trials. Each block ended with a self paced break and after eight blocks a break of 5–10 min was introduced.

The trial sequence for the arrow condition was exactly the same as for the power condition, with the only difference that the power word was replaced with the picture of an arrow pointing up or down. The participant had to decide as quickly and accurately as possible whether the arrow pointed up or down. The arrow condition also consisted of 16 blocks of 64 trials, resulting in 1024 trials.

At the beginning of each condition (power or arrow), before starting with the experimental blocks, a practice block of 20 trials was conducted to familiarize the participants with the tasks and response mapping. The sequence of the arrow and power word blocks was counterbalanced across subjects. After the experiment participants filled in a funneled questionnaire about the purpose of the study which started with general open questions to see what hypotheses the participants had formed spontaneously and moved to more and more specific questions in which the design of the experiment was gradually revealed and the participants were asked whether they noticed any aspects of the design and how this affected their behavior during the experiment. After the questionnaire they were debriefed. The entire experiment lasted 2 h.

3.1.4. EEG measures

The EEG signals were recorded through an Active-Two amplifier system (Biosemi, Amsterdam, The Netherlands) from 32 scalp electrodes according to the 10–20 system (Fp1/2, AF3/4, Fz, F3/4, F7/8, FC1/2, FC5/6, Cz, C3/4, T7/8, CP1/2, CP5/6, Pz, P3/4, P7/8, PO3/4, Oz, O1/2). The 32 Ag/AgCl electrodes were mounted in an elastic cap. Six additional electrodes were attached; to the left and right mastoids serving as reference sites, two outer canthi of the eyes to measure horizontal eye movements (HEOGs), infraorbital, and supraorbital regions of the left eye to measure vertical eye movements and eye blinks (VEOGs). Furthermore, two additional scalp electrodes were used to serve as reference and ground electrodes. Online signals were recorded from DC to 134 Hz. All signals were digitized with a sample rate of 512 Hz and 24-bit A/D conversion.

Offline, a mathematically linked mastoid reference was applied and EEG and EOG activity was filtered with a bandpass of 0.10–30 Hz (phase shift-free Butterworth filters; 24 dB/octave slope). The data were segmented in epochs of 1000 ms, from 200 ms pre-target onset, serving as baseline, to 800 ms post-target onset. After segmentation ocular correction was applied according to the Gratton, Coles, and Donchin (1983) algorithm. The mean 200 ms pre-stimulus period was used for baseline correction. Artifact rejection criteria were minimum to maximum baseline-to-peak allowed voltage -100 to $+100$ μV, and a maximum allowed voltage skip (gradient) of 75 μV per sample point. Grand averages were calculated separately for arrows and power words. The P1 component was defined as the peak amplitude of the waveform in a window from 80 to 130 ms after target presentation, and the N1 component was defined as the peak amplitude in a window from 160 to 200 ms (see for example Eimer (2000) and Doallo et al. (2004) for a similar approach).

3.2. Results and discussion

3.2.1. Behavioral results

The results from our questionnaire showed that participants were not aware of the relation between power and position. Fig. 2 shows the reaction times and errors for the target identification task. The reaction times and error scores for the *power* condition on the target task were submitted to a two (Power: powerful vs. powerless) × two (Position: top vs. bottom) repeated measures ANOVA. No main effect of Power was found ($F < 1$), however the main effect of Position was significant $F(1,20) = 9.38$, $p = .006$. Participants responded faster to targets in the top position compared to targets in the bottom position. However, the predicted interaction between Power and Position was not significant: $F(1,20) = .03$, $p = .86$. The analysis of the error scores also revealed a significant main effect of Position $F(1,20) = 11.92$, $p = .003$. Participants made more errors to targets in the bottom position. No main effect of Power or an interaction effect (all Fs < 1) was found. The between-subjects factor Order of condition (*power* condition vs. *arrow* condition) revealed no significant effect ($F < 1$).

The reaction times and error scores for the *arrow* condition on the target task were also submitted to a two (Arrow direction: pointing up vs. pointing down) × two (Position: top vs. bottom) repeated measures ANOVA. No main effect of Arrow direction was found ($F < 1$), however the main effect of Position was significant $F(1,19) = 5.46$, $p = .031$. As shown in Fig. 2, participants responded faster to targets in the top position compared to targets in the bottom position. Specifically, the predicted interaction between Arrow direction and Position was significant: $F(1,19) = 7.10$, $p = .02$. As shown in Fig. 2, letters in the top position were discriminated faster when they were preceded by an arrow pointing up than when preceded by an arrow pointing down, whereas letters in the bottom position were discriminated faster when they were preceded by an arrow pointing down then when preceded by an arrow pointing up. The analysis of the error scores revealed a significant main effect of Position $F(1,19) = 9.10$, $p = .007$. Participants made more errors to targets in the bottom position. No main effect of Arrow direction or an interaction effect (all Fs < 1) was found.

3.2.2. ERP results

We calculated average signals at all 32 electrode sites for the congruent trials and for the incongruent trials. Targets that were presented at the top of the screen preceded by *powerful* words and targets presented at the bottom of the screen preceded by *powerless* words will be referred to as congruent trials. Targets that were presented at the bottom preceded by *powerful* words and targets presented at the top preceded by *powerless* words will be referred to as incongruent trials. We collapsed the separate conditions into congruent and incongruent trials because the number of trials in the separate conditions (power × target location) was too low to obtain a reliable P1 and N1 component (e.g., Luck, 2005). Averages were calculated separately for the power and the arrow conditions. Based on findings in the literature we expected to find an effect at parietal and occipital electrodes (e.g. Salillas et al. (2008), Ranzini, Dehaene, Piazza, and Hubbard (2009). Therefore we selected ten parietal–occipital electrodes to be included into the analyses, namely, Pz, P3/4, P7/8, PO3/4, Oz, O1/2.

For the *power* condition we performed a two-way congruency (congruent vs. incongruent) × electrodes (Pz, P3/4, P7/8, PO3/4, Oz, O1/2) repeated measures ANOVA and found a significant main effect of congruency in the latency range between 160 and 200 ms (the N1 component) time locked to target (p or q) presentation. As expected, we found a higher N1 amplitude for the congruent condition compared to the incongruent condition, $F(1,14) = 16.946$, $p = .001$, showing that attention was directed to the image-schema congruent location of the power word. However, we found no

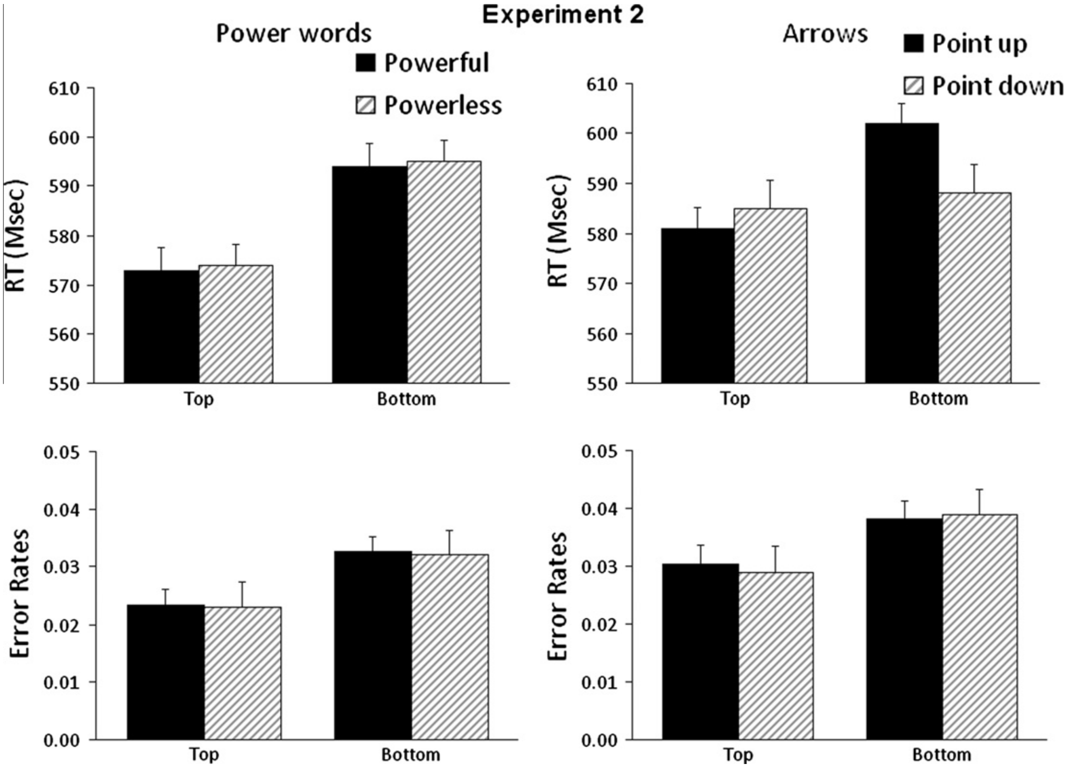

Fig. 2. Reaction times and error rates (in proportions) for the target letter identification task (*p*–*q* judgment) in Experiment 2 for the power word and arrow condition. Error bars represent standard errors of the mean difference between adjacent bars.

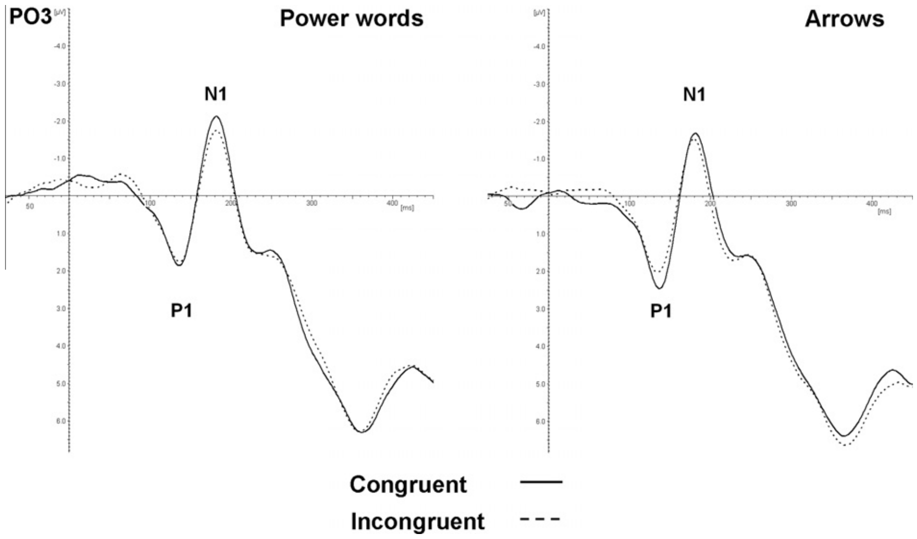

Fig. 3. Analysis was time locked to the onset of the target (*p* or *q*). On the left side of the panel are the averaged ERPs plotted for PO3 for *power words* and on the right side for *arrows*. On congruent trials compared to incongruent trials we see a higher amplitude for the N1 component for *power* words and for the *arrows* we see a higher amplitude for the P1 component. The ERP's on the other parietal–occipital electrode sites showed a similar pattern.

significant main effect of congruency in the first latency range between 80 and 130 ms (the P1 component) time locked to target (*p* or *q*) presentation, $F(1,14) = .709$, $p = .414$. Fig. 3 shows the ERPs for the PO3 parietal–occipital electrode. We found significant congruency effects for the individual electrodes P3, PO3, O2, and P4 (all, $ps < .05$).

For the *arrow* condition we again performed a two-way congruency (congruent vs. incongruent) × electrodes (Pz, P3/4, P7/8, PO3/4, Oz, O1/2) repeated measures ANOVA and found a significant main effect of congruency in the first latency range between 80 and 130 ms (the P1 component) time locked to target (*p* or *q*) presentation. As expected, we found a higher P1 amplitude for the congruent condition compared to the incongruent condition, $F(1,14) = 16.946$, $p = .001$, showing that attention was directed towards the location at which the arrow was pointing. The congruency effect was significant at electrodes P3, PO3, Oz, O2, PO4, P4, and P8. We found no significant main effect of congruency in the latency range between 160 and 200 ms (the N1 component) time locked to target (*p* or *q*) presentation, $F(1,14) = .407$, $p = .534$. The scalp distribution of the P1 and N1 amplitudes is consistent with earlier findings of studies of attention (e.g. Ranzini et al., 2009; Salillas et al., 2008).

In order to test whether the differences in the N1 and/or P1 component could be due to a difference in the baseline epoch we conducted a repeated measures ANOVA over the mean amplitude activity of the baseline epoch (−200 to 0 pre-target). Neither in the power condition nor in the arrow condition did we obtain a significant main effect of congruency, $F(1,14) = .852$, $p = .372$, and $F(1,14) = 2.269$, $p = .154$. Since there are no differences in mean amplitude activity during the baseline epoch we conclude that the congruency effect we found in the N1 component for the power condition reflects a real attention effect as does the attention effect for the arrow condition, reflected by the congruency effects in P1 component.

We also conducted a five-way ANOVA, Task (power word vs. arrow) × Congruency (congruent vs. incongruent) × Component (P1 vs. N1) × Electrodes (Pz, P3/4, P7/8, PO3/4, Oz, O1/2) with Task Order as a between subjects variable in order to investigate whether the order in which participants performed the arrow or power word task influenced the ERPs of the second task (arrow or power). Importantly, we did not find a significant effect of Task Order, $F(1,13) = 1.57$, $p = .232$. Thus, the order in which the participants received the arrow or power word tasks did not influence their performance. Furthermore, only the main effect of Component, $F(1,13) = 162.73$, $p < .0001$ and Electrodes, $F(9,117) = 4.09$, $p < .0001$ were significant. The other effects reaching significance were the three-way interaction Congruency × Component × Electrodes, $F(9,117) = 3.12$, $p = .002$, which reflects the attention effect found for the P1 for arrows compared to the attention effect found in the N1 for power words in different electrodes. Also the two-way interactions Component × Electrodes, $F(9,117) = 40.42$, $p < .0001$, Congruency × Component, $F(1,13) = 9.89$, $p < .008$ and Component × Task order, $F(1,13) = 7.17$, $p = .019$ were significant.

4. General discussion

The present study addressed the question whether thinking about power automatically activates the underlying spatial up–down (verticality) image schema and thereby directs spatial attention in an image schema congruent way. In Experiment 1 we found that after processing labels of powerful and powerless individuals, the identification of unrelated targets was faster when presented in the image schema-congruent location. These results provide strong evidence that when one processes the concept *power* the underlying spatial up–down image schema is automatically activated.

Importantly, in Experiment 2 we showed that for the power words the activation of an up–down image schema caused a shift in spatial attention in an early stage of processing. One of the components that are typically modulated by spatial attention, the N1, was modulated by congruency between the direction of the image schema and the spatial location of the subsequent, unrelated target. This finding strongly supports the idea that the congruency effect is due to a shift in spatial attention caused by the up–down image schema, similar to the effect of direct spatial cues such as arrows. This attentional process might reflect a facilitation of discrimination in the appropriate visual field (Vogel & Luck, 2000).

The effects of the up–down image schema and the up–down arrows were not identical. When spatial attention was directed by the arrows congruency modulated the P1, whereas when spatial attention was directed by the *power* image schema congruency modulated the N1. Thus, the effect of the arrows occurred earlier than the effect of the *power* image schema. This difference could be due to the fact that arrows are more salient in their pointing direction than power words. Generally, an arrow only means one thing, namely direction. An arrow pointing in a certain direction has a direct reference to concrete space. Power words may need more semantic integration between the concrete domain (space) and the target domain (power) than arrows. Therefore, the effect of power words might be somewhat delayed compared to the effect of arrows. Yet, a direct comparison of stimuli with different (physical) features should be interpreted with caution, because different features can lead to corresponding differences in the elicited ERPs. Moreover, such differences affect earlier components related to sensory processing more strongly than later cognitively related components (e.g. Luck, 2005). Furthermore, several ERP studies have shown that improved performance by valid cueing is accompanied by amplitude enhancements of P1 *or* N1 components *or* both. Differential modulations of the P1 and N1 components by attention have been reported from different visuospatial attention tasks (e.g. Doallo et al., 2004; Luck & Hillyard, 1995; Mangun & Hillyard, 1991). The dissociations between the P1 and N1 components could reflect differential attentional processes (for a review see Luck, 1995). Thus, the differential pattern that we found for the arrow and power stimuli could reflect differential underlying attentional processes.

Studies by Salillas et al. (2008) and Ranzini et al. (2009) parallel the results from our study in a different domain. Salillas et al. and Ranzini et al. investigated whether numbers could implicitly serve as a cue for directing attention. In both studies ERPs were measured induced by the perception of lateralized visual targets cued by numbers that differed in magnitude. Number magnitude is thought to be represented on a mental number line with a horizontal spatial orientation. Both studies showed that number magnitude modulated the P1 amplitude. A high number in magnitude (e.g. 9) induced a shift of attention to the right visual field and a low number (e.g. 1) induced a shift of attention to the left visual field. Although the magnitude of the numbers was not indicative for the position of the target; they still served as an implicit cue directing attention to the according visual field. In a similar fashion the *power* words serve as an implicit cue to space corresponding to the up–down image schema in a vertical spatial orientation.

Whereas our results showed modulation of the N1 when the stimuli were power words and modulation of the P1 when the stimuli were arrows, Ranzini et al. (2009) obtained the opposite pattern: an effect of number magnitude on the P1 component but no effect of arrows on the N1 component. Two differences between their study and ours might explain these differences. First, in our study the participants were required to identify a target (either *p* or *q*), whereas in the study of Ranzini et al. the participants had to merely detect a target. This difference in process could underlie the differences in results, since the N1 attention effect is mainly found when subjects are required to make a discrimination response. However, this would be a partial explanation, since this cannot account for the differences in the current study between the *power* and *arrow* condition. Second, there was a difference in the axis in which the targets were presented. In the current study the targets were presented on the vertical axis, whereas in the study of Ranzini et al. the targets were presented on the horizontal axis. However, we are cautious to draw strong conclusions about these differences since the current study is the first study to investigate the allocation of attention due to the implicit direction of power words. The important point from both studies is that both concrete (arrows) and abstract concepts (power and number) directed spatial attention and thereby modulated early spatial attention components in the ERP signals.

Although Experiment 1 showed a significant interaction effect between position of the target and power in the reaction times to the targets, we found no such behavioral interaction effect in Experiment 2. The lack of a behavioral effect was most likely due to a necessary change in the timing of the paradigm in Experiment 2 in order to reduce artifacts in the ERP signal due to response related motor activation, rather than a lack of activation of a vertical image schema. In Experiment 1 the delay between the power decision and the presentation of the target was 200 ms, whereas in Experiment 2 this delay varied between 500 and 700 ms. The longer delay could have masked the behavioral effect. In comparison, Salillas et al. (2008) and Ranzini et al. (2009) also obtained no significant behavioral results. In the study of Salillas et al., the delay between the cue (a number) and the presentation of the target was 450 ms, and in the study of Ranzini et al. the delay was 300, 400, or 500 ms, both comparable to the size of the delay of Experiment 2 in our study. In addition, Eimer (2000) showed that visual–spatial orienting of attention elicited by central cues has a gradual neural build-up. At cue-target intervals of 700 ms a more pronounced attention effect is found compared to short cue-target intervals (200 ms). Therefore, it is not surprising to find a neural effect of attention in our ERP study even though the behavioral effect already has decayed. In our study we had a time lag of 1100–1300 ms between power response and target letter response.

A second explanation for the lack of significant congruency effects in the reaction times in Experiment 2 could be that the number of trials, and repetition of the power words, was significantly higher than in Experiment 1, leading to a practice effect, therefore leaving no room for a behavioral effect. Research has shown that practice reduces the influence of exogenous location cues on attentional processing (e.g., Weaver, Lupianez, & Watson, 1998; Wright & Richard, 1999). However, we are not aware of studies investigating the role of practice on endogenous cueing effects. To examine the possibility that practice reduced the attention effect, we analyzed the data only from the first block of the experiment. Here we also found no significant interaction effect between power and position. It should be noted, however, that the number of participants was substantially lower in Experiment 2 (15) than in Experiment 1 (40), which reduced the power to obtain significant effects with the data from only the first block. However, at present we can only speculate why there was no significant interaction effect between power and target location in the behavioral data in Experiment 2.

Other studies have also found effects when a spatial image schema is activated as a result of the mapping of a concrete concept onto an abstract concept (e.g. Meier & Robinson, 2004). The results of Experiment 1 combined with the ERP results of Experiment 2 give an important insight into the mechanism that drives these effects. As revealed by the modulation of the N1 amplitude, the activation of a spatial up–down image schema leads to attention in the implied direction of the power word. The spatial shift of attention shown in this study could only be driven by the meaning of the power word, and not by an explicit spatial stimulation, since the words were presented centrally. The modulation of the N1 component provides important neural evidence for the hypothesis that a spatial up–down image schema is activated when the concept *power* is activated, leading to more attention in the direction that is implied by the power word.

The current study provides empirical evidence for the Conceptual Metaphor Theory, which states that metaphors provide grounding for abstract concepts by connecting them to more concrete representations. One of the main arguments against the Conceptual Metaphor Theory has been that it is largely based on linguistic analysis (e.g. Murphy, 1996). For a while, it was indeed the case that most of the evidence for the Conceptual Metaphor Theory came from analysis of linguistic data such as metaphorical expressions. Recently, however, an accumulating body of evidence from cognitive experiments has been brought forward, using metaphors from a variety of domains. For example, there is now evidence that *time* can be represented as objects in space (e.g. Boroditsky, 2000; Gentner, 2001), *valence* can be represented in terms of brightness (Meier, Robinson, & Clore, 2004) and vertical position (Crawford, Margolies, Drake, & Murphy, 2006; Meier & Robinson, 2004), and that *divinity* is represented on a vertical dimension (Meier et al., 2007). There is also evidence that the concept *similarity* is represented in terms of spatial proximity (Boot & Pecher, 2010; Casasanto, 2008), that *categories* are represented as containers (Boot & Pecher, 2011), and that *power* is represented in terms of verticality (Giessner & Schubert, 2007; Schubert, 2005), physical force (Schubert, 2004) and size (Schubert, Waldzus, & Giessner, 2009). Furthermore, studies have shown that the concept *importance* is represented in terms of weight (Jostmann, Lakens, & Schubert, 2009) and that *social proximity* is represented as temperature (Ijzerman & Semin, 2009). These empirical results support the view that metaphors are not merely an interesting linguistic phenomenon, but that they play an important role in mental representation. In other words, people do not only speak in terms of metaphors, but they think in terms of metaphors. In conclusion, the current studies combined with these earlier studies demonstrate how abstract concepts derive their structure from concrete domains of experience and how, through the process of metaphorical mapping, they are ultimately grounded in sensory-motor processing.

Appendix A

Powerful		Powerless	
Aanvaller	Attacker	Aanbidder	Worshipper
Aanvoerder	Captain	Arme	Poor person
Advocaat	Lawyer	Au pair	Au pair
Baas	Boss	Baby	Baby
Bondscoach	National coach	Bediende	Servant
Bondskanselier	Chansellor	Bejaarde	Elderly person
Burgemeester	Mayor	Beklaagde	Defendant
Cipier	Warder	Bouwvakker	Construction worker
Coach	Coach	Cassiere	Cassier
Deurwaarder	Bailiff	Dienaar	Servant
Dictator	Dictator	Dienstbode	Maid
Directeur	Director	Gearresteerde	Detainee
Generaal	General	Gehandicapte	Handicapped person
Goeroe	Guru	Gevangene	Prisoner
Heerser	Ruler	Gewonde	Wounded person
Hoofdredacteur	Chief editor	Huishoudster	Cleaning lady
Imam	Imam	Hulpje	Help
Inspecteur	Inspector	Kamermeisje	Chambermaid
Jager	Hunter	Kleuter	Toddler
Kapitein	Captain	Knecht	Labourer
Keizer	Emperor	Koffiejuffrouw	Tea lady
Koning	King	Koorknaap	Choir boy
Leider	Leader	Loonarbeider	Wage labourer
Maffiabaas	Maffia boss	Loopjongen	Errand boy
Manager	Manager	Matroos	Sailor
Meester	Master	Onderdaan	Citizen
Minister	Minister	Patient	Patient
Officier	Officer	Scholier	Pupil
Opperhoofd	Chief	Secretaresse	Secretary
Paus	Pope	Slaaf	Slave

(*continued on next page*)

Appendix A (*continued*)

Powerful		Powerless	
Politicus	Politician	Slachtoffer	Victim
Premier	Prime minister	Stagiair	Trainee
President	President	Vakkenvuller	Grocery clerk
Priester	Priest	Verdachte	Suspect
Rabbijn	Rabbi	Verliezer	Loser
Rechter	Lawyer	Verminkte	Mutilated person
Slavendrijver	Slave driver	Verslaafde	Junky
Tiran	Tyrant	Volgeling	Follower
Topcrimineel	Criminal leader	Vuilnisman	Garbage collector
Tsaar	Tzar	Werkloze	Unemployed person
Voorzitter	Chairman	Zieke	Sick person
Zakenman	Businessman	Zwerver	Tramp/drifter

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