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Polarity Correspondence in Metaphor Congruency Effects: Structural Overlap Predicts
Categorization Times for Bi-Polar Concepts Presented in Vertical Space.

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Abstract

Previous research has shown that words presented on metaphor congruent locations (e.g., positive words UP on the screen and negative words DOWN on the screen) are categorized faster than words presented on metaphor incongruent stimuli (e.g., positive words DOWN and negative words UP). These findings have been explained in terms of an interference effect: The meaning associated with UP and DOWN vertical space can automatically interfere with the categorization of words with a metaphorically incongruent meaning. The current studies test an alternative explanation for the interaction between the vertical position of abstract concepts and the speed with which these stimuli are categorized. Research on *polarity differences* (basic asymmetries in the way dimensions are processed) predicts that +polar endpoints of dimensions (e.g., positive, moral, UP) are categorized faster than –polar endpoints of dimensions (e.g., negative, immoral, DOWN). Furthermore, the polarity correspondence principle predicts that stimuli where polarities correspond (e.g., positive words presented UP) provide an additional processing benefit compared to stimuli where polarities do not correspond (e.g., negative words presented UP). A meta-analysis (Study 1) shows that a polarity account provides a better explanation of reaction times patterns in previous studies than an interference explanation. An experiment (Study 2) reveals that controlling for the polarity benefit of +polar words compared to –polar words did not only remove the main effect of word polarity, but also the interaction between word meaning and vertical position due to polarity correspondence. These results reveal that metaphor congruency effects should not be interpreted as automatic associations between vertical locations and word meaning, but are more parsimoniously explained by their structural overlap in polarities.

Keywords: polarity correspondence; metaphor; concepts; stimulus-response compatibility; embodied cognition.

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In recent years a rapidly growing body of research has emerged that examines how abstract concepts such as power, valence and morality are structured in concrete perceptual dimensions. Inspired by Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999), researchers have examined whether perceptual characteristics of stimuli (e.g., their vertical position) influence the speed with which words referring to abstract concepts (e.g., power, valence, or morality) are categorized. Studies have revealed that positive words are evaluated faster when they are presented on the top (vs. bottom) of the screen, while the reverse is true for negative words (Meier & Robinson, 2004). Since these findings are in line with metaphors such as ‘good is UP and bad is DOWN’, they are referred to as *metaphor congruency effects*. Other studies have revealed that categorizations of concepts such as powerful and powerless (Schubert, 2005), moral and immoral (Meier, Sellbom, & Wygant, 2007), and God and Devil (Meier, Hauser, Robinson, Kelland Friesen, & Schjeldahl, 2007) are similarly influenced by their vertical position on the screen.

Metaphor congruency effects have been interpreted as Stroop-like response interference (Meier & Robinson, 2004; Meier, Robinson, & Clore, 2004; Schubert, 2005). When a stimulus is presented on a perceptual location that is associated with the meaning of the stimulus (e.g., UP for positive words), responses are facilitated, whereas incongruent perceptual information is argued to interfere with the correct categorization of words (e.g., DOWN for positive words, see Meier & Robinson, 2004). However, previous studies do not typically reveal the predicted cross-over interactions between vertical position and word meaning (Meier, Hauser et al., 2007; Meier, Sellbom, et al., 2007; Schubert, 2005). In the current article, an alternative explanation for previously observed metaphor congruency effects is proposed, based on basic asymmetries in the way people process dimensions, which are

known in the literature as *polarity differences* (Batistella, 1990; Clark, 1973; Greenberg, 1963; Lakoff, 1987)¹.

Dimensions consisting of polar oppositions (e.g., good-bad or UP-DOWN) have a default (+*polar*) endpoint (i.e., good, UP) which receives a processing benefit compared to the opposite (-*polar*) endpoint (i.e., negative, DOWN). The reaction times for bi-polar stimuli in bimanual categorization tasks can be accurately predicted based on their polarity benefits (Chase & Clark, 1974; Clark, Carpenter, & Just, 1973; Clark & Chase, 1972; Seymour, 1971, 1973, 1974b, for an overview, see Proctor & Cho, 2006). In the current research, the possibility is investigated that polarity differences in the conceptual dimension (the conceptual meaning of the stimuli, e.g., positive vs. negative) and the perceptual dimension (perceptual characteristics of the stimulus, e.g., being presented on the top or the bottom of the screen) can provide a better explanation for the reaction time patterns observed in metaphor congruency effects.

Previous work on polarity differences has detailed how overlapping polarities in the conceptual and perceptual dimension can produce response time benefits irrespective of whether any conceptual overlap between these two dimensions is present (Proctor & Cho, 2006). In other words, the observed reaction time patterns for valence, power, divinity, and morality related concepts presented UP and DOWN on the screen might be caused by structural overlap between the conceptual and perceptual dimensions due to polarity differences, instead of the hypothesized metaphoric association between the meaning of abstract concepts and vertical space. In this respect, it is interesting to note that many (if not all) conceptual metaphors map conceptual and perceptual domains in such a way that polarities overlap (see Lakens, 2011). According to Lakoff and Johnson (1980, 1999), more, happy, consciousness, health, status, good, rational and control are all represented up in vertical space, while their counterparts are represented down in vertical space. All these metaphors map UP

onto +polar endpoints of conceptual dimensions and DOWN onto –polar endpoints of conceptual dimensions. This raises the question how important structural overlap is when investigating conceptual metaphors. The current article consists of a meta-analysis (Study 1) and an experiment (Study 2) that examine whether the reaction time pattern of metaphor congruency effects is better explained by a polarity account than by an interference explanation. If these studies reveal that a polarity account provides a more parsimonious explanation for metaphor congruency effects than an interference explanation, previous findings should not be interpreted in support of the automatic metaphoric association between perceptual and conceptual dimensions. Instead, earlier findings reflect the structural overlap between the concrete and perceptual dimensions due to polarity differences.

Polarity Differences vs. Interference Effects

People have preferred ways to talk and think about dimensions. For instance, consider the asymmetry in the opposition between tall-short. If someone asks ‘How tall is John?’ one is not suggesting that John is tall, whereas the sentence ‘How short is John’ suggests that John is short. Typically, the category that gives a dimension its name is + polar, such as long (length), happy (happiness), and moral (morality). +Polar endpoints of dimensions tend to be used more frequently in language (e.g., Batistella, 1990; Greenberg, 1963; Zajonc, 1968), and importantly, +polar endpoints of dimensions have an intrinsic processing benefit compared to -polar endpoints (Clark, 1969). Studies with young children have shown that differences in the way +polar and -polar categories are processed are not merely lexical artifacts, but reflect how people learn to think about relations. For instance, McGonicle and Chalmers (1984) show that children first understand ‘big(ness)’, followed by an understanding of ‘not-big’, and finally acquire an understanding of the concept ‘small’. Similar findings were observed for trained monkeys, who displayed a similar reaction time benefit when identifying ‘larger than’ relations compared to ‘smaller than’ relations (McGonicle & Chalmers, 1980). These findings

indicate that asymmetries in conceptual processing are not language dependent, but reflect a fundamental process through which an understanding of relational structures in the world is developed.

Differences in polarity have been argued to be essential aspects of the image schemas that underlie conceptual metaphors (Hampe, 2005; Krzeszowski, 1997), and most image schemas (e.g., up-down, front-back, right-left) are indeed polar opposites (Grady, 1997; Lakoff & Johnson, 1999). Polarity differences have often been discussed as an alternative explanation for metaphor congruency effects (e.g., Pecher, Van Dantzig, Boot, Zanolie, & Huber, 2010; Schubert, 2005; Ulrich & Maienborn, 2010; Vallesi et al., 2008; Van Dantzig, Zeelenberg, & Pecher, 2009; Weger & Pratt, 2008), but whether polarity differences can explain previously observed metaphor congruency effects has never been examined. Given that most studies have examined how concepts are structured in vertical space (see Landau, Meier, & Keefer, 2010), this article examines the mechanisms through which the vertical position of stimuli influence the speed with which abstract bi-polar concepts are categorized.

If polarity differences underlie previously observed metaphor congruency effects, the reaction time pattern in these earlier studies should closely matches the summed reaction time benefits due to polarity differences. There are four polarity related processing benefits in metaphor congruency effects which are expected to influence the categorization times of +polar and –polar stimuli presented on the top and bottom of the screen (e.g., Seymour, 1974b). Previous research has revealed that these polarity benefits are additive (Seymour, 1973, 1974a, 1974b), and Figures 1a to 1e display the four predicted polarity benefits that influence reaction times, with the summed reaction time benefit displayed in Figure 1f.

First, people are faster to process +polar targets (e.g., positive words) compared to –polar targets (e.g., negative words). This expected polarity benefit is represented by the difference between the reaction time pattern in Figure 1a (the baseline) and Figure 1b. Second,

the spatial position of the words (UP vs. DOWN) will influence reaction times (See Figure 1c), with targets presented UP being coded as +polar, and targets presented DOWN coded as – polar. Third, the polarity of the response code (categorizing stimuli with a POSITIVE vs. NEGATIVE or YES vs. NO response) influences response times in speeded bi-manual categorization tasks (Clark & Brownell, 1975; Seymour, 1974a, 1974b). In studies investigating metaphor congruency effects, words are typically categorized on their meaning. Therefore, +polar responses (e.g., categorizing words as positive or moral) will receive a polarity benefit compared to – polar responses (categorizing words as negative or immoral), as shown in Figure 1d.

The fourth factor influencing categorization times is known as the polarity correspondence principle (Proctor & Cho, 2006). The polarity correspondence principle states that *“For a variety of binary classification tasks, people code the stimulus alternatives and the response alternatives as + polarity and - polarity, and response selection is faster when the polarities correspond than when they do not”* (Proctor & Cho, 2006, p. 418). As shown in Figure 1e, the polarity correspondence principle predicts that trials where the polarities of the conceptual and perceptual dimensions overlap (+polar words presented UP and –polar words presented DOWN) should receive a processing benefit compared to when the polarities do not overlap (+polar words presented DOWN and –polar words presented UP).

Note that this fourth processing benefit has a similar influence on response times, but different underlying mechanism, than an interference explanation. An interference explanation attributes the response time benefit of metaphor congruent (vs. incongruent) stimuli to the (in)congruence between the conceptual meaning of the stimulus words and the meaning automatically associated with the vertical position of the stimuli (Meier & Robinson, 2004; Schubert, 2005). The polarity correspondence principle explains the reaction time benefits in these conditions due to a purely structural overlap of + and – polarity codes of the conceptual

and perceptual dimensions. Importantly, if this structural overlap explains the observed differences in categorization times in previous studies, these metaphor congruency effects might not be an indication of an overlap in the meaning of the perceptual and conceptual dimensions (for a related theoretical reasoning, see Eder & Rothermund, 2008; Kinoshita & Peek-O'Leary, 2005; Rothermund & Wentura, 2001, 2004).

The summed reaction time benefits due to the influence of polarity differences in the conceptual, perceptual and response dimensions, as well as due to polarity correspondence, is expected to lead to a specific pattern of categorization times for +polar and –polar words presented UP and DOWN on the screen (see Figure 1f), with fastest responses for +polar words presented UP, followed by +polar words presented DOWN, in turn followed by the hypothesized equally fast categorization times for –polar words presented either UP or DOWN. An interference explanation only has one prediction (see Figure 1g), namely that +polar words presented UP and –polar words presented DOWN will be processed faster than –polar words presented UP and +polar words presented DOWN (Meier & Robinson, 2004; Schubert, 2005). Although an interference explanation does not exclude other factors from influencing reaction times in metaphor congruency studies, it becomes important to provide post-hoc explanations when the observed reaction time pattern does not match a-priori predictions. It will be especially problematic for an interference explanation if the reaction time patterns observed in previous studies are completely explained by a polarity account.

In Study 1, a meta-analysis is presented of 5 studies that have investigated the vertical representation of valence, power, morality, and divinity. This meta-analysis is used to compare the predicted reaction time pattern from an interference explanation with the predicted reaction time pattern of a polarity account, which differ on three points. First, whereas an interference explanation has no reason to predict a reliable difference between the two metaphor congruent conditions (+polar UP vs. –polar DOWN), a polarity account predicts that + polar words

presented UP will be categorized faster than –polar words presented DOWN. Second, whereas an interference explanation predicts that –polar targets (e.g., negative words) will be categorized faster when they are presented on the bottom compared to the top of the screen (see Meier, Hauser et al., 2007; Schubert, 2005), a polarity explanation does not predict a significant reaction time difference when comparing the categorization times for –polar targets presented UP with –polar targets presented DOWN (see Figure 1f).

Third, an interference explanation predicts that categorization times for words presented on the bottom of the screen should be faster in the congruent (-polar words DOWN) than the incongruent (+polar words DOWN) condition (see Figure 1g). As shown in Figure 1f, a polarity account predicts a reversed effect. Since negative words presented DOWN only receive a processing benefit due to the polarity correspondence of the –polar perceptual and –polar conceptual dimensions, whereas +polar words presented DOWN receive processing benefits due to the +polarity in the conceptual *and* response dimensions, -polar words presented DOWN should be processed slower than +polar words presented DOWN. These three different predictions for the simple effects between the conditions of the 2 (word meaning: +polar vs. –polar) x 2 (vertical position: UP vs. DOWN) designs are tested over 5 studies, with the aim to disentangle a polarity account and a response interference explanation.

Study 1: Meta-analysis of metaphor congruency effects

The 5 studies included in the current meta-analysis have all investigated the influence of the vertical position of valence, power, morality, and divinity related words on the speed with which these words were categorized. In these studies, words referring to either endpoint of a bi-polar conceptual dimension (e.g., good vs. bad) were presented UP and DOWN in vertical space. The possible influence of polarity differences in studies that have investigated metaphor congruency effects using related methodologies in other perceptual domains will be addressed in the general discussion. In the vertical dimension, UP is generally considered

+polar (Chase & Clark, 1971, 1974; Clark, 1973; Clark & Brownell, 1975; Proctor & Cho, 2006; Ladavas, 1988; Seymour, 1973, 1974; Weeks & Proctor, 1990), whereas *down* is –polar. In the conceptual dimensions, *positive* (Clark, 1973; Kinoshita & Peek-O’Leary, 2005; De Soto, London, & Handel, 1965), *powerful* (Schubert, 2005²), *moral* (Krzeszowski, 1997) and *God* (Cooper & Ross, 1974) are considered +polar, whereas *negative*, *powerless*, *immoral*, and *Devil* are –polar. The main question in this meta-analysis is whether the pattern of simple effects observed over all five studies is in line with the predictions from a polarity account, or follow from an interference explanation

Method

Literature search. Studies for the meta-analysis were collected by searching both PsychInfo and Google Scholar with the keywords “metaphor”, “spatial”, “vertical”, and “reaction time”.

Inclusion criteria. Data sets were included in the meta-analysis when metaphor congruency effects were investigated using speeded bi-manual categorization tasks. The reaction time tasks should consist of the categorization of abstract target words consisting of polar opposites, while the perceptual characteristics of these words were orthogonally manipulated by presenting them on the top or the bottom of the screen. Only published studies which revealed significant interaction effects were included, because the main goal of the meta-analysis is not to establish whether or not abstract concepts are represented in vertical space (in which case a search for unpublished datasets would have been necessary) but to test whether a polarity account provides a better explanation of the published data than an interference explanation. The five studies included in the meta-analysis (Meier, Hauser et al., 2007, Study 2; Meier and Robinson, 2004, Study 1; Meier, Sellbom, and Wygant, 2007, Study 2; Schubert, 2005, Studies 4 and 5b) are reported in Table 1. Only participants low in psychopathy from the study by Meier, Sellbom, and Wygant (2007) were included in the meta-

analysis, since only these participants showed an effect of vertical location on the speed with which moral words were categorized.

Data Analysis. As a measure of effect size, the unstandardized mean gain was chosen, which is recommended when analyzing comparable reaction time studies (Lipsey & Wilson, 2001). Correlations between the conditions in each study were directly calculated from the raw data through the helpful cooperation of Brian P. Meier and Thomas W. Schubert. Each independent sample was treated as an independent data point. A random effects analysis was used because the studies were heterogeneous (Field, 2001). This analysis assumes that variance around the mean effect size differs by more than sample error, and cannot be completely explained by potential moderators due to the heterogeneity of the sample of studies. This analysis is therefore a more conservative test of the hypotheses than a fixed effects model analysis. The average response times observed in five studies are summarized in Table 1 as a function of the polarity of the target (i.e., valence, power, morality, divinity) and the polarity of the vertical dimension.

The meta-analysis focused on the three previously detailed simple effects of the categorization time differences between conditions where the predictions derived from a polarity correspondence account and an interference explanation diverge. Therefore, the effect sizes were calculated based on the differences between 1) -polar words DOWN and +polar words UP, 2) -polar words UP and -polar words DOWN, and 3) -polar words DOWN and +polar words DOWN.

Results

First, the effect size of the difference between the two metaphor congruent conditions (+polar words UP and –polar words DOWN) was 69.29, which differed significantly from zero (see Table 2). As predicted by a polarity correspondence account, categorization times

were consistently faster for +polar words presented on the top of the screen than for –polar words presented on the bottom of the screen.

Second, the effect size for the difference in reaction times between –polar words UP or DOWN was 6.82, which did not significantly differ from zero. This means that the vertical position of words does not reliably influence categorization times for –polar words (e.g., negative, powerless, and immoral) over the five studies. This lack of a difference between –polar words presented UP or DOWN is again predicted by a polarity correspondence account, but not by an interference explanation.

Third, the effect size for the difference between +polar words DOWN and –polar words DOWN, was 27.15, which differed significantly from zero (see Table 2). In line with the predictions derived from a polarity account, +polar words presented on the bottom of the screen were categorized significantly faster compared to –polar words presented on the bottom of the screen. The direction of this difference is opposite to what would a-priori be expected by a response interference explanation, which predicts that metaphor congruent stimuli (e.g., negative words presented DOWN) should be categorized faster than metaphor incongruent stimuli (e.g., positive words presented DOWN). Finally, it should be noted that the average pattern of reaction times in Table 1 closely matches the predictions from a polarity account as detailed in Figure 1f.

Discussion

The results of the meta-analysis confirm all predictions derived from a polarity account. Instead of a cross-over interaction in the categorization times, which is predicted by an interference explanation, the reaction time pattern reveals that previously observed interactions are driven by the difference in categorization times for +polar words presented UP or DOWN on the screen. For –polar words, the vertical position does not influence

categorization times. This pattern perfectly matches the predictions derived from the summed reaction time benefits due to polarity differences.

One could argue that in addition to polarity effects, interference between the perceptual and conceptual dimensions still plays a role in metaphor congruency effects. For example, the theoretical possibility exists that reaction time benefits due to the polarity correspondence principle (Figure 1e) are complemented by a small interference effect. However, the polarity account is able to explain the complete categorization time pattern, and thus provides the most parsimonious explanation for previously observed metaphor congruency effects. Nevertheless, the meta-analysis provides only descriptive support for the influence of polarity differences. To provide predictive support for the assumption that polarity benefits offer a more parsimonious explanation for metaphor congruency effects, an experiment was performed which tested the prediction that metaphor congruency effects are caused by polarity differences.

Study 2

The goal of the current experiment is to test the hypothesis that the speed with which bi-polar concepts presented UP and DOWN on the screen are categorized is determined by polarity differences. This experiment focused on the domains of morality and valence, for which metaphor congruency effects have already been reported, with moral and positive words being categorized faster when presented on the top (versus bottom) of the screen (Meier & Robinson, 2004; Meier, Sellbom, et al., 2007). The goal of the current experiment is to show that these metaphor congruency effects disappear when the polarity benefits of +polar compared to –polar words are experimentally controlled for. Before performing the metaphor congruency task in which morality and valence related words were presented on the top or bottom of the screen, participants in the current experiment performed a simple word categorization task where words were presented in the center of the screen. The word

categorization task was introduced to be able to manipulate the reaction time benefit of +polar compared to –polar concepts due to polarity differences.

Default polarity benefits are related to the relative frequencies of +polar and –polar endpoints of dimensions in language (Batistella, 1990; Clark, 1969), with faster categorization times for words which occur more frequently. In order to influence the effects of polarity differences on reaction times, the frequency of +polar and –polar targets during the word categorization task was manipulated (the *polarity frequency manipulation*) such that for half the participants, 75% of the trials consisted of –polar words, whereas only 25% of the trials consisted of +polar words. After performing a word categorization task where more –polar words than + polar words were presented, participants had categorized words as immoral (or negative) three times more frequently than that they categorized words as moral (or positive). Whereas moral and positive are normally the default (or salient, Weeks & Proctor, 1990) stimulus alternative when categorizing words on morality or valence, this polarity frequency manipulation should increase the salience of immoral (and negative) words, and was expected to reduce (or even remove) the default polarity benefit of +polar over –polar words in this 75% –*polar words* condition. For the other half of the participants, +polar words were presented on 75% of the trials (with –polar words on 25% the trials). This distribution reflects ordinary language use, where +polar words occur more frequently than –polar words (the 75% +*polar words condition*³). Based on the frequency differences between +polar and –polar words as reported by Zajonc (1968) which averages around a 5:1 for the valence dimension, the 3:1 distribution in the 75% –polar words condition was judged to be a conservative frequency difference. To summarize, the relative frequency of +polar and –polar words was manipulated through the word categorization task with the aim to remove the default polarity benefits in one condition, without changing the default polarity benefit in the other condition.

After the word categorization task, all participants performed the *metaphor congruency task* where moral and immoral (block 1) or positive and negative (block 2) words were presented either on the top or the bottom of the screen. The metaphor congruency task was identical to that used by Meier, Sellbom, and Robinson (2007, Study 2). If polarity differences underlie previously observed metaphor congruency effects, the polarity frequency manipulation in the word categorization task should not only remove the main effect of word meaning caused by polarity differences, but should also remove the interaction between the word meaning and their vertical position. If polarity differences in the conceptual dimension (e.g., faster responses for moral than immoral words) are gone, there can no longer be any structural overlap between the polarity differences in the conceptual and perceptual dimension. Consequently the reaction time benefit due to the polarity correspondence principle should disappear in the 75% -polar words condition, with only the polarity difference in the perceptual dimension (UP vs. DOWN) still influencing categorization times after the polarity frequency manipulation.

A Stroop-like interference explanation for metaphor congruency effects predicts that perceptual information can automatically interfere with the correct categorization of words on their meaning (e.g., Meier & Robinson, 2004; Schubert, 2005). If the association between perceptual information (e.g., vertical location) and conceptual meaning (e.g., morality, valence) is truly automatic, then the frequency differences in the word categorization task could influence the main effect of word meaning in the subsequent metaphor congruency task, but should have no effect on the interference effect that underlies the interaction between word meaning and the vertical position of the stimuli. If the metaphor congruency effect nevertheless disappears for participants who received more -polar targets than +polar targets during the word categorization task (in the 75% -polar words condition), this would provide strong support for the hypothesis derived from the polarity account.

Method

Participants and design. In total, 68 students at Utrecht University (48 women, mean age 21.58) volunteered for partial course credit or a monetary compensation. Participants were randomly assigned to the 75% +polar words or the 75% -polar words condition.

Procedure. All sessions were conducted in individual cubicles on computers running E-Prime software. Participants were instructed that they would perform an experiment to investigate people's ability to categorize words. The experiment consisted of two identical blocks. In the first block, participants categorized moral and immoral words. In the second block, participants categorized positive and negative words. Because the valence concept is more general than (and partly overlaps with) the concept of morality, the block order was fixed, such that the valence block always followed the morality block. Each block consisted of two tasks.

Word categorization task. The first task consisted of the word categorization task, which constituted the experimental manipulation. Twenty moral (e.g., charity, honest, fair) and twenty immoral (e.g., cheat, corrupt, dishonest) words were presented in the center of the screen, and participants were asked to categorize the words as quickly and accurately as possible. In the second block, twenty positive (e.g., party, joy, laugh) and twenty negative (e.g., poison, cancer, failure) words were used. The stimuli were taken from earlier studies (Meier & Robinson, 2004; Meier, Sellbom, et al., 2007), and did not differ on word lemma frequency, word length, or number of syllables. In the 75% +polar words condition, +polar words (moral) were presented on 120 trials and -polar (immoral) words on 40 trials. In the 75% -polar words condition, +polar words were presented on 40 trials and -polar words on 120 trials. The unequal number of +polar and -polar target words was not explicitly mentioned to participants. All words were presented in capitals in an 18 point black Courier font on a white background. At the beginning of each trial a fixation circle was presented at the center of

the screen for 300 ms, followed by a blank screen presented for 300 ms, followed by the presentation the target word, which was presented until a response was made. Participants could respond by pressing the q and p keys on the keyboard, and the key assignment was counterbalanced between participants.

Metaphor congruency task. In the second task, all participants performed a categorization task where the same 20 moral and 20 immoral words of the word categorization task were presented on the top or on the bottom of the computer screen. Before starting this task, participants were explicitly told that unlike the previous word categorization task they had performed, an equal number of moral and immoral words would appear. The task consisted of 80 trials and the stimulus presentation was identical to the word categorization task with the exception of the vertical position of the stimuli. The procedure in the second block was identical to that of the first block, with the exception that positive and negative words were categorized on valence in the word categorization and metaphor congruency tasks.

Results

Two participants whose error rates were close to 50% were removed from the analysis. Inaccurate trials were dropped from the analysis. Key assignment did not influence reaction times ($F < 1$) and is not discussed further. A 2 (polarity manipulation: 75% +polar words vs. 75% -polar words) x 2 (block: morality vs. valence) x 2 (word polarity: +polar vs. -polar) x 2 (position: top vs. bottom) mixed model GLM with polarity manipulation as between-subject factor was conducted on the categorization times. The analysis revealed the expected main effects word polarity and position, $F(1, 64) = 5.84, p = .019, \eta_p^2 = .08$ and $F(1, 64) = 30.56, p < .001, \eta_p^2 = .32$, respectively, indicating that participants were faster when responding to +polar than -polar words, and to words presented on the top (vs. the bottom) of the screen (cf. Meier, Hauser et al., 2007; Meier, Sellbom, et al., 2007; Schubert, 2005). As expected, the main effect of word polarity was qualified by the polarity manipulation, $F(1, 64) = 12.00, p =$

.001, $\eta_p^2 = .16$, indicating only participants in the default polarity benefit condition were faster to respond to +polar words compared to –polar words. The difference in categorization times for +polar and –polar words disappeared for participants in the 75% –polar words condition, indicating the polarity frequency manipulation was successful. The main effect of word position was not influenced by the polarity manipulation, $F(1, 64) = 0.62, p = .44, \eta_p^2 = .01$. In addition, there was a strong difference between reaction times in the morality and the valence block, $F(1, 64) = 93.38, p < .001, \eta_p^2 = .59$, with overall faster categorizations in the valence block that followed the moral block, which in all likelihood constitutes a typical training effect.

The interaction between word polarity and word position was significant, $F(1, 64) = 11.66, p = .001, \eta_p^2 = .15$. Importantly, it was moderated by the polarity manipulation, as indicated by a marginally significant interaction of word polarity, word position, and the polarity manipulation, $F(1, 64) = 3.26, p = .076, \eta_p^2 = .05$. As expected, the word position by word polarity interaction was significant in the 75% +polar words condition, $F(1, 32) = 10.14, p = .003, \eta_p^2 = .24$, replicating earlier findings (Meier & Robinson, 2004; Meier, Sellbom, et al., 2007). However, the interaction between word position and word polarity was no longer significant in the 75% –polar words condition, $F(1, 32) = 1.93, p = .170, \eta_p^2 = .06$ (for averages, see Table 3). These interactions were not further moderated by the different blocks ($F_s < 1$). As expected from a polarity correspondence account, after controlling for the main effect of word polarity, categorization times for +polar and –polar words no longer depended upon their vertical position⁴.

To compare the current results with earlier studies investigating the vertical representation of morality and valence (Meier & Robinson, 2004; Meier, Sellbom, et al., 2007), the morality and valence blocks were analyzed separately using mixed model GLM's with word polarity and position as within participant factors, and polarity manipulation as a

between participant factor. The 75% +polar words condition replicates the metaphor congruency effects observed previously, $F(1, 32) = 9.02, p = .005, \eta_p^2 = .22$ for the morality block, and were marginally significant for the valence block, $F(1, 32) = 2.98, p = .09, \eta_p^2 = .09$. Importantly, simple effects revealed that moral words were categorized faster when presented on the top than on the bottom of the screen, $F(1, 32) = 14.51, p < .001, \eta_p^2 = .30$, whereas vertical position did not influence categorization times for immoral words, $F < 1$ (for averages, see Table 3). Similarly, simple effects in the valence block revealed that positive words were categorized faster when presented on the top than on the bottom of the screen, $F(1, 32) = 10.42, p < .01, \eta_p^2 = .25$, whereas vertical position did not influence response times for negative words, $F < 1$. This pattern of results is identical to the reaction time pattern observed in the meta-analysis, as well as the predictions from a polarity account (see Figure 1f).

Finally, as expected from a polarity account, the interactions between word meaning and vertical position did not reach significance in the 75% -polar words condition, $F(1, 32) = 1.16, p = .29, \eta_p^2 = .04$ for the morality block, and $F(1, 32) = 0.25, p = .62, \eta_p^2 = .01$ for the valence block. The main effects for word meaning were no longer significant, $F(1, 32) = 1.17, p = .29, \eta_p^2 = .04$ for morality block, and $F < 1$ for the valence block, indicating the polarity frequency manipulation successfully removed the default polarity benefit of +polar over -polar words. The only significant difference in the 75% -polar words condition was the main effect of vertical position (see Figure 1c) which was not influenced by the polarity frequency manipulation in the word categorization task. Participants responded faster to stimuli presented on the top (vs. bottom) of the screen, $F(1, 32) = 5.57, p = .03, \eta_p^2 = .15$ for the morality block, and $F(1, 32) = 29.95, p < .001, \eta_p^2 = .48$ for the valence block.

Discussion

The aim of the current experiment was to investigate the role of polarity correspondence in metaphor congruency effects. The results are clear-cut. After the polarity

frequency manipulation, which removed the processing benefit of +polar compared to –polar words for half of the participants in Study 2, both the typical main effect of +polar vs. –polar words, as the interaction between word polarity and the vertical position of the stimuli disappeared. This finding supports the predictions derived from a polarity correspondence account, and would not be predicted by an interference explanation, strongly suggesting that previously observed metaphor congruency effects are the result of a structural (and not necessarily conceptual) overlap between the conceptual and perceptual dimensions.

General Discussion

Both the meta-analysis and Study 2 support the hypothesis that the polarity account provides a better explanation for metaphor congruency effects than an interference explanation. The meta-analysis reveals that the pattern of reaction times to categorize +polar and –polar words presented UP and DOWN on the screen perfectly reflects the predicted summed reaction time benefits due to polarity differences. It seems difficult to explain this reaction time pattern by a Stroop-like response interference explanation. Although researchers have provided post-hoc explanations for asymmetries in the reaction time pattern in their data (e.g., Meier, Hauser, et al., 2007; Schubert, 2005), the polarity correspondence principle predicts such asymmetries a-priori, thus providing a more parsimonious explanation for previously observed metaphor congruency effects.

Study 2 reveals that after controlling for the default polarity benefit of +polar compared to –polar words (the 75% –polar words condition), the main effect of word meaning (moral vs. immoral, or positive vs. negative) disappeared. At the same time, the interaction between the vertical location of words and their meaning (which was present in the 75% +polar words condition, replicating earlier findings) was no longer significant. By controlling for the polarity benefit of +polar words compared to –polar words, not only were moral and positive words categorized equally fast as immoral and negative words, but in addition, the categorization

time of moral words no longer depended on their vertical position. The absence of a significant interaction effect of the vertical position of the stimuli and their meaning in the 75% -polar words condition follows directly from the polarity correspondence principle. Together, the meta-analysis and Study 2 provide converging support for the role of polarity differences in metaphor congruency effects.

The main reason previous researchers used Stroop-like interference paradigms was to investigate the automaticity of the vertical representation of abstract concepts (Meier & Robinson, 2004; Schubert, 2005). Based on the current findings, it seems that researchers should carefully reconsider past conclusions about the automaticity of the vertical representation of abstract concepts. It should be noted that the current article does not aim to cast doubt on the widespread idea that people use concrete dimensions such as vertical space to structure abstract concepts (Clark, 1973; Gattis, 2001; Lakoff & Johnson, 1980; Piaget, 1954; Richards, 1936; Whitney, 1875). Indeed, many studies have provided support for the vertical representation of abstract concepts in paradigms which did not rely on the speeded bimanual categorization of bi-polar opposites. These studies reveal that people structure differences in power (Giessner & Schubert, 2007; Lakens, Semin, & Foroni, in press; Schubert, 2005, Study 1), valence (Crawford, Margolies, Drake, & Murphy, 2006), and divinity (Meier et al., 2007, Study 4) in vertical space. However, the studies that aim to show that the vertical representation of abstract concepts occurs automatically have relied on speeded bimanual categorization tasks, where polarity differences seem to have influenced the categorization times. In light of the current results, conclusions such as: ‘people automatically assume that objects that are high in visual space are good, whereas objects that are low in visual space are bad’ (Meier & Robinson, 2004, p. 247) should be interpreted with caution until such hypotheses are confirmed by additional research.

The current findings complement an emerging body of research which suggests that stimulus-response congruency effects do not need to reflect automatic associations between conceptual and perceptual characteristics of stimuli (see for example Ulrich & Maienborn, 2010). Research has revealed how mechanisms unrelated to automatic associations, such as affective-mapping effects (Eder & Rothermund, 2008), feature salience (Rothermund & Wentura, 2004), contrast effects between the two categories stimuli are categorized on (Scherer & Lambert, 2009), or polarity differences (Proctor & Cho, 2006), can sometimes provide a better explanation of observed reaction time differences. Given that stimulus-response congruency effects can be caused by structural overlap between the two dimensions, instead of conceptual overlap between the two dimensions, categorization time differences should be interpreted with caution when researchers aim to investigate automatic associations (see Eder & Rothermund, 2008; Rothermund & Wentura, 2004). The current research has taken up the challenge to examine the processes underlying metaphor congruency effects, and reveals how important it is to not only demonstrate reaction time differences, but to show the mechanism through which these reaction time differences emerge (Barsalou, 2008; Zwaan, 2009).

The finding that reaction times are influenced by polarity differences is in line with earlier observations about the importance of bi-polar oppositions in the target domain of conceptual metaphors (Hampe, 2005; Krzyszowski, 1997). As an example, take a study by Wilkowski, Meier, Robinson, Carter, and Feltman (2009) who investigated the anger = heat metaphor, and found that anger related words were processed faster when presented against a background figure of a (hot) fire, than when presented against a background picture of (cold) icicles and snow. Surprisingly however, the neutral words presented in the same task were categorized faster against the cold background than when presented against the hot background, even though neutrality has little to do with heat. The authors explain these

counter-intuitive results by stating that: “the defining feature of the control words used in Study 1b was that they were ‘not angry,’ and there is good reason to believe that being ‘not angry’ is metaphorically represented in terms of coldness” (Wilkowski et al., 2009, p. 467). Because neutral words were processed by participants as the bi-polar opposite of anger, a structural mapping emerged between the background images and the target words. These results underline the important role bi-polar opposition plays in metaphor congruency effects: the categorization of neutral words was influenced by perceptual information unrelated to the conceptual meaning of the words. Instead, the relational structure between anger and heat resulted in a structural overlap between their shared opposites, ‘not-angry’ and cold (see Scherer & Lambert, 2009, for a more in depth discussion of related contrast mechanisms).

Controlling for Polarity Effects

Researchers should try to control for polarity correspondence effects when investigating the perceptual representation of abstract concepts by asking participants to perform bimanual categorization tasks, or use paradigms in which polarity benefits do not influence reaction times. There have been a number of studies which have investigated the relation between perceptual and conceptual information without relying on speeded bimanual categorization tasks. Some researchers have simply used explicit judgments to investigate how abstract concepts are influenced by perceptual information. For example, Schubert (2005) manipulated the spatial position of animals on a computer screen, and asked participants to indicate how much respect the creature elicited. For powerful creatures, their spatial position influenced ratings of respect, with higher respect ratings when these animals were presented on the top of the screen, than on the bottom. Similarly, Meier, Hauser, et al (2007) showed that pictures of faces presented on the top of the screen were judged to have a stronger belief in God than people presented on the bottom of the screen. A paradigm which has investigated the perceptual representation of abstract concepts more implicitly has looked at how memory is

affected when people have to remember the location of valenced or divinity related pictures (Crawford, et al., 2006), and such studies for example show that errors are influenced in the direction of the metaphor under investigation (e.g., remembering God related images as being presented higher than they were actually displayed, Meier, Hauser, et al., 2007). At the same time, many studies in linguistics have shown that polarity effects are not only evident in speeded categorization tasks. Children learn +polar concepts more quickly than –polar concepts (Klatzky, Clark, & Macken, 1973), and +polar words are used more often in language (Batistella, 1990; Clark, 1969; Greenberg, 1963; Zajonc, 1968). Whether and how polarity effects might influence the vertical representation of abstract concepts in tasks that do not rely on speeded binary classifications is an important question for future research.

Future studies that aim to show the usefulness of bimanual categorization tasks to investigate metaphor congruency effects could disentangle metaphor congruency effects from the polarity correspondence principle by investigating metaphors where polarities in the source and target domain do not overlap. Although scarce, an example of such a metaphor is provided by Lakoff & Johnson (1980), who discuss the conceptual metaphor ‘unknown = up’, as exemplified in expressions such as “that’s still up in the air”. Where the polarity correspondence principle would predict that words related to the concept ‘known’ will be categorized faster when presented on the top (vs. the bottom) of the screen, conceptual metaphor theory would predict that the concept ‘unknown’ will be categorized faster when presented on the top (vs. the bottom).

When researchers want to investigate the automaticity of metaphor congruency effects using reaction time paradigms for metaphors where the polarities in the source and target dimensions correspond, they might consider manipulating both endpoints of the perceptual and/or conceptual dimension between participants to exclude polarity correspondence effects. Switching from bi-manual responses in a categorization task to uni-manual responses in a

detection task might lead to weaker results, but should still reveal a congruency effect if the perceptual and conceptual dimension are strongly associated (for example, see Weger and Pratt, 2008). Manipulating perceptual or conceptual dimensions of stimuli between instead of within participants might even determine whether perceptual representations of abstract concepts emerge. For example, recent studies indicate that powerful groups are associated with UP vertical space in the context of powerless groups, whereas powerful groups in isolation are not structured in relative vertical space (Lakens et al., in press).

Open Questions

Although polarity differences clearly influenced categorization times for +polar and – polar words presented UP and DOWN on a computer screen, an important question is whether a similar effect of polarity differences plays a role in other source domains, such as size (Meier, Robinson, & Caven, 2008; Schubert, Walz, & Giessner, 2009) or brightness (Meier, Robinson, & Clore, 2004). The main effects reported in earlier studies reveal that polarity differences at least account for some of the variance in reaction time patterns, and similar asymmetries as observed in the meta-analysis in Study 1 have been observed for metaphor congruency effects between size and valence (Meier et al., 2008). Although currently not enough studies have been done in other source domains to allow for firm conclusions, it seems that perhaps except for the association between size and power (Schubert et al., 2009) previous studies in the source domains of brightness and size reveal response patterns which cannot be completely accounted for by an interference explanation. Future studies might investigate whether polarity correspondence can account for some of the irregularities in these findings.

One might argue that a polarity correspondence principle would also predict an interaction effect in previous studies where participants have been asked to categorize stimuli (e.g., positive and negative words) on their perceptual characteristics (e.g., brightness, Meier,

et al., 2004, study 4). Indeed, the polarity correspondence principle does not predict the asymmetrical influence of the perceptual (source) dimension on the conceptual (target) dimension which is a theoretical assumption in conceptual metaphor theory (Lakoff & Johnson, 1999). One possible reason that the valence of stimuli did not interfere with brightness categorizations (Meier et al., 2004) might have been that participants did not process the affective meaning of the words before categorizing them on their brightness. More recent studies reveal that the moral meaning of stimuli can interfere with the correct categorization of the brightness of words (Sherman & Clore, 2009), and several studies have revealed a bi-directional association between concepts such as weight and importance (Jostmann, Lakens, & Schubert, 2009; Schneider, Rutjens, Jostmann, & Lakens, in press) or affection and warmth (IJzerman & Semin, 2010; Williams & Bargh, 2008; Zhong & Leonardelli, 2008). The circumstances under which the relationship between perceptual and conceptual dimensions is asymmetric remains a question for further research.

Conclusion

The current research reveals that basic asymmetries in the way people process dimensions, with faster reaction time for +polar stimuli (e.g., positive, moral, UP) compared to –polar stimuli (e.g., negative, immoral, DOWN) can account for previously observed metaphor congruency effects, where the vertical position of bi-polar concepts influences the speed with which these stimuli are categorized. Therefore, it is not the automatic association between the meaning of words and the meaning of UP and DOWN vertical space that underlie previously observed metaphor congruency effects, but the structural overlap between the polarity differences in the conceptual and perceptual dimensions.

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Footnotes

¹ These asymmetries are often referred to as linguistic markedness. However, polarity benefits are not restricted to linguistic stimuli but extend to non-verbal stimuli such as arrows or up-down responses (Proctor & Cho, 2006). To acknowledge this more general response facilitation for the default endpoint of a dimension, unmarked endpoints of abstract and vertical dimensions are referred to as + polar, while marked categories are referred to as – polar (e.g., Gattis, 2001).

² Note that although Schubert (2005) suggested that powerful is the marked endpoint and powerless the unmarked endpoint of the power dimension, he agrees that powerful is the +polar endpoint of the power dimension (personal communication, December 2008).

³ One could argue that by presenting more +polar than –polar words in the word categorization task, the unequal word frequencies do not merely reflect ordinary language use, but strengthen the influence of polarity differences in the 75% +polar words condition. A direct comparison of the response times in the 75% +polar words condition of Study 2 with earlier studies reveals this is not the case. Categorization times for moral and immoral words presented up and down on the screen were analyzed with a 2 (word meaning: moral vs. immoral) x 2 (vertical position: up vs. down) x 2 (sample: Meier, Sellbom, et al., vs. Study 2) repeated measures analyses with sample as only between subjects factor. In addition to a main effect of sample (with faster categorizations in Study 2, likely due to the additional word categorization task) there was only a significant interaction between word meaning and sample $F(1, 86) = 5.12, p = .03, \eta_p^2 = .06$. Opposite to what one might expect, this interaction actually revealed that the default polarity benefit (faster categorization times for moral compared to immoral words) was stronger in the experiment by Meier, Sellbom and Wygant (2007) than in Study 2. Identical comparisons of categorization times for the valence block in Experiment 1 and the data collected by Meier and Robinson (2004) revealed only a main effect of sample,

but no interaction between sample and word meaning, vertical position or their interaction (F 's < 1). Since these analyses reveal that performing a word categorization task where more +polar than –polar words are presented does not strengthen (or might even slightly reduce) the default polarity benefit of +polar words, this condition is interpreted as revealing the default polarity benefit.

⁴ An analysis over items revealed identical results. Most importantly, the interaction between polarity and word position was significant in the 75% -polar words condition, $F(1, 78) = 9.87, p = .002, \eta_p^2 = .11$, whereas this interaction was not significant in the 75% -polar words condition ($F < 1$). This analysis reveals that the observed effects are not limited to the current stimulus set.

Table 1

Average Response Times, Target Domain and Number of Participants as a Function of the Polarity of the Source and Target Dimensions

Studies	+ Target	+ Target	- Target	- Target	Target	<i>n</i>
	UP	DOWN	UP	DOWN	Domain	
M&R, 2004 (Study 1)	837	873	910	895	Valence	34
S, 2005 (Study 4)	785	825	871	881	Power	40
S, 2005 (Study 5b)	817	853	856	856	Valence	35
MS&W, 2007 (Study 2)	876	935	941	969	Morality	55
MHRKF&S, 2007, (Study 2)	758	807	801	802	Divinity	47
Average RT	815	859	876	880		

Table 2

Summary of the Effect Sizes for the Three Simple Effects Between Conditions

Comparison	ES	SD	95% CI	Z	p	k	Q	p
+polar UP minus -polar DOWN	69.29	4.72	60.05 to 78.54	14.70	< .001	5	31.06	< .001
-polar UP minus -polar DOWN	6.82	4.43	-1.85 to 15.50	1.54	n.s.	5	5.46	n.s.
+polar DOWN minus -polar DOWN	27.15	4.07	19.18 to 35.13	6.67	< .01	5	22.53	< .001

Note. ES Unstandardized mean gain of the reaction time differences, representing the mean effect size; 95% CI the 95% confidence limits of ES; SD weighted standard deviation of the mean effect size; Z: z test for the mean effect sizes; p probability of z test; k number of samples associated with the mean effect size; Q heterogeneity of the effect-sizes; p = probability of Q test.

Table 3

Average Categorization Times (and Standard Deviations) in the Metaphor Congruency Task as a Function of Word Meaning, Vertical Position, Block and Condition

	75% +Polar Words				75% -Polar Words			
	Moral Block		Valence Block		Moral Block		Valence Block	
	Moral	Immoral	Positive	Negative	Moral	Immoral	Positive	Negative
Top	755	795	670	717	773	770	700	705
SD	116	121	90	102	82	81	79	85
Bottom	810	804	709	729	806	789	755	752
SD	101	95	70	91	77	72	87	103

Figure 1

Predicted Reaction Time Benefits Due to Polarity of the Word, Verticality, Response and Polarity Correspondence for +Polar (+) and –Polar (–) Words Presented Up and Down on the Screen.

Note. The average predicted reaction time patterns (a) baseline (no reaction time differences between conditions (b) polarity benefit due to processing +polar and –polar targets, (c), polarity benefit due to the vertical position of the stimuli (d), polarity benefit due to performing +polar and –polar responses, (e) reaction time benefit due to polarity correspondence, (f) summed reaction time benefits due to polarity effects, and (g) and example of the predicted reaction time pattern based on an interference explanation.

Author Note

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