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Hemispheric differences in word-meaning processing: Alternative interpretations of current evidence

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Abstract

Background—Drawing heavily on results from studies with divided visual field (dvf) presentation, current models of hemispheric differences in word semantic processing converge on a proposal (henceforth, "the standard model") that is increasingly being applied in studies of individuals with brain damage. According to this model, left hemisphere processes focus word meanings to their core, whereas right hemisphere processes keep wider representations active.

Aims—This paper has three aims: (a) to raise concerns about methodological aspects of the dvf studies that are usually cited in support for the standard model, specifically assumptions about interpretation of lateral dvf prime presentation and priming measures; (b) to highlight areas of further research and theoretical clarification, with reference to studies with central presentation and general models of word-meaning processing; and (c) to discuss the implications of these concerns for deriving a model of hemispheric differences in word-meaning processing, using evidence from paired word priming studies as an example.

Main Contribution—The paper discusses problematic assumptions about paired word priming studies of hemispheric contributions to word semantic processing and proposes further research to clarify these assumptions. Furthermore, it introduces an alternative interpretation of the available data, which provides a more parsimonious account of hemispheric engagement in the paired word semantic priming task.

Conclusions—Current evidence about hemispheric differences in word-meaning processing is far from conclusive. It is important to consider alternative interpretations of the available evidence when applying models based on this evidence to the study of language disorders. The alternative account proposed in this paper suggests that LH processing, rather than generally reducing activated word meanings to their core, is important for maintaining meanings that are unambiguous and consistent.

Over the last several decades a focused research effort has addressed hemispheric differences in the processing of word meanings. Based mainly on evidence from priming studies with divided visual field presentation, several models of such differences have been suggested (e.g., Beeman, 1998, Burgess & Lund, 1998; Chiarello, 1998; Koivisto & Laine, 2000). According to these models, the left cerebral hemisphere (LH) and the right cerebral hemisphere (RH) support distinct cognitive architectures and computations that underlie the representation, activation, and processing of word meanings (for ease of exposition, these distinctions will be referred to as *LH processing* and *RH processing* in the rest of this paper). Although the models differ in assumptions of underlying processing mechanisms, they all converge on the following proposal (referred to as the *standard model* in this paper): After initial broad activation of a word's features or meanings, LH processing focuses meaning access to the word's core meanings through inhibition or decay of less related or inconsistent features or interpretations.

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Thus, only *strongly related* meanings are maintained for further processing. Conversely, RH processing maintains *weakly related* features or meanings to make them available for further processing. These sustained meanings are thought to facilitate the processing of unexpected interpretations, non-literal intent, or inferences.

The standard model has become widely accepted. It has the potential to provide an important contribution to our understanding of how meanings are activated and integrated in language comprehension, and therefore it is highly relevant to the study of language disorders. Not surprisingly, research in comprehension deficits after right- and left-brain damage increasingly refers to this model, (e.g., Brownell, 2000; Copland, Chenery, & Murdoch, 2002; Grindrod & Baum, 2003; McDonald et al., 2005). However, the evidence relevant to the standard model is not yet conclusive and thus the model requires further development. This review presents some methodological concerns about the usual interpretation of evidence linked with the standard model, discusses areas of further research and theoretical clarification with reference to studies with central presentation and general models of word-meaning processing, and, based on the arguments herein, provides a possible alternative interpretation of the available evidence.

WORD MEANING ACTIVATIONS IN DIVIDED VISUAL FIELD PRESENTATION

A key finding in the study of word-meaning processing is the semantic priming effect: participants recognise target words more quickly and accurately when preceded by a related prime word (e.g., *dog–cat*) than when preceded by an unrelated prime (e.g., *fig–cat*). Researchers infer from this effect that the prime meaning was activated at the time of target presentation (e.g., Neely, 1991). Thus, semantic priming measures the activation state of the prime. This effect has been used extensively in central presentation (i.e., when prime and target are presented in the centre of the visual field) to study various processing dynamics of word meaning activation and integration. To investigate the time course of prime activation, studies have varied stimulus-onset-asynchrony (i.e., the interval between prime onset and target onset, abbreviated “SOA”). They have shown that several manipulations affect semantic priming effects at moderate and long (250+ ms) but not at short (0–250 ms) SOAs (see Neely, 1991, for a review), for example, the proportion of related versus unrelated word pairs. Therefore, meaning activation is considered to be automatic within the first 250 ms, and after 250 ms it is considered to be controlled, that is, mediated by attentional/strategic effects (but see Neely & Kahan, 2001, and Stolz & Besner, 1999, for further discussion).

Investigations of hemispheric differences in word-meaning processing combine semantic priming with divided visual field (dvf) presentation. In dvf presentation, visual stimuli are presented to the side of one visual field so that stimulus information initially reaches only the contralateral hemisphere. Performance advantages (e.g., faster response times) for stimuli presented to one visual field over the other are interpreted as representational or processing advantages of the target hemisphere for the particular type of stimulus used. The main source of support for the standard model derives from dvf studies that investigated effects of semantic relatedness, meaning dominance, and context on meaning activations in LH and RH processing. These studies used word pairs with targets more or less related to the prime meaning (e.g., *arm–leg; arm–nose*), ambiguous primes paired with targets related to the more frequent (dominant) and to a less frequent (subordinate) meanings of the prime (e.g., *bank–money; bank–river*), and stimuli in which ambiguous primes were preceded by a disambiguating sentence context, again followed by targets related to either meaning of the prime (e.g., *I took my check to the bank – money/river; I stood on the bank – money/river*) (e.g., Burgess & Simpson, 1988; Chiarello, Richards, & Pollock, 1992; Faust & Chiarello, 1998). Results suggest that for left hemisphere processing, after initial broad activation, only strongly related, dominant, and contextually appropriate meanings are maintained at long SOAs, and weakly related, subordinate, and contextually inappropriate meanings are inhibited. For RH processing these meanings were maintained. Thus, the standard model appears to be a parsimonious explanation of these data.

METHODOLOGICAL CONCERNS

There are two sources of methodological concern about dvf word priming studies. First, challenges of the dvf method necessitate a high degree of replication and corroboration of results. Second, priming patterns differ depending on the prime field of presentation and the priming measure used. To date there is no consensus on the theoretical significance of these differences. This lack of clarity can lead to inconsistencies in the interpretation of results.

Divided visual field presentation

In dvf presentation, observed differences between the two visual fields can depend on attentional and arousal factors (Kosselyn, Gazzaniga, Galaburda, & Rabin, 1999) or specific stimulus and task conditions (Hellige & Sergent, 1986; Sergent & Hellige, 1986). Not surprisingly, inconsistent results have been reported, leading some to question the validity of the dvf procedure in general (Beaumont, 1997; Efron, 1990). However, the dvf procedure should not be dismissed easily. Several findings are quite robust, for example, the right visual field–left hemisphere (rvf–LH) advantage for words. Others are substantiated with meta-analysis, for example, the left-visual field–right hemisphere (lvf–RH) advantage for visual stimuli with low spatial frequency (Van Kleeck, 1989). These and other findings are consistent with evidence from neuropsychological and imaging studies (e.g., Cabeza & Nyberg, 2000; Hellige, 1993; Kosselyn et al., 1999; Robertson & Lamb, 1991). But because dvf effects are so susceptible to other influences, results from these studies require a high degree of replication and corroboration through other methods (e.g., ERP with source localisation, imaging techniques, lesion data). Thus, a larger body of literature is needed to support the standard model.

Interpretational inconsistencies

One area of methodological variation is the field of prime presentation. In dvf priming studies, the target is always presented in the lateral visual field, but primes can be presented either laterally or in the centre of the visual field. Lateral prime presentation is often seen as a purer measure of the capabilities of individual hemispheres (Chiarello, Liu, Shears, Quan, & Kacinik, 2003; Hutchinson, Whitman, Abeare, & Raiter, 2003). Evidence in support of this view comes from a study that used both central and lateral prime presentation with the same set of word pairs, and found the expected hemispheric differences only with lateral primes (Chiarello, Burgess, Richards, & Pollock, 1990). However, studies that use central prime presentation (e.g., Burgess & Simpson, 1988; Nagakawa, 1991) are also usually cited in support of the standard model (e.g., in Chiarello et al., 2003; Koivisto & Laine, 2000). If central prime presentation is not a good measure of hemispheric differences, these data should be irrelevant for the standard model. It could be argued that including data from central prime presentation is justifiable because central presentation is not invalid as such, but rather less sensitive in detecting hemispheric differences. But such an argument can lead to reporting bias: if results from a dvf study with central prime presentation fit with the standard model, they are accepted as valid evidence; if not, they might be attributed to a lower degree of sensitivity.

Another area of methodological inconsistency is the choice of priming measure. The most frequently used measure is *priming*, that is, a comparison of the difference in the dependent variable—usually target response time (RT)—between unrelated and related prime–target pairs (e.g., *dog–cat; fig–cat*). Some studies include a third type of word pair with so-called neutral, semantically empty primes (e.g., *blank* or *xxxx*). These studies report two other measures of prime activation: *facilitation* (comparison of neutral vs related) and *inhibitio*n (comparison of neutral vs unrelated). Scrutiny of results shows that these different measures can provide conflicting outcomes. For example, Nakagawa (1991) reported significant *inhibition* for weakly related prime–target pairs presented to the rvf–LH, consistent with the standard model. Yet, inconsistent with the standard model, these word pairs also showed an unanalysed 28-ms *priming* effect (effect size [ES] .33). Another study compared *facilitation* and *inhibition* for associated prime–target pairs that had a literal (e.g., *stinging–mosquito*) or a metaphoric (e.g., *stinging–insult*) relationship (Anaki, Faust, & Kravetz, 1998). As predicted by the standard model, rvf–LH targets showed significant facilitation only for literal associates, and lvf–RH targets showed facilitation only for metaphoric associates. However, the unanalysed priming effects show priming only for literal rvf–LH targets (see Table 2 later), inconsistent with the standard model. Again, the two different priming measures lead to conflicting results, and caution is necessary to avoid a reporting bias.

Obviously researchers need a better understanding of the theoretical significance of each of these methods and their validity in measuring the targeted effect. This goal will require a research effort that systematically compares the different methods with stimulus materials, lists, and response tasks that reflect different levels of semantic processing, automatic and controlled conditions, and several methods of studying hemispheric differences. But in the absence of such evidence, researchers need to decide on *a priori* criteria as to what constitutes acceptable evidence for studying hemispheric differences in word-meaning processing to avoid reporting bias. One such set of plausible criteria follows.

With respect to field of prime presentation, the argument can be made that central, rather than lateral prime presentation is ecologically more valid. Although lateralised primes might provide a “better” measure of hemispheric capabilities, the extent to which these capabilities play a role in normal, everyday processing conditions is unclear (Joanette & Goulet, 1998). The standard model predicts that meaning processing is lateralised whenever a word is read or heard. For reading, the normal condition is central presentation. Because the priming task is meant to assess activation for *prime* meanings, central prime presentation might better reflect meaning processing under normal comprehension conditions. If this is true, evidence from studies with central prime presentation is more relevant to the standard model than evidence from lateralised prime studies.

With respect to the most appropriate priming measure, three reasons suggest choosing *priming*. First, priming can be derived from all studies, whereas only studies with neutral primes provide data on facilitation and inhibition. Second, the validity of neutral primes has been questioned because frequently repeated and semantically empty primes might be processed differently from other word primes (e.g., Brown, Hagoort, & Chwilla, 2000; Jonides & Mack, 1984). Third, neutral primes can show different effects depending on the visual field to which they are presented (Chiarello, 1998). In several dvf studies neutral primes have resulted in uninterpretable results (Anaki et al., 1998; Burgess & Simpson, 1988; Shears & Chiarello, 2003). For example, the crucial finding in the study by Anaki and colleagues—facilitation for metaphorically related meanings for lvf–RH targets—derived from an unexplainable increase in RT for neutral prime–target pairs in the lvf–RH metaphor condition. This increase happened neither at an earlier stimulus onset asynchrony nor in any other neutral condition in either hemifield. Thus, it is unlikely that it reflects any real effect of hemispheric differences.

While the reported difficulty of getting stable baselines with neutral primes suggests that these primes are especially problematic, *priming* results can also be misleading. RTs to words differ for many reasons, and even though carefully designed studies try to control for extraneous variables, it is impossible to rule them out completely. If such extraneous variables change the RTs differently in the experimental conditions, priming effects are unreliable. The widely used difference score (unrelated – related) is especially susceptible to such variations. Researchers

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should consider the appropriateness of other, mathematically more robust measures of priming (e.g., proportions; ratios) or covariance analyses to minimise such differences, as needed.

INTEGRATION WITH GENERAL MODELS OF WORD-MEANING PROCESSING

By its nature, the study of hemispheric differences suggests an attempt to discover a single factor that distinguishes LH and RH processing. However, a single-factor dichotomy can mask important distinctions when studying the known complexity of word-meaning processing (Chiarello, 2003). The goal of studying hemispheric differences is to understand how complementary processing systems supported by the LH and RH interact to produce observable behaviour. Thus, results and models from central and dvf studies need to be integrated. Attention to distinctions evident in general models of word-meaning processing can further the evidential and theoretical base for the standard model. This section addresses distinctions involving (a) lexical versus semantic processing and (b) processing dynamics underlying semantic relatedness, meaning dominance, and context.

The standard model addresses semantic processing; therefore, prime–target pairs should reflect semantic rather than lexical relatedness. The relevant dvf studies use associated prime–target pairs. However, several authors have argued that association arises from lexical co-occurrence and reflects a lexical rather than semantic relationship (e.g., Fodor, 1983; McRae & Boisvert, 1998; Shelton & Martin, 1992). If this is true, observed hemispheric asymmetries in associative word priming might derive from word-form rather than word-meaning processing. Thus, for clarity of evidence, dvf studies should use non-associated semantically related stimuli (Chiarello et al., 2003).

The evidence in support of the standard model summarised above also reflects three different aspects of meaning processing. Studies using word pairs with different degrees of semantic relatedness assess the breadth of activation of the prime's semantic network, whereas studies using ambiguous primes with targets related to the dominant and subordinate meanings investigate dominance effects, that is, the degree of activation for two incompatible and competing prime meanings (e.g., Chiarello et al., 2003; Hutchinson et al., 2003). Studies that add sentence context allow researchers to investigate how bottom-up word-meaning activation interacts with contextual constraints (e.g., Simpson, 1994).

In studies with central prime/target presentation, these three effects have different priming patterns, suggesting that different processing dynamics give rise to them. Less closely related meanings are not inhibited at long SOAs (e.g., Becker, 1980; McRae & Boisvert, 1998), but subordinate meanings are (e.g., Hino, Lupker, & Sears, 1997; Simpson & Burgess, 1985). Furthermore, initial activation for subordinate meanings can be suppressed in contexts with strong dominant-meaning bias (for a review, see Simpson, 1994). Thus, a model of hemispheric differences needs to account for how the LH and RH systems contribute to these processing dynamics. If the standard model is correct, the evidence suggests that for semantic relatedness, priming in studies with central presentation is driven by both LH and RH processing (priming of strongly and weakly related targets), whereas for meaning dominance, priming would have to be driven solely by LH processing (inhibition of subordinate meanings). Further research would need to address why this is the case. This issue does not arise in the alternative interpretation of results presented in the next section of this paper.

One way to introduce a more systematic investigation of these distinctions is to address the confound of meaning dominance and semantic relatedness in studies with ambiguous primes. This confound arises in both central and dvf presentation, because the studies tend to pair the ambiguous prime with a *strongly* associated target related to the *dominant* prime meaning (e.g., *bank–money*), and with a *weakly* associated target that is related to the *subordinate* prime meaning (e.g., *bank–river*). Thus, these studies confound the effect of dominance with degree of relatedness, and observed hemispheric differences could be due to strength of semantic relatedness, meaning dominance, or an interaction of both. One dvf study designed to address this confound (Atchley, Burgess, & Keeney, 1999) did not include the critical condition of a target strongly related to the subordinate meaning of the prime, and therefore is inconclusive. Another study that controlled the degree of association for dominant and subordinate targets, using central presentation (Hino et al., 1997), found complete inhibition of priming for subordinate meanings. However, results showed no effects of semantic relatedness, which is inconsistent with the vast majority of the investigations of this effect (e.g., Cañas, 1990; McRae & Boisvert, 1998; Stolz & Neely, 1995). Therefore the manipulation of this variable might not have been successful, possibly because the targets' degree of relatedness was too low. Thus, further studies need to control for degree of relatedness in such a way that both dominant and subordinate targets are highly related to the prime.

AN ALTERNATIVE INTERPRETATION OF CURRENT EVIDENCE

An alternative interpretation of current evidence, detailed in this last portion of this paper, derives from the recommendations made above. It is based only or studies that use central primes and the *priming* measure of semantic activation (for studies in which these were not analysed, raw priming data are used). The review separates studies of semantic similarity and meaning dominance, and therefore is restricted to paired priming studies. To date, data are not available to address (a) the question of whether effects of semantic similarity are replicable with unassociated prime–target pairs, and (b) the confound of meaning dominance and semantic similarity in the meaning dominance studies. Also, there are too few studies to allow the use of meta-analytic techniques, and only half of the studies available supplied relevant measures of variance necessary for calculating effect sizes for the contrasts of interest, making inter-study comparisons more difficult. Because the standard model addresses hemispheric differences after initial activation stages, this review includes only studies that report priming effects at SOAs of 600 ms or longer (see Chiarello et al., 2003, for a review of priming patterns at early SOAs). Only RT data are reported because they tend to be more sensitive than accuracy data to the cognitive processes under investigation. All studies used lexical decision as the response task, with the exception of two studies (Atchley, Burgess, Audet, & Arambel, 1996; Burgess & Lund, 1998), which used naming.

Semantic relatedness results

Only three studies investigated different degrees of semantic relatedness with centrally presented primes (see Table 1). The first two are related studies that use the same stimulus set of category coordinates. Strongly related category coordinates were associated and weakly related ones were not (Chiarello et al., 1990;Chiarello et al., 1992). In the third study (Nakagawa, 1991) strongly related word pairs were antonyms, and weakly related word pairs were remote associates. The three studies differ in the proportion of related targets to all word targets. Higher relatedness proportions lead to increases in semantic priming and are considered to reflect controlled/strategic processing effects (e.g., Neely, 1991).

According to the standard model, RH processing maintains broad meaning activations of words. The observed priming for weakly related lvf–RH targets (Table 1) is consistent with this prediction. However, the model also predicts that LH processing results in inhibition of such meanings, and therefore weakly related rvf–LH targets should *not* be primed at this SOA. This is not the case in the reviewed studies (Table 1), and thus the results are inconsistent with the standard model. An effect of meaning relatedness (strong>weak) is evident in some conditions, and might be more likely and stronger for rvf–LH targets. The lack of a relatedness effect in the first study (Chiarello et al., 1990) might be due to the low relatedness proportion, which reduces such effects (Cañas, 1990;Stolz & Neely, 1995).

According to the standard model, LH word-meaning activation follows a specific time course: after initial broad activation word meanings are narrowed over time to their central meanings. Only Nakagawa's (1991) investigation included a short SOA condition necessary to assess such effects. The priming data for Nakagawa's 67 and 750 ms SOA conditions (ES .33 and .36, respectively) suggest that activation levels do not change over time. But because no data are available for intervals between these two SOAs, it cannot be ruled out that priming effects would increase after 67 ms and decrease before 750 ms SOA, which would reflect a reduction of activation levels for less related meanings in LH processing. Clearly, more data are needed to evaluate these time course predictions of the standard model. Nakagawa's data do, however, rule out *complete* inhibition of less related meanings in LH processing.

Meaning dominance

Six studies have addressed meaning dominance effects in dvf word priming studies with centralised primes (see Table 2). They include three different operationalisations of meaning dominance. Four studies (Atchley et al., 1996;Burgess & Lund, 1998;Burgess & Simpson, 1988;Hasbrooke & Chiarello, 1998) used ambiguous word primes paired with targets that are associated with each meaning (*bank–money*, *bank–river*). In these studies, dominance is determined by association norms: dominant meanings are those meanings that elicit the majority of associates. Another study (Atchley et al., 1999) used targets that were semantic features more (dominant) or less (subordinate) compatible with the prime word meaning (e.g., *apple–round*, *apple–rotten*). The last study (Anaki et al., 1998) used adjective primes that had literal (dominant) or metaphoric (subordinate) meaning relationships with their respective noun targets (*stinging–mosquito*, *stinging–insult*). All studies used a relatedness proportion of .50, which is compatible with controlled processing (e.g., Stolz & Neely, 1995).

Again, the standard model predicts that LH processing results in meaning maintenance only for dominant meanings at long SOAs. Conversely, RH processing should maintain subordinate meanings. Four studies presented priming patterns consistent with these predictions (Atchley et al., 1996; Atchley et al., 1999; Burgess & Lund, 1998; Burgess & Simpson, 1988). All four investigations also included an early SOA, at which subordinate targets were primed when presented to the rvf–LH. Thus, the lack of rvf–LH priming at the long SOA was not due to some problem in eliciting priming with these studies' materials or methods. Instead, it indicates complete inhibition of priming effects over the time course investigated.

The results of two other studies are inconsistent with the standard model because they do not show priming for subordinate lvf–RH targets. As noted above, the "subordinate" stimuli in one study (Anaki et al., 1998) were metaphoric adjectives with their associated nouns (e.g., *stinging–insult*). Such constructions might be strong collocations, for which the association relies heavily on lexical co-occurrence. For this purely lexical relationship, lvf–RH priming might not be expected. The study by Hasbrooke and Chiarello (1998) used a dominance criterion quite different from other studies with similar stimulus sets. Whereas the other studies required that at least 60% of the associates of a prime were related to the dominant meaning (Atchley et al., 1996), this study accepted meanings as dominant when only 40% of associations were related to the prime. This criterion might have lowered dominance strength and affected priming results. These arguments, though post-hoc and speculative, might account for differences in results between these two studies and the other four. All in all, with four of six studies being in agreement, the most likely interpretation of the aggregated evidence is that subordinate meanings presented to the rvf–LH are completely inhibited over time, consistent with the standard model.

To summarise, the evidence reviewed above suggests that for rvf–LH targets, priming results at SOAs longer than 600 ms reflect the degree of meaning similarity of prime and target, and complete inhibition of subordinate inconsistent meanings. This interpretation differs from the standard model because, against the predictions of that model, weakly related meanings are not inhibited. Priming results for lvf–RH targets are consistent with the standard model as they show priming for both weakly related and subordinate meanings. The data suggest that effects of meaning relatedness might be weaker for lvf–RH targets than for rvf–LH targets, but more data are needed before conclusions can be drawn with any confidence.

IMPLICATIONS FOR HEMISPHERIC DIFFERENCES OF WORD-MEANING PROCESSING

This alternative interpretation of evidence about hemispheric contributions to word-meaning processing suggests that cognitive processes reflected in rvf–LH priming do not focus meanings to only their core meanings. Instead, they appear to be involved in maintaining meaning interpretations of perceived words (and possibly larger language units) that are consistent and unambiguous. RH processing appears to allow for maintenance of competing meanings of ambiguities. It might be expected that such meanings are accessed in situations that require more complex search, retrieval, and resolution of interpretations.

As discussed above, the studies of meaning dominance confound dominance with semantic relatedness, which could not be addressed in this review. Furthermore, the available data do not rule out the possibility that controlled LH processing somewhat reduces activation levels for less related meanings at long SOAs. Thus, observed complete inhibition of priming for rvf–LH targets in meaning dominance studies could also reflect the interaction of a reduction of activation levels for both weakly related and subordinate meanings. Such a processing pattern would suggest that LH processing bolsters dominant meaning interpretations by weakening rather than completely eliminating access to subordinate inconsistent meanings.

Interestingly, in this interpretation of the data the priming patterns from rvf–LH targets are consistent with priming patterns in studies with central presentation reviewed above. Therefore, this interpretation of data is more parsimonious because it allows the inference that in general for simple word priming/lexical decision tasks, which do not require complex meaning integration, lvf–RH processing is not engaged. Of course, this conclusion is quite speculative. As discussed in this review, the available evidence is far from conclusive, and inferences need to be tentative. More research is needed to clarify the issues and confounds listed above. Given this state of affairs, it is important to consider alternative interpretations of available evidence when applying models based on this evidence to the study of language disorders. This paper presents one such alternative interpretation.

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TABLE 1

Overview of priming results (response times) for prime words paired with strongly vs weakly related target words

Study	Strong vs weak semantic relationship between prime and target	RP[1]	rvf–LH[2] significant priming (effect size)[4]			lvf–RH[3] significant priming (effect size)		
			Strong	Weak	Strong vs weak	Strong	Weak	Strong vs weak
Chiarello et al., 1990	Associated vs non-associated category coordinates	.25	yes	yes	s=w[5]	yes	yes	s=w[6] (26 ms difference)
Chiarello et al., 1992	Associated vs non-associated category coordinates	.70	yes	yes	s>w	yes	yes	s=w
Nakagawa, 1991	Antonyms vs remote associates	.50	85 ms[7] (1.11)	28 ms (.33)	57 ms (.78)	57 ms (.54)	20 ms (.17)	37 ms (.36)

[1]Relatedness proportion (# related targets/# word targets).

[2]Right visual field/left hemisphere.

[3]Left visual field/right hemisphere.

[4]Significant effect according to *priming* measure (response time unrelated – response time related prime–target pairs). Effect sizes (*d=priming*/standard deviation) are reported in parentheses when available.

[5]s=strong, w=weak.

[6]It is not quite clear whether the relevant significance test was performed, effect size not calculable.

[7]No significance testing available for *priming* measure, therefore *priming* effects are reported in milliseconds.

TABLE 2

Overview of priming results (response time) for targets related to a dominant and subordinate prime meaning

Study	Dominant vs subordinate meaning relationship between prime and target	rvf-LH[1] significant priming (effect size)[3]			lvf-RH[2] significant priming (effect size)		
		Dominant	Subordinate	Dominant vs subordinate	Dominant	Subordinate	Dominant vs subordinate
Anaki et al, 1998	Literal vs metaphoric adjectives primes of noun targets	34 ms[4] (.35)	−12 ms (−.12)	46 ms (.47)	1 ms (.01)	–4 ms (–.03)	−5 ms (−.04)
Atchley et al, 1996	Dominant vs subordinate associates of ambiguous primes	yes	no	d>s[5]	yes	yes	not reported
Atchley et al, 1999	Features more vs less compatible with prime meaning	yes (.23)	no (−.03)	d>s (.26)	yes (.33)	yes (.25)	d=s (.08)
Burgess & Lund, 1998[6]	Dominant vs subordinate associates of ambiguous primes	yes	no	d>s	yes	yes	~40 ms
Burgess & Simpson, 1988	Dominant vs subordinate associates of ambiguous primes	yes (.55)	no (−.56)	d>s (1.10)	yes (.41)	yes (.42)	d=s (−.01)
Hasbrooke & Chiarello, 1998	Dominant vs subordinate associates of ambiguous primes	yes	no	d>s	yes	no	d>s

[1] Right visual field/left hemisphere.

[2] Left visual field/right hemisphere.

[3] Significant effect according to *priming* measure (response time unrelated – response time related prime–target pairs). Effect sizes (*d=priming*/standard deviation) are reported in parentheses when available.

[4]No significance testing available for *priming* measure, therefore *priming* effects are reported in milliseconds.

[5]d=dominant, s=subordinate

[6]These data are only reported in a figure in a book chapter. The chapter text implies that significance tests were conducted on dominant and subordinate priming in each visual field condition.