Psychon Bull Rev (2016) 23:540–547
DOI 10.3758/s13423-015-0932-2

BRIEF REPORT

Uncovering underlying processes of semantic priming by correlating item-level effects

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Published online: 2 September 2015

Abstract The current study examines the underlying processes of semantic priming using the largest priming database available (i.e., Semantic Priming Project, Hutchison et al. *Behavior Research Methods*, *45*(4), 1099–1114, 2013). Specifically, it compares priming effects in two tasks: lexical decision and pronunciation. Task similarities were assessed at two different stimulus onset asynchronies (SOAs) (i.e., 200 and 1,200 ms) and for both primary and other associates. To evaluate how consistent priming is across these two tasks, item-level priming effects obtained in each task were correlated for each condition separately. The results revealed significant correlations at the short SOA for both primary and other associates. The correlations at the long SOA were significantly smaller and only reached significance when z-transformed response times were used. Furthermore, this pattern remained essentially the same when only asymmetric forward associates (e.g., *panda-bear*) were considered, suggesting that the cross-task stability at the short SOA was not merely caused by retrospective processes such as semantic matching. Instead, these findings provide evidence for a rapidly operating, item-based, relational characteristic such as spreading activation.

Keywords Semantic priming · Item-level priming effects · Task comparison · Lexical decision · Pronunciation

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Introduction

Traditionally, the semantic priming effect is (partially) ascribed to activation spreading from the prime to the target (Neely, 1977; Posner & Snyder, 1975). That is, a concept such as *cat* is assumed to automatically activate related concepts such as *dog*, *animal*, and the like. Pre-activated targets are recognized faster when they are subsequently presented, thus producing a priming effect. However, the activation decays rapidly, hence its potential facilitative effect decreases as stimulus onset asynchrony (SOA) between prime and target increases.

Besides spreading activation, other processes have been argued to yield semantic priming as well. For one, participants may (consciously) generate a number of candidate targets based on the prime. If the candidate set contains the actual target, word identification is often facilitated (Becker, 1980). However, in contrast to spreading activation, expectancy generation is thought to be a slower acting, controlled process that requires an SOA of more than 200 ms to have its effect (Neely & Keefe, 1989).

Spreading activation and expectancy generation are both prospective mechanisms, as they are triggered by the presentation of the prime. Priming effects may also arise as a result of retrospective processes, which are initiated upon target presentation. Neely (1977) described how retrospectively checking whether the target is semantically related to the prime might produce priming in the lexical decision task. In this task, participants have to judge whether target letter strings form an existing word. To aid their decision, participants may use relatedness as a cue (i.e., if the target is related to the preceding prime, it must be a word; if they are unrelated, the target is more likely to be a nonword), which in turn can result in a priming effect.

These latter two processes, expectancy generation and retrospective semantic matching, are considered to be strategic as they depend on task and subject characteristics, whereas automatic priming is argued to reflect the true structure of the mental lexicon (Lucas, 2000). Nevertheless, the automatic spreading activation account has drawn some criticism over the years. Stolz and Besner (1996) claimed that there is no such thing as automatic semantic activation of the prime in the first place. They found that semantic priming was eliminated when participants performed a letter search on the prime, unless the presentation of the probe letter was delayed. This was taken to mean that the letter search task requires attentional control which precludes activation from spreading from the word recognition level to the semantic level. Hence, priming is not automatic in terms of Posner and Snyder's criteria (1975) because it is not a capacity-free process.

Recently, De Wit and Kinoshita (2015) argued that priming in the lexical decision task is driven by different processes than in semantic categorization, which raises doubt about a potential general mechanism like automatic spreading activation. Their conclusion was based on a comparison of the response time (RT) distributions in both tasks (at an SOA of 240 ms). They found that the priming effect increased across the RT distribution in the lexical decision task, whereas it remained constant in the semantic categorization task.

Current study

The present study sought to build on this work as it also compares priming in two tasks: lexical decision and pronunciation. Within the original three-process account of Neely and Keefe (1989), priming in the lexical decision task is the result of automatic spreading activation, expectancy generation, and retrospective semantic matching. The impact of each of these mechanisms is argued to depend on SOA, with spreading activation decaying over time, whereas expectancy generation and retrospective semantic matching require longer SOAs. A similar explanation was proposed for the pronunciation task, except that retrospective semantic matching was presumed to play no role as the detection of a semantic relation between prime and target provides no information regarding pronunciation of the target. Note that some of these assumptions have been contradicted by more recent empirical evidence. That is, backward priming has been found at short SOAs, suggesting either that there are other retrospective processes besides semantic matching or that semantic matching does occur at short SOAs (Hutchison, Heap, Neely, & Thomas, 2014; Kahan, Neely, & Forsythe, 1999). Also, Thomas, Neely, and O'Connor (2012) showed that retrospective processes might play a role in pronunciation as well. Combining these results with the original three-process model of Neely and Keefe would suggest that (a) at a short SOA, spreading activation and retrospective processes may produce priming in both lexical decision and pronunciation and (b) at a long SOA, priming in both tasks could be the result of retrospective processes and expectancy generation.

The aim of the present study was to assess whether the same processes underlie priming in both these tasks. More specifically, it critically examines the (potential) role of spreading activation. However, instead of relying on RT distribution analyses to compare tasks, we opted to correlate item-level priming effects. In a typical priming experiment, half of the participants see a certain target in the related condition (e.g., *king-queen*), whereas the other half receives the unrelated version (e.g., *brook-queen*). Item-level priming effects can be obtained by subtracting the average RT to a target in the related condition from the average RT to the same target in the unrelated condition. This thus results in a separate priming effect for every target item. The present paper sought to examine whether such item-level effects obtained in two different tasks are stable. That is, if the same mechanisms produce priming in both tasks, one would expect consistency across tasks in terms of the magnitude of the item-level priming effect (henceforth item-level consistency). Suppose that the pair *king-queen* shows a relatively large priming effect in one task, one might expect a large effect in the other task as well, that is if priming has a common source. This should be especially the case at the short SOA, because spreading activation is supposedly ubiquitous. It is noteworthy that this prediction is explicitly embedded in the three-process model of priming: "Since lexical access presumably occurs in both the lexical decision task and the pronunciation task, spreading activation should produce similar priming effects in these two tasks" (Neely, 1991, p. 294). However, one could also assume activation spreading from the target's lexical/semantic representation to its phonological/orthographic representation. For instance, Borowsky and Besner (1993) hypothesized that "activation for words related to the prime in the semantic system causes activation of their corresponding representations in the orthographic input lexicon via feedback" (p. 832). The bottom line is that spreading activation should have an analogous effect in lexical decision and pronunciation. It ought to produce comparable priming effects because the target's semantic, lexical, orthographic, and/or phonological representation is presumably preactivated to a similar degree relative to a neutral baseline.

Note, though, that theories of priming vary in their view on prime-target relatedness. Specifically, distributed models (primarily) consider the degree of feature overlap between concepts to underlie priming (McRae & Boisvert, 1998; Plaut, 1995), whereas, for instance, Fodor's modular view (1983) attributes priming to the associative strength between prime and target. Regardless of whether priming is the result of feature overlap and/or associative strength, if either of them plays a role in both lexical decision and pronunciation, one would expect consistency in item-level priming effects, especially at the short SOA. In contrast, the use of strategies such as expectancy generation and retrospective semantic matching have been shown to vary across individuals (Hutchison, Heap, Neely, & Thomas, 2014). One should therefore expect less consistency at a longer SOA, because individual differences in strategy use would decrease the consistency of item-level priming effects.

At first glance, these hypotheses seem contradictory to findings from Stolz, Besner, and Carr (2005). They only found consistent priming effects within the lexical decision task when the task conditions encouraged the use of controlled processes like semantic matching and expectancy generation (i.e., long SOA, high-relatedness proportion). However, Stolz and colleagues looked at *person-level* consistency, which involves calculating the priming effect per participant by averaging across items. It thus assesses whether person-level priming effects are stable over items. In contrast, the present study examines whether item-level priming effects are stable across participants. The stable interindividual differences Stolz et al. found in the long SOA, high-relatedness proportion conditions presumably reflect people's prime recruitment strategies. This is in line with the claim that people high in attentional control tend to rely more on the expectancy generation strategy than their low attentional control counterparts (Hutchison et al., 2014). High attentional control participants thus exhibit greater prospective priming *across all items*, which can explain the person-level consistency observed by Stolz and colleagues.

Here, we focus on item-level consistency. If spreading activation indeed plays a role in both lexical decision and pronunciation, one would expect more consistency in terms of item-level priming effects at the short SOA. To specifically test this hypothesis, we also examined item-level consistency for asymmetric forward associates at a short SOA (e.g., *panda-bear*). The assumption is that priming for forward associates cannot be attributed to semantic matching as there is no backward target-to-prime association. Thomas and colleagues (2012) provided support for this assertion by examining the effect of target degradation for different association types. That is, priming effects have been shown to increase when the target stimulus is visually degraded (e.g., Balota, Yap, Cortese, & Watson, 2008). The idea is that target degradation increases reliance on the prime because related primes are especially useful in disambiguating degraded targets (Balota et al., 2008). Thomas and colleagues further examined the priming × target degradation interaction, thereby distinguishing between three association types: asymmetric forward associates (FA), asymmetric backward associates (BA), and symmetric associates (SYM). Given that encountering a degraded target more likely prompts recruitment of the prime, one might expect a greater priming effect in all three conditions. However, the priming × target degradation interaction was only observed for BA and SYM pairs, which led Thomas et al. to conclude that "a backward target-to-prime association seems necessary for the retrospective priming mechanism to be invoked" (p. 637). More recent work provided further support for the validity of the distinction between association types (Heyman, Van Rensbergen, Storms, Hutchison, & De Deyne, 2015; Hutchison et al., 2014). These studies respectively showed that FA priming disappeared under a high working memory load and was positively related to attentional control. In contrast, BA priming remained stable under a high working memory load and was not significantly related to attentional control.

Given that FA priming can solely be attributed to prospective processes, as suggested by the studies discussed in the previous paragraph, spreading activation accounts of priming would expect a correlation between item-level priming effects for FA pairs at a short SOA. On the other hand, if there were no common underlying process(es), one would expect no consistency in priming effects across tasks.

Method

To answer the questions raised in the introduction, we analyzed the data from the Semantic Priming Project (see Hutchison et al., 2013, for a complete description). This database contains priming data for 1,661 targets, all of which were the primary associate to one cue (e.g., *below-above*) and another associate to a different cue (e.g., *upstairs-above*). Targets (e.g., *above*) were preceded by a related prime (in this example either *below* or *upstairs*) or by an unrelated prime. Unrelated pairs were created by combining each target with a different (unrelated) prime (e.g., *postage-above* and *mildew-above*). This procedure thus yields priming effects for 1,661 primary associate pairs and 1,661 other associate pairs. Of the 1,661 primary associates, 492 were asymmetric in that their backward associative strength was zero (i.e., FA pairs). The number of FA pairs among the other associates was 1,080. Note that because all prime-target pairs have a forward association above zero, there are no asymmetric BA pairs in the database.

Participants were assigned to the pronunciation task ($N = 256$) or the lexical decision task ($N = 512$). The nonword stimuli for the lexical decision task were created by changing one or two letters in the target words. The entire experiment, both the lexical decision and the pronunciation variant, comprised 1,661 trials, which were divided into two sessions that were administered on different days. The relatedness proportion was .50 in both experiments. In the lexical decision task, half of the trials featured a nonword target, thus yielding a nonword ratio of .67. SOA was manipulated within participants, as they received in each session a block with an SOA of 200 ms and another block with an SOA of 1,200 ms (the order of which was counterbalanced across participants).

A total of 32 lists was made for the lexical decision task to rotate targets across all SOA (200 ms vs. 1,200 ms) × session (first sessions vs. second session) × relatedness (related vs. unrelated) × associate type (primary vs. other) × lexicality (word vs. nonword) conditions.[1] Only 16 lists were necessary for the pronunciation task as all stimuli were words. Participants were assigned to one of the lists based on participant number. On each trial participants first saw a fixation cross for 500 ms, followed by the uppercase prime, which was presented for 150 ms. Then, a blank screen was shown for 50 or 1,050 ms, depending on the SOA condition. Finally, the lowercase target appeared, requiring either a word/nonword decision or a pronunciation response. Participants were told to be as fast and accurate as possible.

Results

RT and zRT correlations for all items

Priming effects per item were calculated by subtracting the average RT to the target in the related condition from the average RT in the unrelated condition after outliers and incorrect responses were removed. Outliers were defined per participant for each SOA × associate type condition separately. That is, RTs more extreme than 3 *SD*s above or below the participant's condition-specific average RT were excluded. The entire procedure resulted in the removal of 6.3 % of the lexical decision data and 5.5 % of the pronunciation data. The item-level priming effects were then calculated separately for each task × SOA × associate type condition (see Table 1 for the average priming effect per condition). In a next step, item-level priming effects were correlated across tasks keeping SOA and associate type constant (see Table 2). The correlation between priming effects at the short SOA was significant for both primary and other associates, $t(1,659) = 3.82$, $p < .001$ and $t(1,659) = 3.89$, $p < .001$, respectively. At the long SOA, the correlations were not significant and even numerically negative, $t(1,659) = -1.05$, $p = .29$, for primary associates and $t(1,659) = -1.48$, $p = .14$, for other associates.

As can be seen in Table 2, the obtained correlation coefficients are low. However, comparing raw response latencies may deflate the estimated consistency over tasks. Instead, transforming every participant's RTs into z-scores has been argued to correct for differences in processing speed across groups/tasks (Faust, Balota, Spieler & Ferraro, 1999; Hutchison, Balota, Cortese & Watson, 2008). For the present purposes, each participant's RTs were standardized within each SOA × associate type condition. Repeating the analyses using these zRTs showed significant positive correlations in three out of four conditions: $t(1,659) = 8.90$, $p < .001$, for primary associates at SOA 200, $t(1,659) = 5.37$, $p < .001$, for other associates at SOA 200, $t(1,659) = 3.92$, $p < .001$, for primary associates at SOA 1,200, and $t(1,659) = 1.79$, $p = .07$, for other associates at SOA 1,200. Even though the results of the zRTs reveal that there is some consistency at an SOA of 1,200, the consistency at the 200 SOA is larger according to both RT and zRT analyses. That is, comparing the magnitude of the correlations using Fisher's *r*-to-*Z* transformation shows that the correlations at the short SOA are substantially larger ($Z = 3.44$, $p < .001$ and $Z = 3.50$, $p < .001$ for SOA differences in RT and zRT, respectively, among primary associates and $Z = 3.80$, $p < .001$ and $Z = 2.54$, $p = .01$ for these SOA differences among other associates).

Table 1 Average item-level priming effect (in ms) as a function of task, stimulus onset asynchrony (SOA), and associate type for all pairs and forward associate (FA) pairs

	Lexical decision		Pronunciation	
	SOA 200	SOA 1200	SOA 200	SOA 1200
All pairs				
Primary	29	22	8	9
Other	20	15	4	4
FA pairs				
Primary	20	16	5	4
Other	18	11	2	4

Within-task consistency

Despite the fact that the correlations became larger after the z-transformation, one might still argue that the effect sizes are low. However, consistency across tasks necessarily depends on consistency *within* tasks. Previous research has already shown that the reliability of priming effects is rather low (Hutchison et al., 2008). To assess within-task consistency in the present study, we split the data in half and correlated the two resulting vectors containing item-level priming effects. The reliability was estimated by applying the Spearman-Brown prediction formula and this procedure was run 100 times to avoid capitalizing on chance. Averaging across those 100 measures eventually gives us a reliability estimate (see Table 3). As expected, the reliability was overall rather low (we will revisit this issue in the Discussion). Interestingly, the estimates were higher when the SOA was short, which corroborates with the larger cross-task correlations observed in the latter condition. Critically, the relatively low cross-task correlations are expected given the limited within-task consistency. One might wonder, though, what the cross-task correlation would have been if the item-level priming effects were more consistent within tasks. One way to address this is by applying

[1] Although nonwords were rotated across session and SOA conditions, they were actually never preceded by a semantically related prime.

Table 2 Correlations between item-level response times (RTs), z-transformed RTs (zRTs), and residual priming effects as a function of stimulus onset asynchrony (SOA) and associate type for all pairs and forward associate (FA) pairs

	RT		zRT		Residuals	
	SOA 200	SOA 1200	SOA 200	SOA 1200	SOA 200	SOA 1200
All pairs						
Primary	.09 [.05– .14]	–.03 [−.07– .02]	.21 [.17– .26]	.10 [.05– .14]	.17 [.13– .22]	.06 [.02– .11]
Other	.10 [.05– .14]	–.04 [−.08– .01]	.13 [.08– .18]	.04 [−.00– .09]	.11 [.06– .16]	.04 [−.01– .08]
FA pairs						
Primary	.09 [−.00– .17]	–.01 [−10– .08]	.19 [.10– .27]	.07 [−.02– 16]	.17 [.08– .25]	.06 [−.03– .15]
Other	.07 [.01– .12]	–.04 [−.10– .02]	.14 [.08– .20]	.04 [−.02– .10]	.12 [.06– .18]	.03 [−.03– .09]

Note: 95 % confidence intervals for the correlation coefficient are in brackets

Spearman's correction for attenuation formula (1904) to the present data. Doing so would give us an estimate of the cross-task correlation when one could measure item-level priming effects with perfect reliability. In other words, it estimates the cross-task correlation taking the within-task inconsistency into account. Concretely, the disattenuated correlation is given by dividing the obtained cross-task correlation by the square root of the product of the reliability coefficients. As an illustration, the estimated cross-task correlation for z-score priming from primary associates at a short SOA is $.21/\sqrt{(.30 \times .34)} = .67$.

Forward associates

As noted in the introduction, additional analyses were conducted using only FA pairs to isolate the (potential) effect of prospective processes. The rationale is that FA pairs have no target-to-prime association, thus the potential contribution of retrospective semantic matching is minimized. As can be seen in Table 2, the results are very similar, though the confidence intervals for FA pairs are wider due to the smaller amount of items on which the calculations are based. Therefore, the observed consistency is likely due to some other process than semantic matching. This should not be taken to mean that semantic matching did not *occur* at all. Indeed, part of the priming effect for pairs with a backward target-to-prime association can conceivably be attributed to semantic matching.

Table 3 Reliability estimates for the item-level priming effects based on z-transformed response times as a function of stimulus onset asynchrony (SOA), associate type, and task

	SOA 200	SOA 1200
Lexical decision		
Primary	.30	.20
Other	.33	.17
Pronunciation		
Primary	.34	.18
Other	.35	.08

However, the cross-task *consistency* is presumably not merely caused by such a retrospective process.

Controlling for prime and target characteristics

Thus far, the assumption was that consistency in item-level priming effects across tasks signifies that the same underlying priming processes produce these effects. In other words, consistency was attributed to characteristics of the prime-target relation. However, it is possible that prime and/or target characteristics per se might cause the consistency. For instance, Hutchison and colleagues (2008) found that priming in both lexical decision and pronunciation was inversely related to the length of the related prime. They argued that easily identified primes can more readily exert their influence. Now, suppose that priming in pronunciation is initiated by process A and in lexical decision by process B, it is still very plausible that both processes depend on (the ease of) prime identification. A similar argument can be made for target characteristics. For example, the magnitude of priming is positively correlated with baseline RT to the target, which might suggest that difficult items in general benefit more from their related prime (Hutchison et al., 2008). Additional analyses were carried out to examine the possibility that the observed cross-task consistency is merely due to prime and/or target characteristics. In a first step, we regressed the item-level priming effects, based on the z-transformed RTs, on four prime and four target variables derived from Hutchison et al. (2008). This was done for each task × SOA × associate type combination separately. The regression analyses comprised the following word characteristics, both of the targets and the related primes: word length, log-transformed subtitle frequency (Brysbaert & New, 2009), baseline RT (derived from the English Lexicon Project, Balota et al., 2007; naming latencies were used for the analysis of the pronunciation data and lexical decision times for the lexical decision data), and number of orthographic neighbors. In a next step, the resulting residuals, obtained from the lexical decision analysis on the one hand and the pronunciation analysis on the

Table 4 Bayes factors for the correlations between item-level response times (RTs), z-transformed RTs (zRTs), and residual priming effects as a function of stimulus onset asynchrony (SOA) and associate type for all pairs and forward associate (FA) pairs

	RT		zRT		Residuals	
	SOA 200	SOA 1200	SOA 200	SOA 1200	SOA 200	SOA 1200
All pairs						
Primary	**28.20**	*29.47*	**>100**	**41.20**	**>100**	*1.83*
Other	**36.64**	*17.04*	**>100**	*10.33*	**>100**	*17.98*
FA pairs						
Primary	*4.56*	*27.43*	**>100**	*8.72*	**27.29**	*11.39*
Other	*4.07*	*15.39*	**>100**	*20.77*	**43.92**	*23.64*

Note: Values in bold indicate evidence in favor of the alternative hypothesis, values in italic indicate evidence in favor of the null hypothesis

other hand, were correlated. The rationale was that after taking into account prime and target characteristics, the residual effects truly reflect the underlying priming mechanisms. If these mechanisms play a role in both lexical decision and pronunciation, one would expect consistency in the residuals. The analyses clearly showed this was the case (see Table 2). The overall pattern looks very similar to that of the zRT priming effects, although the correlations seem to decrease slightly, suggesting that prime and/or target characteristics may also contribute to priming consistency across tasks.

Bayesian analysis

Finally, one could argue that we did not give the null hypothesis (i.e., the cross-task correlation equals zero) a fair chance. As noted in the introduction, the null hypothesis is theoretically interesting as it entails that priming effects in the lexical decision and pronunciation task are produced by different processes. However, the analyses conducted thus far did not allow us to actually provide support for this hypothesis. Therefore, Bayes Factors were calculated using Wetzels and Wagenmakers' (2012) method with the observed correlations as input. Assuming that both the null and the alternative hypothesis were equally likely a priori, one can state that the null (or alternative) hypothesis is X times more likely than the alternative (or null) hypothesis given the data. The results are shown in Table 4. In general, the alternative hypothesis is preferred when the SOA is short, whereas the null hypothesis is favored when the SOA is long.

Discussion

The aim of the present study was to examine whether priming effects in the lexical decision and the pronunciation task are produced by the same underlying processes. Concretely, it sought to critically evaluate the role of spreading activation in both tasks. To this end, we correlated item-level priming effects over tasks. The rationale is that if semantic priming in two different tasks is caused by the same underlying process(es), then the item-level priming effects must be correlated to a certain extent.

The results indeed showed significant correlations, both for primary and other associates. Additional analyses ruled out that the consistency was merely caused by certain prime and/or target characteristics (i.e., length, frequency, baseline RT, and number of orthographic neighbors). However, correlations at the short SOA were higher than their long SOA counterparts. The latter did not even reach significance when raw RTs were used instead of z-transformed RTs. Moreover, the obtained Bayes Factors in the long SOA condition suggested that the data were more likely under the null hypothesis (see the rightmost part of Table 4). In contrast, there was strong evidence for the alternative hypothesis when the SOA was short. Interestingly, when only forward associates with no backward association were considered, the pattern remained essentially the same. Given that a retrospective process like semantic matching is assumed to require a backward association to produce priming, these findings suggest that fast prospective process(es) such as spreading activation partly underlie priming in both lexical decision and pronunciation.[2] In this sense, the present findings extend those of De Wit and Kinoshita (2015), who emphasized the role of retrospective semantic matching in lexical decision based on RT distribution analyses.

A potential concern is the fact that the reliability of semantic priming is generally low (Stolz et al., 2005). This is relevant here because correlations between two measures can be severely attenuated if the reliability of either one of these measures is low. The reliability estimates for the present dataset were mostly in line with previous studies (Heyman, De Deyne, Hutchison, & Storms, 2015; Hutchison et al.,

[2] Note though that the correlational analysis supports spreading activation, but it remains agnostic as to whether this process is really automatic. That is to say, participants in the Semantic Priming Project were informed about the prime, hence it is unclear whether semantic activation and subsequent spreading activation is truly automatic.

2008). Interestingly, the estimates were higher when the SOA was short, which again supports the idea of a general, fast-acting process such as spreading activation. Still, the reliability estimates are undeniably low, even in the short SOA condition. In what follows, we will address two potential causes: inter- and intra-individual variability.

Interindividual variability in the extent to which two concepts are related could conceivably explain why item-level priming effects are not stable across participants. The strength of the connection between, say, *alto* and *soprano* might vary over individuals. Averaging across participants will thus introduce variability. Relatedly, there may be interindividual differences in the strategies participants use (Hutchison et al., 2014). Even though a short SOA should reduce the prevalence of strategies, merely reading versus ignoring the prime may already have an impact. Secondly, it is possible that item-level priming is not stable *within* participants. One could for instance assume that there is intra-individual variability in the degree of target pre-activation. To our knowledge, no study has looked at test-retest reliability of item-level priming, perhaps because it requires four observations of the same target (i.e., twice in the related and twice in the unrelated condition). Consequently, it is difficult to evaluate the potential role of intra-individual differences.

In conclusion, is the relatively low reliability problematic? First of all, the reliability of item-level priming effects is not by definition low. Doubling the number of participants would already yield reliability estimates around .50 for the short SOA conditions. Hence, this is not an intrinsic property of the semantic priming paradigm, but something to keep in mind when designing a study. Secondly, the fact that semantic priming has been found to be relatively low in terms of reliability might explain why the reported cross-task correlations are, in general, rather small. However, it does not explain the *pattern* of correlations. Taken together, we argue that item-level correlations meaningfully reflect the underlying process of semantic priming. Specifically, we found that (a) item-level priming effects showed consistency at the short SOA and (b) that a subset featuring only forward associates exhibited the same pattern, which was interpreted as evidence for a prospective mechanism such as spreading activation that is sensitive to item-based relational characteristics.

Acknowledgments We thank Melvin Yap for his helpful comments on earlier versions of this manuscript. Tom Heyman is a research assistant at the Research Foundation-Flanders (FWO-Vlaanderen).

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