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ARTICLE

A multi-analyses approach of inductive/deductive asymmetry in the affective priming paradigm

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Abstract
Rapidly evaluating our environment's beneficial and detrimental features is critical for our successful functioning. A classic paradigm used to investigate such fast and automatic evaluations is the affective priming (AP) paradigm, where participants classify valenced *target* stimuli (e.g., words) as good or bad while ignoring the valenced *primes* (e.g., words). We investigate the differential impact that verbs and adjectives used as primes and targets have on the AP paradigm. Based on earlier work on the Linguistic Category Model, we expect AP effect to be modulated by non-evaluative properties of the *word stimuli*, such as the linguistic category (e.g., if the prime is an adjective and the target is a verb versus the reverse). A reduction in the magnitude of the priming effect was predicted for adjective–verb prime-target pairs compared to verb–adjective prime-target pairs. Moreover, we implemented a modified crowdsourcing of statistical analyses implementing independently three different statistical approaches. Deriving our conclusions on the converging/diverging evidence provided by the different approaches, we show a clear deductive/inductive asymmetry in AP paradigm (exp. 1), that this asymmetry does not require a focus on the evaluative dimension to emerge (exp. 2) and that the semantic-based asymmetry weakly extends to valence (exp. 3).

KEYWORDS
affective priming, crowdsourcing analyses, deductive/inductive asymmetry, linguistic category model, multiverse analysis

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Detailed descriptions of each additional analysis, additional references, data sets, and related statistical decisions are available in the open repository: https://figshare.com/projects/Inductive_deductive_asymmetry_in_the_Affective_priming_paradigm_a_multi_statistical_approaches_test/87383.

INTRODUCTION

In our dynamic and complex environment, we need to process and evaluate quickly and efficiently the objects around us to assign positive and negative valence to them (Arnold, 1960; Lazarus, 1968; Scherer et al., 2001; Storbeck & Clore, 2007). Our evaluation or appraisal processes are carried out so widely, routinely, and automatically (Kissler et al., 2007) that irrelevant stimuli can trigger these processes outside of our awareness (e.g., Gaillard et al., 2006; Naccache et al., 2005). Notably, investigating rapid evaluative processes has been a core area of research in psychology (see: Fazio, 2001; Klauer & Musch, 2003).

A standard paradigm in this area is affective priming (AP), where the participants' task is to classify valenced *target* stimuli as positive or negative while ignoring the valenced *primes* that precede the targets. The typical results show a performance advantage in trials where prime and target have the same valence (i.e., '*congruent*' trials) relative to trials where prime and target are of opposite valence (i.e., '*incongruent*' trials). There are numerous theories attempting to explain these and related effects like *spreading activation models* (e.g., Bargh et al., 1992; Fazio et al., 1986) and *'conflict' models* (e.g., Bartholow et al., 2009; Wentura & Rothermund, 2003). Despite the considerable significance of these processes, the systematic and rigorous stimuli selection, and the work on moderating factors of the congruity effect (e.g., the role of 'integrativity' as shown by Ihmels et al., 2016), to date, we do not fully understand how such automatic evaluations relate to other non-evaluative properties of the stimuli (for a discussion on non-evaluative dimensions see also Ansorge et al., 2013). The case of *word stimuli* is of interest here as little attention has been given to the possible differential impact of linguistic categories (i.e., verbs vs. adjectives) used as primes and targets. Surprisingly, other areas of investigation in emotion word processing also seem to have neglected this aspect (see for a review Citron, 2012).

The primary aim of the present work is to fill this gap by investigating the differential impact that verbs and adjectives as prime and targets have in the AP paradigm and the resulting priming effect. The literature on the interplay between language and cognition provides the supporting framework for this investigation.

First, let us consider the approach to stimulus selection in AP literature. The careful stimulus selection has been generally based on valence and/or arousal as well as basic linguistic features such as the frequency in language and length of the word (for a review, see: Klauer & Musch, 2003). This approach derives from the fact that evaluative processes were the main focus of investigation, and valence congruency was the robust principle underlying the effect (e.g., Fazio, 2001). Moreover, the approach was driven by an implicit assumption that linguistic categories would not have a differential effect on AP and/or are of no theoretical relevance. This assumption is indirectly challenged by a large body of research on the Linguistic Category Model (LCM) that has demonstrated the different psychological implications of using adjectives versus verbs in domains such as attribution theory (e.g., Semin & Fiedler, 1988; 1991; Semin, 2011). Interestingly, this experimental work has relied on interpersonal terms in the form of verbs or adjectives as succinct descriptors (e.g., 'to help' vs. 'helpful') that are the same type of stimuli often used in AP studies as primes and targets.

Based on LCM, verbs (i.e., Susan '*helps*' the old lady) are generally more concrete and have been used to represent behavioural information. On the other hand, adjectives (e.g., Susan is '*helpful*') have the highest level of abstractness, and they are used to represent traits (cfr. Maass, Karasawa, et al., 2006). There is substantial literature derived from the LCM investigating the possible psychological consequences of different linguistic categories and providing explanations for known phenomena (e.g., actor–observer discrepancy, fundamental attribution error; see Semin & Fiedler, 1989; Semin, 2011) or for new ones (linguistic intergroup bias; e.g., Maass et al., 1989, 1995).

Rather than investigating the semantic meaning and their semantic associates, this literature is more concerned with 'meta-semantic features' of language and their systematic cognitive properties (cfr. Semin, 2011). It is worth noting that the properties by which the abstractness–concreteness dimension has been operationalized by the LCM and in subsequent research is generic to the entire predicate classes (i.e., adjectives or verbs). Semin (2011) suggested a new look at the language–cognition interface, suggesting that linguistic classes may differentially direct attention and, thus, guide cognitive processing.

In relation to the AP paradigm, this suggests that different linguistic categories may moderate cognitive processing during AP (for a review and discussion, see Semin, 2011). The current research aims to test this suggestion.

In the AP paradigm, the influence of the prime's implicit processing on the explicit processing and evaluation of the target is the central focus. If, however, different linguistic categories systematically guide cognitive processing, then the processing of the target and the resulting AP effect, namely its magnitude/presence, may be differentially influenced by the linguistic category of the stimuli used as prime and target in addition to their valence. We know that researchers consistently report priming effects using different types of primes and/or targets like nouns, adjectives, and combination of different types of words (for a review, see Klauer & Musch, 2003). However, to our knowledge, no study has systematically investigated whether the linguistic category of the stimuli moderates AP and how. Will the priming effect be present and of the same magnitude in the case of verbs versus adjectives as primes and targets? Moreover, even more interestingly, what if the prime is a verb and the target is an adjective or vice versa?

Concerning the latter question and in line with LCM and the subsequent literature, verbs are comparable to behavioural descriptors and adjectives are to trait descriptors. Given these functional differences between verbs and adjectives, using different linguistic categories for primes and targets invites significant questions. How does the valence of a behavioural descriptor as a prime affect the processing of the valence of a trait descriptor (i.e., verb-prime/adjective-target). How does the valence of a trait descriptor as a prime affect the processing of a behavioural descriptor (i.e., adjective-prime/verb-target)? In other words, these two combinations allow us to examine the influence of implicit processing as a function of the two linguistic categories (verbs and adjectives) upon the AP processing.

In the domain of person perception, these two combinations are called inductive inference (i.e., *inferring* from a specific to a general construct) and deductive inferences (i.e., *predicting* the specific from a general construct). Within the person perception domain, deductive/inductive distinction is particularly relevant as they are characterized by different inferential powers (Maass et al., 2001, 2005; Maass, Cadinu, et al., 2006; Maass, Karasawa, et al., 2006). Individuals make behaviour-to-trait (inductive) inferences spontaneously, without attention or awareness, and largely online. In contrast, individuals make less trait-to-behaviour (deductive) inference, and when they do, then they usually do so in a memory-based fashion (e.g., Uleman, 1987; for a discussion, see Maass, Cadinu, et al., 2006).

Despite the obvious differences between trait inferences and fast evaluative processing, there seems to be a general tendency to 'induction' in online cognitive processes, while deduction is based on memory and has a much less prominent tendency. Thus, it is plausible that in the processes captured by the AP, different linguistic categories might lead to different cognitive processes and systematically modulate the presence and/or magnitude of the resulting AP effect.

OVERVIEW OF THE RESEARCH

The present study will, *first*, test whether verbs versus adjectives as stimulus materials in the AP paradigm systematically affect the priming effect magnitude. We are particularly interested in the possible modulation when prime-target stimulus pairs are of different linguistic categories (i.e., adjective–verb, verb–adjective). Within the LCM framework and in line with the inductive-deductive asymmetry (IDA), we expect a modulation of the priming effect with a reduction of the priming magnitude in the case of adjective–verb prime-target pairs (exp. 1).

The *second* goal is to determine if any modulations of the priming effect are present also when there is no evaluation demand (implementing a word/no-word task instead of a positive/negative evaluation; exp. 2).

The *third* goal of the study is to investigate whether any modulation is due to the behaviour-trait[trait-behaviour] semantic link (e.g., 'Susan helps the old lady' – 'Susan is helpful') or it is a general tendency that also applies to a combination where no direct link (except valence) is present (e.g., 'Mary insulted the old lady' – 'Mary is lazy', both negative). While experiment 1 implements pairs that are semantically linked, experiment 3 will use stimuli that are not.

The *fourth* and final goal of the present study is methodological. Recently, Silberzahn et al. (2018) crowdsourced the statistical analyses of the same data set to 29 analysts who were asked to answer the same research question. Using this innovative approach, the authors demonstrated the effect of good faith, yet subjective, analytic choices on the results found by the 29 teams. The authors reported considerable variability in the estimation of effect sizes as a result of researchers' choices and assumptions, with approximately only two-thirds of the teams reporting significant results. Despite the clear benefits of such an approach in showing a much more accurate picture of the robustness of results and in improving the scientific endeavour, as these authors pointed out, crowdsourcing statistical analyses present some significant constraints: First, the flexibility in analytic choices is dependent on the complexity of the data set; second, finding over 20 different teams to analyse a given data set is practically difficult. For these reasons, but in the light of the benefits highlighted by the demonstration provided by Silberzahn et al. (2018), we trialled a more practical version of the crowdsourcing statistical analyses by implementing three different statistical analyses on the data sets to ground our conclusions on the convergence/divergence of the results across the different independently-applied approaches. An advantage of analysing the data through different statistical methods is that doing so allows one to spot *patterns* in the results, given that each method is sensitive to different data features. For example, although the ANOVA F-test is designed to be sensitive to differences among means, it is also sensitive to differences among the variances and differences in skewness. It is important to stress that performing more than one statistical analysis is in line with a multiverse analysis approach (Steegen et al., 2016; for the specific case of reaction times, see Moríz Fernández & Vadillo, 2020), namely, to perform suitable statistical analyses in combination with alternative data pre-processing decisions. This last goal has, therefore, a direct say on the first three goals.

METHOD

Given the methodological connection among the three experiments (i.e., exp. 2 builds on exp. 1 and exp. 3 builds on exp. 1 and 2), these are presented in blocks that describe their key features.

Participants

A total of 166 native-speaker Dutch undergraduate students participated in the three experiments (different participants in each experiment); 58% were female, and the grand mean age was 20.69 ± 2.97 SD (see Table 1). The sample size (50–65 participants) for the experiments was decided in advance based on design and similar experiments in the literature.

The ethical requirements of the VU Amsterdam (The Netherlands) were fulfilled for each of the experiments. Participants gave written, informed consent following the principles of the Declaration of Helsinki (WMA, 2013).

Priming tasks

The priming task was similarly constructed for all three experiments. The structure of the trials (see Figure 1) was as follows: First, a fixation point appeared on the screen for a randomly variable interval (between 250 and 2500 ms) that was replaced by the first word (prime), which remained on the screen for 200 ms. This, in turn was replaced by a blank screen (150 ms), and then the target word appeared on the screen and remained until the participant gave a response, which was followed by the next trial after an inter-trial interval of 1000 ms. Thus, stimulus onset asynchrony (SOA) in this paradigm was 350 ms. Participants received practice trials during which they also received feedback. The priming task consisted of multiple blocks of trials with a short break between blocks (see Figure 1). The pairs were randomly presented for each participant. The word stimuli sets were the same for primes and targets (i.e., the same

TABLE 1 Demographics of the participants in the three experiments.

Experiment	Gender (M_{age} ± SD) [range$_{age}$] Males	Females	Total	Age	Range
1	30 (20.90 ± 3.12) [18–30]	17 (21.65 ± 3.98) [18–34]	*47*	18–34	21.17 ± 3.43
2	26 (21.27 ± 3.63) [18–35]	33 (19.60 ± 1.97) [18–24]	*59*	18–35	20.34 ± 2.92
3	14 (21.21 ± 1.85) [19–25]	46 (20.5 ± 2.78) [18–31]	*60*	18–31	20.67 ± 2.60
Total (gender)	*70*	*96*			
Total			*166*		
Total age range				*18–35*	
Total M_{age} ± SD					*20.69 ± 2.97*

Italic values for aggregated numbers across the 3 experiments (e.g., total participant sample).

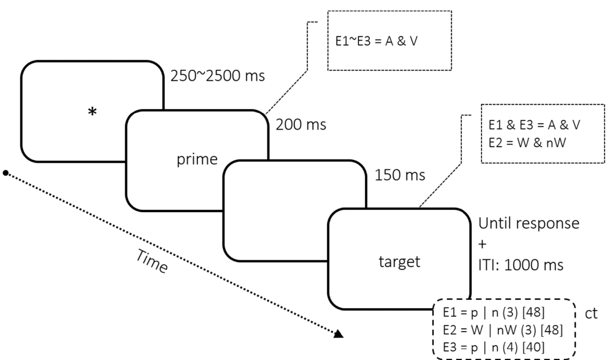

FIGURE 1 Illustration of the sequence of events in the experiments. E1-E3 = Experiment 1–3. *ITI* = inter-trial interval; *A & V* = valenced adjectives and verbs; *W & nW* = valenced words (adjectives and verbs) and non-words; E1 ~ E3 = experiments 1 to 3; *ct* = classification task (*p* | *n* = positive vs. negative, and *W* | *n* = word vs. non-word). The number of blocks in each experiment and the number of trials per block are shown in parentheses and brackets, respectively.

list of adjectives/verbs were used as prime and target), and each pair was generated randomly for each participant by picking one stimulus word as prime and one as the target. Thus, each word of the lists was presented as prime and as target with the only exception of no-words in experiment 2 that were used only as targets. No feedback was given during the experimental trials.

Stimuli

The stimuli used in each of the three experiments are shown in the Appendix 1.

Experiment 1

The experimental stimuli consisted of a set of 12 Dutch words (6 verbs and 6 adjectives) related to positive and negative expressions used as prime and target. Words were used in earlier research and had been selected and pretested for valence and other features (Foroni & Semin, 2009). These words were implemented to permit that the prime and target would be semantically related (in congruent trials) while avoiding the same word-stem.

Experiment 2

The stimulus set was as in experiment 1 with the addition of 12 non-words created to be adjective-like or verb-like. Half of the trials presented a word as target (used in the analyses) generated so that equal numbers of prime-target pair types (i.e., adjective-verbs and verb-adjectives) were presented. The other half of the trials with non-words targets were not analysed. Because of the inclusion of trials with non-word targets, we decided to focus only on two conditions to maintain the task of similar length: adjective-prime/verb-target, and verb-prime/adjective-target.

Experiment 3

The stimuli material was selected from a larger set of pairs of words formed by an adjective and a verb that share the same stem (e.g., 'helpful' and 'to help') selected from Fockenberg (2008). Congruent stimuli pairs were selected so that they had same valence but were not semantically linked to each other. A different sample of participants (n = 21) rated each one of the words on valence. The selected 80 words were analysed via ANOVA with the within participants factors of valence (positive vs. negative) and word category (adjective vs. verb). The results showed that positive words ($M = 7.54 \pm .57$) were rated more positive than negative ($M = 2.41 \pm .51$), F (1,20) = 577.52, $p < .001$ (no other effect was significant). The number of letters of the stimuli was subsumed to 2 (valence: positive vs. negative) x 2 (word category: adjective vs. verb) analysis of variance. Results showed that adjectives ($M = 9.6 \pm .2.1$) had, on average more letters than verbs ($M = 8.3 \pm 1.7$; $p < .01$), but no difference was found based on valence ($p = .91$) and no interaction between valence and linguistic category ($p = .73$).

Procedure

Upon arrival, participants were ushered to individual cubicles where the experiment was presented as a computer-administered concentration task in which they would be repeatedly exposed to a series of two words. Their task was to neither attend nor respond to the first word, but to indicate as quickly and accurately as possible if the second word was positive or negative (exp. 1 and 3) or a word/no-word (exp 2) using one of two keys (counterbalanced between participants). Congruent trials are trials where the prime and target have the same valence (i.e., positive–positive, negative–negative) while incongruent trials are trials where the prime and target are of opposite valence (i.e., positive–negative, negative–positive).

After the task, participants answered a series of questions regarding the task (manipulation check) and their demographics. At the end of the task, participants were thanked and debriefed.

Statistical analyses

Three different statistical analyses were performed on the data from each experiment: (i) repeated measure-ANOVA (*RM-ANOVA*), (ii) robust statistics (*RS*), and (iii) generalized additive models of location scale and shape (*GAMLSS*). In all analyses, only correct trials were analysed. In both the RM-ANOVA and GAMLSS analyses, only RT responses that were 300 ms < RTs < 2000 ms were retained for analyses. RM-ANOVA was applied to mean RTs per participant per condition, a method based on 20% trimmed means was used in the robust statistical analyses, and un-aggregated RTs were used in the GAMLSS modelling. Accessible introductions to RS and GAMLSS can be found in Mair and Wilcox (2020) and

Stasinopoulos et al. (2018), respectively. Detailed descriptions of each additional analysis, additional references, data sets, and related statistical decisions are available in the open repository: https://figshare.com/projects/Inductive_deductive_asymmetry_in_the_Affective_priming_paradigm_a_multi_statistical_approaches_test/87383.

RESULTS

Here we report in detail the results of the RM-ANOVA on the RT data and provide the overall results of the other two methods.

Experiment 1

Five participants were excluded because their performance was poor, with an error percentage higher than 25%, leaving a final sample of $N = 43$. Trials with incorrect responses (7.2%) or with response times (RTs) below 300 ms (0.3%) or above 2000 ms (0.6%) were excluded from the analyses (total excluded trials: 7.8%). Average RTs constituted the dependent variable. The design was a 2 (*Prime-Target valence congruency*: congruent vs. incongruent) × 2 (*Prime category*: adjective vs. verb) × 2 (*Target category*: adjective vs. verb) with all factors manipulated within subjects. *Prime category* and *Target category* variables produce 4 different Prime/Target pair types (see Figure 2: i.e., adjective-adjective [a_a]: adjective prime and adjective target; adjective-verb [a_v]: adjective prime and verb target; verb adjective [v_a]: verb prime; and adjective target; verb-verb [v_v]: verb prime and verb target).

As shown by Figure 2 (top panel), the predicted three-way interaction between *Prime-target valence congruency*, *Prime category*, and *Target category* was significant, $F(1,42) = 5.53$; $p = .023$, $\eta^2_p = .12$, as was the *Prime-target valence congruency*, $F(1,42) = 13.59$, $p = .001$, $\eta^2_p = .24$. In addition, *Target category* was also significant, $F(1,42) = 5.74$, $p = .021$, $\eta^2_p = .12$, as was the interaction between *Prime category* and *Target category*, $F(1,42) = 17.02$, $p < .001$, $\eta^2_p = .29$. No other effect reached significance (ps > .14).

Accuracy analysis (see repository) did not show any evidence of speed-accuracy trade-off, and neither was there a significant three-way interaction.

An analysis of the simple means for each prime/target pair type (i.e., adjective–adjective, verb–verb, verb–adjective, and adjective–verb) revealed, as expected, that the classic congruence effect was present and significant only in the case of three of the four combinations: adjective–adjective ($t(42) = 3.83$, $p < .001$; Cohen's $d = 1.18$), verb–verb ($t(42) = 2.98$, $p = .005$; Cohen's $d = 0.92$), and verb–adjective ($t(42) = 2.10$, $p = .042$; Cohen's $d = 0.65$) combination. When adjectives were primes, and verbs were targets (i.e., adjective–verb combination), no AP was present, $t(42) < 1$, ns.

Experiment 2

Four participants were removed from the analyses because they had very poor performance in the classification task (more than 40% errors), leaving a final sample of $N = 52$. Only trials with a word as a target were considered. Trials with incorrect responses (6.2%), or with RTs that were below 300 ms (0.9%) or above 2001 ms (0.8%) were excluded from the analyses (total excluded trials: 7.6%). Average RTs constituted the main dependent variable. The design was a 2 (*Prime-Target valence congruency*: congruent vs. incongruent) × 2 (*Prime/Target pair type*: adjective–verb vs. verb–adjective) with both factors manipulated within subjects.

As shown by Figure 2 (mid panel), the predicted two-way interaction between *Prime-Target valence congruency* and *Prime-Target pair type* was significant, ($F(1,51) = 6.34$; $p = .015$, $\eta^2_p = .11$) while the *Prime-Target valence congruency* in this case was only marginally significant, $F(1,51) = 3.04$, $p = .087$, $\eta^2_p = .06$. An analysis of the simple means for each of the two Prime/Target pair types (i.e., verb–adjective and adjective–verb) revealed, as expected, that the classic congruence effect was present only for the verb–adjective pair type ($t(51) = 3.07$, $p = .003$; Cohen's $d = 0.86$) combination. On the contrary, again, when adjectives were prime, and verbs were targets (i.e., adjective–verb combination), no AP was present, $t(51) < 1$, ns.

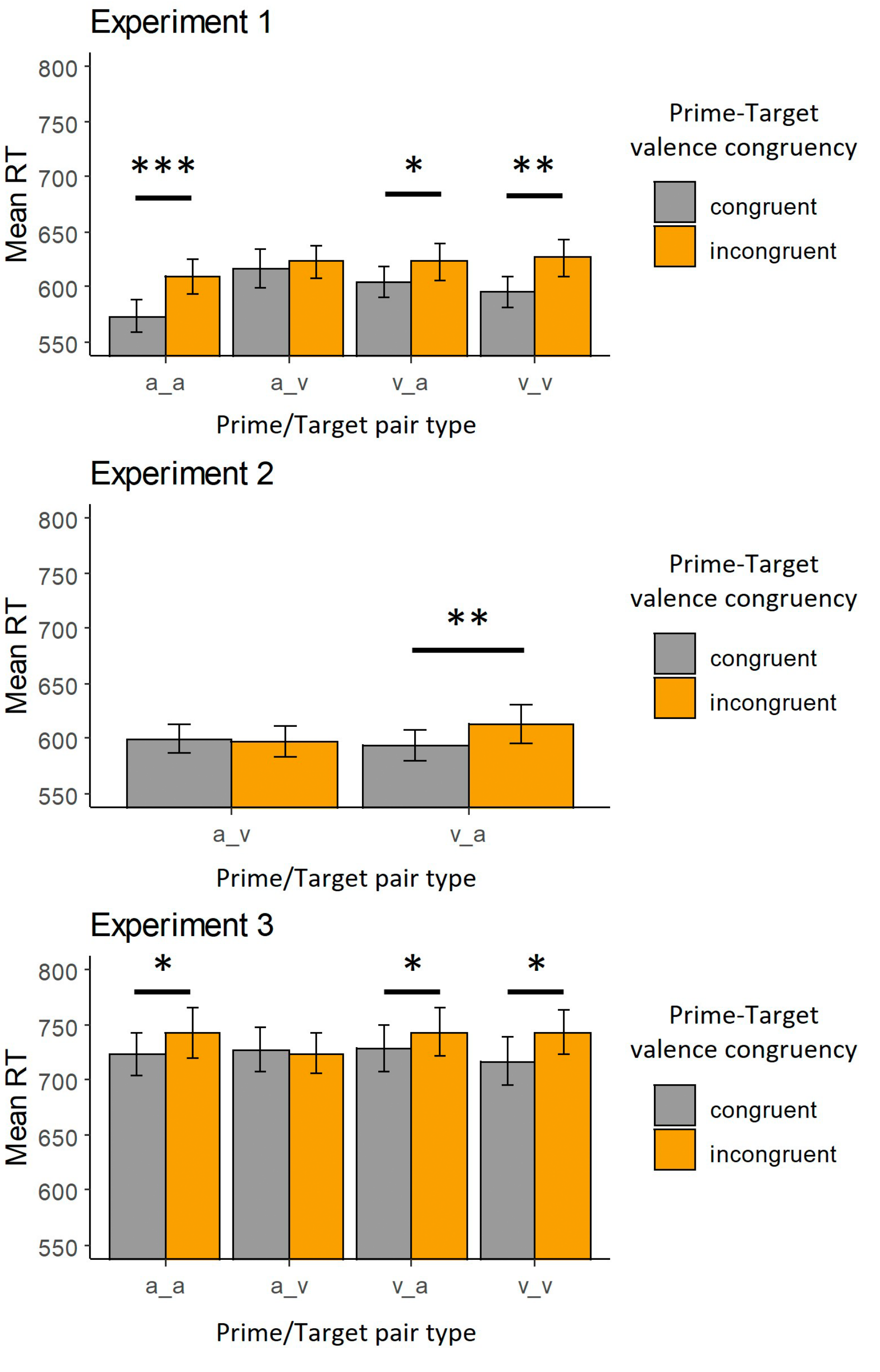

FIGURE 2 Mean RTs (ms) and SE of mean (error bars) as a function of experiment based on RM-ANOVA approach. *Experiment 1 design*: *Prime-Target valence congruency* (congruent vs. incongruent), *Prime category* (adjective vs. verb), and *Target category* (adjective vs. verb). *Experiment 2 design*: *Prime-Target valence congruency* (congruent vs. incongruent) and *Prime/Target pair type* (adjective-verb vs. verb-adjective). *Experiment 3 design*: *Prime-Target valence congruency* (congruent vs. incongruent), *Prime category* (adjective vs. verb), and *Target category* (adjective vs. verb). Prime/Target pair types across experiments: a_a = adjective prime and adjective target; a_v = adjective prime and verb target; v_a = verb prime and adjective target; v_v = verb prime and verb target. Significant Affective Priming effects are indicated by: * = $p < .05$; ** = $p < .01$; *** = $p < .001$.

Accuracy analysis (see repository) did not show any evidence of speed-accuracy trade-off nor was there a significant two-way interaction.

Experiment 3

One participant was excluded because their performance was poor, with an error percentage higher than 25%, leaving a final sample of $N = 59$. Trials with incorrect responses (7.0%) or with RTs below 300 ms (0.2%) or above 2000 ms (1.5%) were excluded from the analyses (total excluded trials: 8.5%). Average RTs constituted the dependent variable. The design was a 2 (*Prime-target valence congruency*: congruent vs. incongruent) × 2 (*Prime category*: adjective vs. verb) × 2 (*Target category*: adjective vs. verb) with all factors manipulated within subjects. As in Experiment 1, *Prime category* and *Target category* variables produce 4 different Prime/Target pair types (see Figure 2).

As shown by Figure 2 (bottom panel), the predicted three-way interaction between *Prime-target valence congruency*, *Prime category*, and *Target category* was significant, ($F(1,58) = 4.00$; $p = .05$, $\eta^2_p = .06$), as was the *Prime-target valence congruency*, $F(1,58) = 11.83$, $p = .001$, $\eta^2_p = .17$. In this case *Target category* was only marginally significant ($F(1,58) = 2.11$, $p = .15$, $\eta^2_p = .04$). No other effects were significant ($ps > .21$).

An analysis of the simple means for each of the Prime/Target pair type (i.e., adjective–adjective, verb–verb, verb–adjective, and adjective–verb) revealed, as expected, that the congruence effect was significant only for the same three combinations (as experiment 1): adjective–adjective ($t(58) = 2.22$, $p = .030$; Cohen's $d = 0.53$), verb–verb ($t(58) = 2.52$, $p = .014$; Cohen's $d = 0.66$) and verb–adjective ($t(58) = 2.20$, $p = .032$; Cohen's $d = 0.58$) combination. When adjectives were prime and verbs were targets (i.e., adjective–verb combination) no AP was present, $t(58) < 1$, ns.

Accuracy analysis (see repository) do not show any evidence of speed-accuracy trade-off and neither there was a significant three-way interaction.

Table 2 provides a summary of the results for the three experiments across the three statistical approaches.

TABLE 2 Snapshot of the pattern of results found across three analytical approaches

		Effects								
Experiment and design	**Analytical approaches**	**A**	**B**	**C**	**D**	**C•D**	**A•B**	**A•C**	**B•C**	**A•B•C**
1 A•B•C	*RM-ANOVA*		O	O			O			O
	RS		O	O			O			O
	GAMLSS	O	O	O			O	O	O	O
2 C•D	*RM-ANOVA*					O				
	RS					O				
	GAMLSS									
3 A•B•C	*RM-ANOVA*			O						O
	RS			O						
	GAMLSS			O						

Note: Grey-shaded boxes indicate the effects included in the design for each experiment. Dark grey-shaded boxes indicate key predicted effects. The symbol 'O' indicates the main effect and/or interaction was significant at $\alpha < .05$ (non-significant results are left blank). RM-ANOVA = traditional approach via aggregated means submitted to repeated measured ANOVAs; RS = robust statistical approach; GAMLSS = distributional modelling via GAMLSS. A = *Prime category*; B = *Target category*; C = *Prime-Target valence congruency*; D = *Prime/Target pair type*. A•B•C = a model with three main effects, three two-way interactions, and one three-way interaction. C•D = a model with two main effects and one two-way interaction.
• = interactions.

DISCUSSION AND CONCLUSIONS

Experiment 1 implemented a standard AP paradigm to test whether valenced stimuli pairs of different linguistic categories (i.e., verbs vs. adjectives) will produce a modulation of the priming effect. We used pairs made of a prime and a target that were semantically related but did not share the same word-stem (e.g., 'to smile', 'funny'). The three statistical approaches converged in experiment 1, showing among other lower-level significant effects, the expected significant three-way interaction. Indeed, the priming effect was modulated by the linguistic category of the prime and target, suggesting that linguistic classes may guide differently the cognitive processing involved in the priming task (cfr. Semin, 2011).

When looking within each combination of adjectives and verbs, a significant priming effect was present in the prime-target combinations adjective–adjective, verb–verb, and verb–adjective but not when adjectives were primes and verbs were targets. Notably, the largest priming effects are present in the adjective–adjective and verb–verb prime-target combinations. We are particularly interested in the fact that verb–adjective combination produced a priming effect while adjective–verb did not as this asymmetry could be parallel to IDA, reported extensively in person perception (e.g., Maass et al., 2001; Uleman, 1987). Experiment 2 replicates these two combinations and their comparison in a word/no-word task. Two of the three statistical approaches converged in showing the expected significant two-way interaction in experiment 2, showing that evaluative categorization was not a necessary condition for the difference to emerge. Notably, in these experiments, the participants are not required to 'remember' behaviours [trait] of a person that they have been presented with, rather they evaluate a target word (exp. 1), or they determine whether the target is a word/no-word (exp. 2). Nevertheless, the results show that the valence of a behavioural descriptor (i.e., verb as prime) affects the valence processing of a trait descriptor (i.e., adjective as target) but not vice versa.

In the literature on person perception, inductive inferences occur spontaneously, without attention or awareness, and appear to be done online during the encoding stage, whereas deductive inferences tend to occur in a memory–based fashion (Maass, Cadinu, et al., 2006). Different methods have been used to measure inferences in person perception ranging from the original cued-recall paradigm (Uleman, 1987; Uleman & Moskowitz, 1994; Winter & Uleman, 1984), to other procedures based on trace activation (e.g., Bassili, 1989; Uleman et al., 1996; Van Overwalle et al., 1999), and task developed to measure learning advantages (e.g., Carlston & Skowronski, 1994) but mostly focusing on memory and recognition. The present results go beyond that by implementing a priming paradigm. They provide further support for the notion of IDA by providing evidence for IDA here and by showing that it does not require the focus on evaluation to emerge (even though in this latter context, the effect is possibly weaker). Together, these results suggest that the linguistic category of prime and target may impact the priming effect with adjective–verb combinations showing no priming.

The stimuli used in experiments 1 and 2 were carefully piloted and selected so that the valence of adjectives did not differ from valence of verbs (see Foroni & Semin, 2009). Thus, if one puts aside the IDA account of the present results, it remains to be explained why no priming effect was found when adjectives were primes and verbs were targets. Understandably, differences at the stimulus level across categories (e.g., arousal) could be present but like other domains (see Citron, 2012) also, AP literature has been scarce on the possible effect of non-evaluative properties of the stimuli (see Ansorge et al., 2013). However, some features specific to the Dutch language were not controlled in the selection of the stimuli for experiments 1 and 2, and one may wonder whether they may have determined the current results. One example could be the conditional probability (or grammaticality) differences between adjective–verb and verb–adjective order or even the frequency of co-appearance of two words of certain pairs (one adjective and one verb of the list) in the language. We would like to argue that the frequency of co-appearance of pairs of words cannot explain why the pairs of verb–adjectives and adjectives–verbs show different patterns in this priming task as the pairs are made by the same pair of words (one adjective and one verb) just reversed in the order. On the other hand, if conditional probability indeed would impact AP, this would still be indirect support of the contention that linguistic classes differently affect the processing involved in the priming task. Nevertheless, while such features may account for some specific differences in the speed of processing of the different targets (e.g., the difference in conditional probability inducing difference in speed of processing; Moers et al., 2017), they cannot account for the results here. Here, stimuli are presented both as prime, and target, and the results on the AP effect reflect the difference in performance between congruent and incongruent trials; notably, the language category of prime and target are maintained constant in congruent and incongruent trials (e.g., A_V congruent vs. A_V incongruent trials) and the only difference is congruency of valence between prime and target.

In the present context, we are not arguing what the mechanism underlying the priming effect in general is, but any attempt to provide a valuable account (e.g., Bargh et al., 1992; Bartholow et al., 2009; De Houwer & Hermans, 1994; Fazio et al., 1986; Klauer et al., 2005; Wentura & Rothermund, 2003) will need to consider and account for the asymmetry reported here. AP effects have been reported with varying lengths of the SOAs (for a review Klauer & Musch, 2003). According to the SOAs, target processing may, in fact, benefit (/suffer) to different degrees by the processing of the prime. The current SOA is generally considered the upper limit of automatic processing as longer SOAs may allow more substantive processing of the prime and allow extraneous factors to contribute to the priming effect. Thus, future research should investigate whether different SOAs could lead to a difference in the presence of the asymmetry reported here. Moreover, considering that in the priming literature, working memory load has also been implemented to investigate whether priming effects require cognitive resources or are relatively effortless at different SOAs (e.g., Heyman et al., 2015), future research could also consider this avenue to determine if this asymmetry also reflects different is cognitive requirements.

Maass, Cadinu, et al. (2006) discussed the nature of the asymmetry and tested the hypothesis that the IDA is specifically a social–perception phenomenon (i.e., when information is embedded in a social context). They defined ‘social context’ as a situation where the information is attributed to a person. The asymmetry emerged indeed when information was attributed to a person but not when attributed to a natural non-human entity (i.e., the wind) or simply part of a list of words (see also Todorov & Uleman, 2002). Maass, Cadinu, et al. (2006) concluded that IDA is a social–perception phenomenon. Our experiments 1 and 2 do not qualify as a social context (cfr. Maass, Cadinu, et al., 2006) as information was not attributed to any individual. Participants need to process targets without further instruction of encoding, remembering, using the information or reference to anyone (i.e., comparable to the word list condition used in experiment 4 by Maass, Cadinu, et al., 2006).

Nevertheless, we see an asymmetry emerging. One possible explanation for this is possibly in the nature of the behaviours/traits used here (e.g., 'to smile', 'funny', etc.). These are typical of humans. Thus, one possibility is that in specific cases it is not necessary to provide a social context as certain information is integral to the word meaning and use. To address this possibility, a careful selection of human-related stimuli versus non-human stimuli could be a solution. However, despite being an interesting thought experiment, such a solution may not be easily achievable as these two types of stimuli may vary on other dimensions.

In experiments 1 and 2, the prime and target were evaluatively and semantically related (e.g., ‘to smile’ and ‘funny’ are semantically related and are both positive in valence) aside from the controlled linguistic categories (i.e., verb–adjective). Consequently, the semantic and evaluative relations between them were confounded. A possible additional limitation is that in the first two experiments, we relied on limited number of stimuli within each category. However, the stimuli in experiments 1 and 2 required to fulfil several criteria that limit the number of stimuli available: (i) prime and target that are semantically linked (in congruent trials) while avoiding the same word-stem; (ii) concepts are represented in the stimulus set with both the verb and the adjective form; (iii) a comparable number of letters across valence and word type; and (iv) stimuli differ significantly only on valence. The stimuli used fulfil all the requirements, were piloted in Dutch with a sample of participants from the same student population and were successfully used in previous research (Foroni & Semin, 2009). Experiment 3 addresses the possible limitation of experiment 1: first, it eliminated the semantic relation; then, the stimuli set included a larger set of stimuli.[1]

[1]One may wonder whether addressing these two issues at once may unintendedly create a confound limiting our ability to attribute the reported effect to the larger set of stimuli or to the lack of semantic relationship (we thank an anonymous Reviewer for pointing out this possibility).

Here verb/adjective with the same word-stem were used, but primes and targets of different word-stem were paired randomly. This situation tested whether the asymmetry in the AP effect could emerge even without a semantic link between prime and target across a larger and different set of stimuli. Notably, IDA has been linked to the general tendency toward abstraction in social information processing and interpersonal communication (Hastie & Kumar, 1979; Semin & Fiedler, 1988; Semin & Smith, 1999) paralleled by a similar argument in cognitive psychology (e.g., see also Posner & Keele, 1968, 1970; Strange et al., 1970). However, experiment 3 does not provide clear support for this. Only one of the three approaches returned a significant three-way interaction suggesting that the IDA under these circumstances is not present or at the very best is not strong. Interestingly, consistency of proof across the three methods appears to be associated with effect sizes of the RM-ANOVA method (see Table 2[2]). Future research should further investigate this possible association. The convergence of evidence of the presence of IDA in the AP paradigm presented here (i.e., stronger evidence in experiments 1 and 2 and weaker evidence in experiment 3) is in line with the interpretation that pairs of verbs/adjectives need to be semantically related to produce IDA within the AP paradigm. In the literature on spontaneous trait inference a trait is inferred from a semantically related behaviour (i.e., that could be considered diagnostic of the trait).

The IDA phenomenon has been linked to associative network models based on the principle of spreading activation (e.g., Van Overwalle & Labiouse, 2004) and the memory distortion reported by Maass et al. (2001) seems to be in line with both semantic network models (e.g., Carlston & Skowronski, 1986; Srull & Wyer, 1989) and connectionist models (e.g., Kashima & Kerekes, 1994; Van Overwalle & Labiouse, 2004). Our results support this notion, and over three experiments, we have provided converging evidence for the differential effect that linguistic categories may have in a target processing during an AP task.

We tested our hypotheses using a modified, more modest and practical, version of Silberzahn et al.'s (2018) crowdsourcing by independently applying three different statistical approaches in line with a multiverse analysis approach (Steegen et al., 2016; for the specific case of reaction times see Moríz Fernández & Vadillo, 2020). Different statistical tests are sensitive to different aspects of the data (see Marmolejo-Ramos & González-Burgos, 2013). Concerning the response variable, methods based on a 20% trimmed means are better able to isolate how distributions differ in the sense that they are much less sensitive to other differences among the distributions (e.g., for skewed distributions, comparing means is not the same as comparing 20% trimmed means; see Wilcox, 2017a, 2017b). Classic inferential methods perform well when comparing identical distributions, and they might continue to perform well when distributions differ. However, skewed distributions and/or heavy-tailed distributions (often characteristic of reaction time data) could cause classic methods to yield misleading results (see Wilcox, 2017a, 2017b). This is why it is key to assess the *robustness* of any finding by submitting it to several statistical tests sensitive to different aspects of the data (see Nosek et al., 2021).

The current approach follows Silberzahn et al.' (2018) crowdsourcing of statistical analyses by combining different statistical approaches to test the same hypotheses (for a discussion, see Silberzahn et al., 2018). The results of our attempt are particularly promising as important conclusions were reached with the confidence of the convergence of different approaches (i.e., exp. 1 and 2). Furthermore, the lack of convergence, when it occurred (i.e., exp. 3), was nevertheless very informative. The fact that certain main effects and/or interactions 'survive' different tests that assess them differently, speaks in favour of the *robustness* of the effect. Thus, the modified version of the crowd sourcing analysis resulted in a more accurate picture of the results and their robustness while maintaining a manageable complexity that could possibly be easily implemented in future research.

AUTHOR CONTRIBUTIONS

Francesco Foroni: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; supervision; writing – original draft; writing – review and editing. **Fernando**

[2]We thank an anonymous Reviewer for pointing out this point.

Marmolejo-Ramos: Data curation; formal analysis; visualization; writing – review and editing. **Rand Wilcox:** Data curation; formal analysis; writing – review and editing. **Fernanda de Bastiani:** Data curation; formal analysis; writing – review and editing. **Gün R. Semin:** Conceptualization; methodology; resources; writing – review and editing.

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CONFLICT OF INTEREST

All authors declare no conflict of interest.

OPEN RESEARCH BADGES

This article has earned Open Data and Open Materials badges. Data and materials are available at [https://figshare.com/projects/Inductive_deductive_asymmetry_in_the_Affective_priming_paradigm_a_multi_statistical_approaches_test/87383].

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in figshare at https://figshare.com/projects/Inductive_deductive_asymmetry_in_the_Affective_priming_paradigm_a_multi_statistical_approaches_test/87383.

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APPENDIX 1

STIMULUS MATERIAL

Stimuli were presented in Dutch (in parenthesis). The English translation is shown, and it may not fully correspond to the original meaning. In Dutch, the infinitive form of verbs is clearly distinct from other forms.

Experiments 1 and 2

Positive adjectives: comical (komisch), funny (grappig), entertaining (lollig).

Positive Verbs: to smile (glimlachen), to laugh (lachen), to grin (grinniken).

Negative Adjectives: irritating (irritant), frustrating (frustrerend), annoying (vervelend).

Negative Verbs: to frown (fronsen), to cry (huilen), to squeal (janken).

**Adjective-like non-word*: Warstig, zunisch, stierp, niberend, flotarerend, spondisch.

**Verb-like non-word*: koepfeppen, zalden, plograten, trimpen, peiken, reunen.

* Non-words were used only in experiment 2, where the classification task was word/no-word.

Experiment 3

Positive adjectives: active (actief), amusing (amusant), appreciating (waarderend), caring (zorgzaam), charming (charmant), comforting (troostend), constructive (constructief), creative (creatief), encouraging (aansporend), forgiving (vergevingsgezind), healing (genezend), helpful (behulpzaam), helpful (hulpvaardig), interested (geïnteresseerd), jubilant (juichend), loving (liefdevol), reconciliating (verzoenend), thankful (dankbaar), thankful (erkentelijk), understanding (begrijpend).

Positive Verbs: to activate (activeren), to amuse (amuseren), to appreciate (waarderen), to assist (helpen), to care (zorgen), to charm (charmeren), to comfort (troosten), to construct (construeren), to create (creëren), to encourage (aansporen), to forgive (vergeven), to heal (genezen), to help (helpen), to interest (interesseren), to jubilate (juichen), to love (liefhebben), to reconcile (verzoenen), to thank (danken), to thank (erkennen), to understand (begrijpen).

Negative Adjectives: alienating (vervreemdend), annoying (storend), annoying (vervelend), belittling (kleinerend), bragging (brallerig), coercing (dwingend), deceiving (misleidend), desperate (wanhopig), discriminating (discriminerend), distrusting (wantrouwig), dying (stervend), frustrating (frustrerend), full of lies (leugenachtig), insulting (beledigend), irritant (irritant), nagging (zeurderig), rejecting (afwijzend), repelling (afstotelijk), sinful (zondig), threatening (bedreigend).

Negative Verbs: to alienate (zondigen), to annoy (sterven), to annoy (wantrouwen), to belittle (dwingen), to brag (brallen), to coerce (frustreren), to deceive (wanhopen), to despair (storen), to die (kleineren), to discriminate (misleiden), to distrust (vervreemden), to frustrate (afwijzen), to insult (discrimineren), to irritate (beledigen), to lie (afstoten), to nag (bedreigen), to reject (irriteren), to repel (zeuren), to sin (vervelen), to threaten (liegen).