On the adaptive flexibility of evaluative priming

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Abstract If priming effects serve an adaptive function, they have to be both robust and flexible. In four experiments, we demonstrated regular evaluative-priming effects for relatively long stimulus-onset asynchronies, which can, however, be eliminated or reversed strategically. When participants responded to both primes and targets, rather than only to targets, the standard congruity effect disappeared. In Experiments 1a–1c, this result was regularly obtained, independently of the prime response (valence or gender classification) and the response mode (pronunciation or keystroke). In Experiment 2, we showed that once the default congruity effect was eliminated, strategic-priming effects reflected the statistical contingency between prime valence and target valence. Positive contingencies produced congruity, whereas negative contingencies produced equally strong incongruity effects. Altogether, these findings are consistent with an adaptive-cognitive perspective, which highlights the role of flexible strategic processes in working memory as opposed to fixed structures in semantic long-term memory or in the sensorimotor system.

Keywords Affective priming · Congruity effect · Cue utilization · Congruity-proportion effect · Strategic influence

For priming effects to serve their adaptive function—to prepare behavioral responses to the environment, to signal danger, security, or attraction—their behavioral effects have to be robust and reliable. Yet, they must also be flexible and malleable. Absolute automaticity that is not amenable to strategic control would be dysfunctional. To be functional

in a complex and ever-changing world, a prime's influence on behavior has to be quick and robust by default, but flexible and context sensitive when required.

However, neobehaviorist accounts of many behavioral phenomena often neglect the flexible control of priming processes, which are instead conceived as automatic and stimulus determined. The mere presentation of a prime is often supposed to explain such significant behaviors as aggression (Todorov & Bargh, 2002), cooperation (Smeesters, Warlop, van Avermaet, Corneille, & Yzerbyt 2003), creativity (Friedman, Fishbach, Förster, & Werth 2003), phobic reactions (Amir, Foa, & Coles 2000), goal pursuit (Fishbach, Dhar, & Zhang 2006), or mood-congruent judgments (Hunt & Forand, 2005).

Robust flexibility of evaluative priming

This deterministic assumption is particularly prominent in evaluative priming (EP),¹ which is the focus of the present research. The common congruity effect in EP (Draine & Greenwald, 1998; Fazio, Jackson, Dunton, & Williams 1995; Hermans, De Houwer, & Eelen 1994; Klauer & Musch, 2003; Musch, 1999) refers to the facilitation of evaluative responses to targets preceded by valence-congruent primes. Positive primes are supposed to facilitate positive target evaluations, whereas negative primes should facilitate negative target evaluations. EP is commonly deemed to be so robust and automatic that positive or negative attitudes toward the prime can be diagnosed from

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¹ We refer to “evaluative priming” rather than to the more common notion of “affective priming,” because the latter term allows for multiple dimensions of affective meaning, whereas the experimental variable in this paradigm is always the evaluative dimension that discriminates positive and negative evaluation of stimuli.

fast (or accurate) reactions to positive or negative targets, respectively (Fazio, 2001; Fazio et al., 1995; Wittenbrink & Schwarz, 2007). For example, a negative attitude, or prejudice, toward Black people is inferred when a Black face as a prime induces faster subsequent responses to negative than to positive target stimuli.

The present research, in contrast, highlights both the generality and the strategic flexibility of EP. On one hand, we establish regular EP effects even for relatively long stimulus-onset asynchronies (SOAs) of more than 1,000 ms. Several failures to obtain EP effects with longer SOAs (Castner, Chenery, Copland, Coyne, Sinclair, & Silburn 2007; Gawronski, Deutsch, & Seidel 2005; Hermans, De Houwer, & Eelen 2001; Hermans, Spruyt, & Eelen 2003; Klauer, Rossmagel, & Musch 1997; Payne, Cheng, Govorud, & Stewart 2005) led to the belief that EP is restricted to a very short time window. Although this restriction is incompatible with the automaticity view and with EP accounts of behavioral phenomena covering a longer time window, such as aggression or attitudinal reactions, this belief is shared by many researchers. The underlying assumption is that conscious correction processes undo recognizable priming influences. One initial purpose of the present research is to refute this belief and to establish regular EP effects for longer SOAs, which facilitate the study of flexible strategic influences.² We thus demonstrate that EP is actually more robust and less restricted than expected (for further evidence, see also Aguado, Garcia-Gutierrez, Castañeda, & Saugar 2007; Averó & Calvo, 2006; Carroll & Young, 2005; Hayashi, 2007; Hietanen & Korpela, 2004; Korpela, Klemettilä, & Hietanen 2002).

On the other hand, however, our major goal is to point out strategic influences that can moderate and even reverse EP effects. We are particularly concerned with two fundamental ways in which people strategically regulate priming processes. It must be possible, first, to actively suspend or eliminate a seemingly predetermined priming effect and, secondly, to modify behavioral responses to primes according to the demands of changing environments. Without the former possibility, suspending a priming effect, organisms would be paralyzed in a flood of mutually interfering primes in complex environments. Getting rid of old and obsolete primes is at least as important as being responsive to new and relevant primes. Regarding the latter

possibility, an organism must be able to learn that the prime's predictive function can change. When primes predict incongruent rather than congruent targets (e.g., in deception situations), it must be possible to reverse the congruity effect.

Strategic influences on evaluative priming

Eliminating EP Eliminating old and irrelevant primes can be as important as being sensitive to new primes (Fiedler, 2003; Sparrow & Wegner, 2006). An aversive prime that signals danger will exert its adaptive function most effectively when previous appetitive primes are ignored. For a positive prime to exert its optimal EP impact on trial k , previous negative primes (or targets) from trials $k-1$, $k-2$, and so on, should be eliminated. This process calls for active inhibition (Ratcliff & McKoon, 1996), beyond passive decay.

Previous findings show that priming effects can be eliminated deliberately, through implementation intentions (Gollwitzer, 1999) or explicit instructions (Degner, 2009). In the present research, we are concerned with another kind of active intervention that will hardly ever reveal its goal or outcome—namely, actively responding to the prime. This task feature has been found to eliminate or suspend priming effects in various paradigms (Fiedler & Schenck, 2001; Fiedler, Schenck, Watling, & Menges 2005; Huber, Shiffrin, Lyle, & Ruys 2001; Maringer & Stapel, 2007; Marsh, Hicks, & Bink 1998; Martin, 1986; Sparrow & Wegner, 2006). Thus, verbal priming effects on subsequent person judgments disappear when judges react to the primes, as if they were operating a "reset" key (Lieberman, Förster, & Higgins 2007; Martin, 1986). Or, the facilitative influence of pictures or film clips on the identification of related traits is reduced when participants verify the meaning of pictorial primes (Fiedler & Schenck, 2001; Fiedler et al., 2005). No prior research, however, has ever tested this phenomenon in the EP paradigm.

Why should reacting to primes eliminate their influence? Prime elimination could actually be derived theoretically as a variant of a Zeigarnik (1927) effect. Analogous to this seminal idea, categorizing an evaluative prime as positive or negative signals that the mental job elicited by the prime is complete and gives way to a separate mental job related to the evaluation of a target. An extra prime judgment may thus segment the stream of stimulus events into separate mental episodes, closing the prime episode before the target episode. Let us refer to this Zeigarnik-like account as the "segmentation hypothesis." This idea is not meant to imply that segmentation is unique in functionally separating the prime from the target. It can be understood as a special variant of a larger class of factors (such as prime salience or

² We neither assume that strategic influences are confined to overly slow processes, nor do we restrict the term to intentional influences of which an individual is consciously aware. We rather use the term *strategic* to refer to the utilization of context cues that affect the diagnosticity or usefulness of responses to stimuli, when the stimuli themselves are held constant. Many heuristic strategies (lexicographic decision rules), base-rate driven strategies (probability matching), or pay-off strategies (win–stay–lose shift) are independent of conscious insight and intentional control.

focus of attention) that may facilitate prime discounting as specified in the ROUSE model (Huber et al., 2001) or prevent primes from being misattributed to the target (Jacoby & Whitehouse, 1989). Likewise, segmentation may be one of several factors that prevent the merging of primes and targets during compound cue formation (Ratcliff & McKoon, 1988) or integrative-prime construction (Estes & Jones, 2009).

Utilizing prime valence flexibly Flexible strategies should not only enable people to eliminate or reduce the impact of old, obsolete, or functionally separated primes. It must also be possible to utilize prime signals in a context-sensitive way. In particular, EP should be sensitive to the statistical contingency of prime and target valence. Some empirical evidence already exists to support this prediction. The relatedness-proportion effect in semantic priming refers to stronger facilitation when the proportion of related prime–target pairs is high rather than low (De Groot, 1984; Neely, Keefe, & Ross 1989; Seidenberg, Waters, Sanders, & Langer 1984). Analogous congruity proportion effects in EP (i.e., enhanced EP when the proportion of congruent pairs is high) were first reported by Klauer and colleagues (Klauer, Mierke, & Musch 2003; Klauer et al., 1997) and were later replicated by Spruyt, Hermans, De Houwer, Vandromme, and Eelen (2007).

Interplay of both influences Both influences—the prime elimination effect on specific trials and the utilization of valence contingencies across the entire list—can be conceived as complementary aspects of the same adaptive function, namely, to make the environment predictable. From an adaptive-learning perspective, the congruity of the immediately preceding prime and the contingency across the entire list can be considered as two competing predictive cues. Although the contingency cue reflects recent learning of the list context, the adaptive value of the congruity cue must also reflect an old correlation-learning experience (i.e., ontogenetic or phylogenetic) that says that the valence of temporally and spatially adjacent stimuli tends to be congruent. In the competition of these two cues, the congruity of the individual trial can be expected to dominate the priming process if the prime and target are not functionally separated and if no other contingency is apparent across the list context. In contrast, if the prime of the current trial is detached from the target, and if a clear-cut contingency can be detected across the list context, the context-specific contingency cue should override the default congruity cue.

Within this flexible cue-utilization approach, notably, the elimination of a standard congruity effect does not imply that reacted-to primes are erased or discarded irreversibly. Rather, the prime valence cue is still there, ready to be used

for contingency-driven inferences.³ We not only expect that a pronounced congruity effect can turn into an incongruity effect when prime and target valence correlate negatively rather than positively, we also expect that active prime responses should support the contingency effect for two reasons: because the competing default congruity cue is suspended, and because actively attending to primes should facilitate contingency assessment.

Theoretical implications of the predicted strategic EP effects

These assumptions about flexible cue utilization in EP should not be discarded as unrealistic. They are well in line with Brunswik's (1952) notion of vicarious functioning, with Kohler's (1956) famous mirror-glass experiments, and with recent evidence that organisms can utilize allegedly automatic cues (such as fluency or Stroop interference) in flexible ways (see, e.g., Chajut & Algom, 2003; Garner, 1974; Unkelbach, 2006, 2007). However, the predicted strategic influences are not compatible with EP as an automatic stimulus-determined process, and with its two most prominent explanations: spreading activation and response interference.

Spreading activation in semantic memory (Collins & Loftus, 1975; DeCoster & Claypool, 2004; De Houwer & Randell, 2004; Ross & Bower, 1981) strictly predicts congruity. It is hardly possible to invent an associative network architecture that predicts incongruity. One can form two clusters for positive stimuli and negative stimuli so that the associative distance between items of the same valence is minimized while the distance between items of opposite valence is maximized. However, it is impossible to form two clusters that minimize opposite-valence and maximize same-valence distance. Spreading activation can thus explain neither the impact of contingencies nor the predicted elimination when responding to primes. Any theory that relies on long-term memory structures cannot predict priming elimination or reversals induced by short-term interventions or strategies.

Response interference approaches (Collins & Loftus, 1975; Dehaene, Naccache, Le Clec, Koechlin, Mueller, Dehaene-Lambertz, & Le Bihan 1998; De Houwer, Hermans, Rothermund, & Wentura 2002; Fazio, 2001; Klauer et al., 1997; Klinger, Burton, & Pitts 2000) explain EP as a result of compatible versus incompatible response

³ This assumption is well in line with the ROUSE model (Weidemann, Huber, & Shiffrin 2008), which does not assume that discounting deletes the prime's information.

tendencies elicited by primes and targets, similar to Stroop interference. The motor response (or efferent impulse) to a positive prime is compatible with a correct target response on congruent trials (“positive”), but is incongruent with a correct target response on incongruent trials (“negative”). Congruity may thus reflect a peripheral response-compatibility effect, as distinguished from a central influence of semantic memory.

Because the response-interference account also relies on fixed constraints imposed on the sensorimotor system, they cannot account for the strategic utilization of contingencies, either. Response interference might offer, however, an alternative account for the expected EP elimination when participants actively respond to the prime. If prime responses involve the same response keys as target responses, the double use of the same motor path in close temporal succession might cause interference. Although one might conjecture that congruent trials (calling for the same response for primes and targets) might suffer less from interference than do incongruent trials, it is also possible that repeating the same motor response twice is harder than producing different responses. To rule out this possibility, we manipulate the response mode across experiments, using either the same response keys for primes and targets or vocal responses for the primes. If vocal prime responses preceding target keystrokes also eliminate standard EP effects, this can be hardly due to peripheral response interference.

Convergent evidence for prime responses involving keystrokes and vocal responses would, however, support a simple segmentation hypothesis, which requires only an explicit response to close the prime episode. Prime episodes may even be closed and priming effects eliminated when prime responses do not refer to valence, but to an irrelevant stimulus aspect. To explore this possibility, we let participants in another experiment classify positive and negative primes by grammatical gender. If EP effects are eliminated by such irrelevant prime responses, this would support the segmentation hypothesis.

Convergent evidence for prime elimination through different prime responses (valence and gender) and response modes (vocal and keystrokes) would cause difficulties for other theoretical explanations that introduce stronger assumptions than mere segmentation. For example, if actively evaluating a prime saturates the valence activation process (Zou, Morris, & Benet-Martínez 2008), it is hard to see why gender classification should have the same effect and why primed valence can still be used for contingency-based strategies. Likewise, if responding to primes means that prime valence is deliberately corrected for (Wegener, Petty, & Dunn 1998), discounted (Huber et al., 2001), excluded from the target (Bless & Schwarz, 2010), or not misattributed to the target (Jacoby &

Whitehouse, 1989), one would have to introduce ad hoc assumptions to explain why a distracting grammatical-gender task causes correction, discounting, exclusion, and veridical attribution. Moreover, one would have to explain why prime valence continues to be utilized for contingency-based strategies.

Preview of experiments

In the present article, we report four experiments in which we test these considerations. In Experiment 1a, we first establish the common congruity effect when only target responses are called for, but, in the same task setting, we demonstrate the elimination of the basic congruity effect when both primes and targets have to be evaluated. In Experiment 1b, we replicate the same pattern when primes are evaluated vocally, while keystrokes are used to evaluate targets, ruling out superficial motor interference. In Experiment 1c, positive and negative primes are categorized by an irrelevant attribute, linguistic gender. Across all three experiments, the congruity effect is replicated with relatively long SOAs, but disappears under all three prime–response conditions. The results of Experiment 2, then, demonstrate the sensitivity of EP to the contingency between prime valence and target valence, causing a strong reversal (i.e., incongruity) when the contingency is negative. Moreover, the contingency-based cue’s impact is enhanced when the default congruity cue effect is eliminated through active prime reactions.

Experiments 1a–1c

Method

Participants and Design Experiments 1a–1c represent different versions of the same basic design, involving the between-subjects manipulation of response conditions (respond to Target-Only vs. respond to Prime + Target) and the orthogonal within-subjects variation of prime valence and target valence. Participants were randomly assigned to experimental groups. The Target-Only group had to classify only targets. The Prime + Target group classified both primes and targets. Participants were male and female Heidelberg students of psychology and other disciplines ($n = 50, 51$, and 48 for Experiments 1a, 1b, and 1c, respectively). They participated either for payment (2.50 €) or to fulfill a study requirement.

Materials In Experiments 1a and 1b, six positive and six negative nouns served as primes, and 12 positive and 12 negative adjectives were used as target stimuli (see the

Appendix).⁴ These stimuli had been shown by Mannhaupt (1983) and Musch (1999) to produce regular priming effects. Positive and negative primes did not differ significantly in word length, $M_s = 4.67$ (1.03) versus 4.83 (1.17), $t < 1$. The word length of positive and negative targets was identical, $M = 6.75$ (1.86). In Experiment 1c, new sets of 10 positive and 10 negative nouns allowed us to vary prime gender orthogonally to valence; half of the primes from each valence category were grammatically masculine and feminine (see the Appendix).

Procedure Participants were received individually or in small groups of two to six and were seated at separate computer work stations. A VisualBasic program presented all instructions and stimuli. The program used a high-resolution timer (based on code by Neumann, 2003) to achieve chronometric accuracy. The opening instructions explained that we measured the relative speed with which the valence of words could be determined. Participants were told that each trial involved two words, of which the first appeared only briefly on the screen, maybe too briefly to be identified, whereas the second word would remain on screen until the participant had classified it, as quickly as possible, as either positive or negative. Participants used the index fingers of their right and left hands to press either the “y” and the “-” key on a German QWERTZ-keyboard for positive and negative responses, respectively.⁵ All primes and targets appeared in the center of the screen in a black 32-pt Arial font type. Participants were also told that the first words (primes) were always identified by a 512×384 rectangle background in violet color (RGB: 128, 0, 128), whereas the second words (targets) were highlighted by using a green background color (RGB: 0, 255, 0).

In the Prime + Target conditions, participants were also instructed to respond to the brief stimulus word at the beginning of each trial. In Experiment 1a, they were told to use the same response keys as those for the targets to classify primes as either positive or negative. If the first (prime) word could not be identified, they were supposed to provide their best guess. In Experiment 1b, using vocal prime reactions, they were told to respond to primes by saying either “positive”

or “negative” before the appearance of the second stimulus. In Experiment 1c, we used gender classification; the same keys as in Experiment 1a served for prime and target reactions. However, the meaning of the keys changed from prime to target within each trial. After the onset of a fixation cross, gender labels appeared on the screen, preparing the participant for a gender judgment. Then, after categorizing the prime as masculine or feminine, or, if no prime reaction occurred, the meaning of left and right response keys changed from gender to valence classification, as indicated by labels on the screen and by the different background colors.

Each trial started with a fixation cross in the middle of the screen. After 1,000 ms, a prime stimulus was presented for 250 ms, followed by a blank screen, and a target stimulus with an SOA of 1,450 ms to provide sufficient time for prime responses in Experiments 1a and 1c. In Experiment 1b, the vocal prime response allowed for a shorter SOA of 750 ms. In all experiments, the target words were erased after they had been classified as positive or negative. The intertrial interval was 1,000 ms. No error feedback was provided. Upon completion of the 15-min experiment, participants were thanked and debriefed.

A Microsoft Visual Basic program randomly selected (with replacement) one prime and one target from the appropriate valence category until the series of 96 trials was complete, under the constraint that every combination of prime and target valence appeared in each block of 24 trials. Experiments 1b and 1c included 24 additional warming-up trials to familiarize participants with the relatively demanding switch of task modes. These initial trials were excluded from data analyses.

Preparation of raw data Separately for each participant, the raw latency data were transformed and prepared as follows: All target response latencies were trimmed to the range between 300 ms and 1,500 ms. This interval spanned approximately two standard deviations of the latency distribution around the overall median. Each participant’s 96 latencies were multiplied by the ratio m/m_i , whereby m_i is the median latency of participant i , whereas m is the overall median across all participants. Thus, the latencies of fast responders were expanded, whereas the latencies of slow responders were compressed so that each participant contributed the same overall proportion of latency variance. None of the results obtained in this and in subsequent experiments are peculiar to these latency transformations.⁶

Within each participant, we computed the average response latency (and error rate) for all four combinations

⁴ Using restricted sets of repeatedly presented primes and targets may be problematic in that subjects might learn multiple stimulus response mappings (Horner & Henson, 2009). However, given 12×24 stimulus combinations and 96 trials, this is very unlikely to happen. The expected frequency of Prime + Target repetitions within the 24 trials of each type is 3.8; the expectancy of stimulus pairs repeated more than twice is close to zero. Moreover, if stimulus–response binding is the driving force, rather than evaluative priming proper, then the congruity effect should increase rather than decrease for the Prime + Target condition of Experiment 1, for the same motor responses are used for prime and target responses.

⁵ The keys “y” and “-” correspond to “z” and “/” on U.S.-American QWERTY-keyboards.

⁶ All analyses were repeated with trimmed raw latencies, without any log transformation or median correction. The critical pattern of significant results remained invariant. For convenience, the reported results are based on the transformed data, for the sake of comparability to other priming results from our lab.

of positive and negative primes and targets—that is, the mean geometric latency (antilog of mean log latency) separately for all trials involving positive primes and positive targets (PP), for positive primes and negative targets (PN), for negative primes and positive targets (NP), and for negative–negative trials (NN), counting only trials with correctly classified targets. The overall proportion of incorrectly classified targets was 4.88%, 9.25%, and 12%, respectively, for Experiments 1a, 1b, and 1c.

Results and discussion: experiment 1a

Response latencies An EP effect should be manifested in fast responses on PP and NN trials, and in slow responses on PN and NP trials. Statistically, this amounts to a Prime-Valence x Target-Valence interaction. Figure 1 (upper chart) presents this typical congruity effect for the Target-Only condition (shaded bars): Responses were faster on valence-congruent trials ($M_{PP} = 753$ ms; $M_{NN} = 766$ ms) than on valence-incongruent trials ($M_{PN} = 805$ ms; $M_{NP} = 798$ ms). The congruity advantage, which amounts to 41 ms, was more apparent for PP trials than for NN trials. This asymmetry, though often concealed by the habit to collapse all congruent and incongruent trials, is actually consistent with that of prior studies on evaluative priming (cf. Unkelbach, Fiedler, Bayer, Danner, & Stegmüller 2008). Nevertheless, the Prime Valence x Target-Valence interaction was clearly significant in a two-factorial ANOVA conducted within the Target-Only condition, $F(1, 23) = 11.16$, $p < .01$, $d = 1.39$. Neither valence nor main effect was significant (both $F_s < 1$).⁷

Consistent with the predicted impact of active prime reactions, the interaction disappeared in an analogous two-factorial ANOVA for the Prime + Target condition, $F(1, 23) = 1.29$, *ns*. Although PP trials were still slightly faster ($M_{PP} = 777$ ms) than all other trial types ($M_{PN} = 798$ ms; $M_{NP} = 800$ ms; $M_{NN} = 803$ ms), the overall congruity effect was not significant (black bars in Fig. 1). The average difference between incongruent and congruent trials shrunk from 41 ms to 9 ms. A marginally significant tendency toward a prime-valence main effect, $F(1, 23) = 3.31$, $.05 < p < .10$, $d = 0.73$, reflects somewhat faster target responses after positive primes. Again, there was no target-valence main effect, $F(1, 23) = 1.24$, *ns*. Thus, EP was eliminated when participants verified the valence of primes.

When the between-participants comparison of the target-only and the Prime + Target conditions was included in a three-factorial ANOVA, in addition to the within-subjects factors prime valence and target valence, a significant three-

way interaction, $F(1, 46) = 4.93$, $p < .05$, $d = 0.65$, corroborated the elimination of the EP effect. The only other significant result was a Prime-Valence x Target-Valence interaction, $F(1, 46) = 11.82$, $p < .01$, $d = 1.01$, demonstrating the congruity advantage with enhanced statistical power. The absence of a response condition main effect, $F(1, 46) = 1.62$, *ns*, shows that neither interference nor cognitive overload caused the congruity effect to fade away in the Prime + Target condition.

The prime reaction latency differences in the Prime + Target condition ($M_{PP} = 859$; $M_{PN} = 860$ ms; $M_{NP} = 879$ ms; $M_{NN} = 871$ ms) were negligible (all $F_s < 1.2$).

Accuracies Error rates were generally small; therefore, no main effect or interaction reached statistical significance, regardless of whether raw accuracy rates or the arcsine-transformed rates were analyzed. This rules out the operation of a speed–accuracy trade-off. Responses to primes in the Prime + Target condition were also accurate; the overall error rate was less than 6%. Differences between trial types were negligible (all $F_s < 1$).

Discussion The results of the first experiment testify to the viability of our paradigm. A typical evaluative-priming effect was obtained despite the relatively long SOA; it was actually stronger than in most frequently cited studies with shorter SOAs (as reviewed in Unkelbach et al., 2008). Also typical is the asymmetrically stronger congruity advantage for positive than for negative stimuli (cf. Unkelbach et al., 2008). Given this regular pattern, the contention must be refuted that EP is confined to short and subliminal primes (see Hermans, Spruyt, De Houwer, & Eelen 2003).

However, the congruity effect in the Target-Only condition was eliminated in the Prime + Target condition. Apparently, reacting to primes functionally separated the prime from the immediately following target. Prime responses thus eliminated EP effects, similar to “unpriming” effects in various other paradigms (Fiedler et al., 2005; Martin, 1986; Sparrow & Wegner, 2006).

Yet, eliminating the congruity effect may reflect the superficial influence of response interference. Because the same response keys were used in Experiment 1a to classify primes and targets, prime responses may have interfered with immediately following target responses. Such response interference is ruled out in Experiment 1b, in which response keys were used only for target evaluations, whereas primes were evaluated vocally.

Results and discussion: experiment 1b

Response latencies In the Target-Only condition, latencies again exhibited a typical EP effect (see Fig. 1, middle).

⁷ Because the interaction was significant in separate analyses of the first and second half of trials, the congruity effect cannot be attributed to stimulus–response learning during the task.

Fig. 1 Mean latencies (in milliseconds) and standard error bars for target responses as a function of response conditions and trial types in Experiments 1a–1c. *PP*, positive prime, positive target; *PN*, positive prime, negative target; *NP*, negative prime, positive target; *NN*, negative prime, negative target

Targets were evaluated faster on congruent ($M_{PP} = 666$ ms; $M_{NN} = 663$ ms) than on incongruent trials ($M_{PN} = 682$ ms; $M_{NP} = 720$ ms). The Prime-Valence $\times$ Target-Valence interaction was significant, $F(1, 25) = 5.26$, $p < .05$, $d = 0.92$, but the main effects for prime valence, $F(1, 25) = 2.40$, $p > .10$, and target valence, $F(1, 25) = 2.84$, $p > .10$, were not.

In contrast, when target manual reactions followed vocal prime evaluations in the Prime + Target condition, the congruency effect disappeared again ($M_{PP} = 601$ ms; $M_{NN} = 630$ ms; $M_{PN} = 619$ ms; $M_{NP} = 601$ ms; see Fig. 1, middle). Neither the interaction nor the prime-valence main effect was significant, $F_s < 1$. Only a significant target-valence main effect, $F(1, 24) = 6.93$, $p < .05$, $d = 1.07$, reflects generally faster responding to positive than to negative targets. In a combined analysis, the almost completely eliminated priming effect is manifested in a significant three-way interaction between the within-subjects factors Prime Valence $\times$ Target Valence and the between-subjects manipulation of response conditions, $F(1, 49) = 5.48$, $p <$

$.05$, $d = 0.67$. Apparently, prime elimination is independent of whether primes are evaluated in the same or in a different response mode.

Accuracies In the present study, error rates showed the same pattern as did the response latencies. Accuracy rates in the Target-Only condition were higher for valence-congruent than for valence-incongruent trials ($M_{PP} = .97$; $M_{NN} = .95$ vs. $M_{PN} = .89$; $M_{NP} = .82$). The Prime-Valence $\times$ Target-Valence interaction was significant, $F(1, 25) = 6.61$, $p < .05$, $d = 1.03$. A prime-valence main effect, $F(1, 25) = 4.85$, $p < .05$, $d = 0.88$, reflects generally more accurate target responses after positive than after negative primes. No target-valence main effect was found, $F(1, 25) = 1.09$.

In the Prime + Target condition ($M_{PP} = .96$; $M_{NN} = .95$; $M_{PN} = .95$; $M_{NP} = .93$), all accuracy differences disappeared (all $F_s < 1$). A three-way interaction involving prime valence, target valence, and the response manipulation reached a conventional level of significance only in a one-sided test, $F(1, 49) = 3.52$, $p < .05$, $d = 0.54$.

Discussion Experiment 1b not only corroborates the results of Experiment 1a with a shorter SOA and a different prime-categorization task, it also rules out an alternative account in terms of response inference. Even though prime and target responses involved different response modalities, the regular EP effect obtained in the Target-Only condition disappeared in the Prime + Target condition, consistent with the segmentation hypothesis.

As already mentioned, however, the results reported so far are open to various theoretical interpretations. EP effects may be eliminated because of correction, saturation, discounting, or exclusion or attribution processes, independently of response modality. However, all of these interpretations would hardly imply prime elimination in Experiment 1c, when primes have to be categorized by gender. Responding to such an irrelevant stimulus attribute can be hardly expected to induce valence saturation, to exclude the prime's evaluative features from the target representation, to enforce a valence correction process, or to prevent participants from misattributing prime valence as belonging to the target. Replicating prime elimination with an irrelevant gender-classification task would thus suggest that segmentation alone is sufficient to functionally detach the prime from the target.

Results and discussion: experiment 1c

Response latencies In the Target-Only condition, again, a significant Prime Valence $\times$ Target Valence interaction (see Fig. 1, bottom) reflects a reliable congruity effect, $F(1, 23) = 6.46$, $p < .05$, $d = 1.06$. Target responses on valence-congruent trials were faster on congruent ($M_{PP} = 727$ ms; $M_{NN} = 732$ ms) than on incongruent ($M_{PN} = 757$ ms; $M_{NP} = 763$ ms) trials. Both main effects were negligible, $F_s < 1$.

In contrast, in the Prime + Target condition, the congruity effect was eliminated ($M_{PP} = 717$ ms; $M_{NN} = 735$ ms; $M_{PN} = 738$ ms; $M_{NP} = 710$ ms). The facilitation of congruent trials decreased from 31 ms to -2 ms. The Prime-Valence $\times$ Target-Valence interaction disappeared, $F(1, 23) = 0.11$. The only significant result was a target valence main effect, $F(1, 23) = 5.04$, $p < .05$, $d = 0.94$, reflecting faster responses to positive than to negative targets. There was no prime-valence main effect ($F < 1$).

Including the comparison between the Target-Only and Prime + Target conditions, the three-way interaction was significant, $F(1, 46) = 5.32$, $p < .05$, $d = 0.68$, confirming the same elimination effect when primes were categorized by gender as when they were categorized by valence. No other effects were significant.

Accuracies In the accuracy ANOVA, the Target-Only condition yielded only a nonsignificant congruity tendency

($M_{PP} = .92$; $M_{PN} = .91$; $M_{NN} = .86$; $M_{NP} = .90$). There was no congruity advantage in the Prime + Target condition ($M_{PP} = .90$; $M_{PN} = .84$; $M_{NN} = .89$; $M_{NP} = .84$), $F < 1$.

Discussion Again, the results are straightforward. A regular EP effect in the Target-Only condition was eliminated in the Prime + Target condition, even though prime responses referred to an irrelevant attribute (gender) that was orthogonal to the crucial valence attribute. The persistence of this pattern across different prime responses and response modes constrains theoretical explanations of prime elimination. Any prime response that serves to functionally separate the prime from the target appears sufficient to eliminate the priming effect, consistent with a simple segmentation hypothesis. Stronger accounts in terms of correction, saturation, exclusion, or attribution processes would have to introduce auxiliary assumptions to explain why even responding to irrelevant prime attributes (i.e., grammatical gender) can eliminate EP. Although the present evidence does not allow us to strictly discard these extant explanations, the convergent results of Experiments 1a–1c highlight the nonspecificity of responses that can functionally detach primes from targets.

Experiment 2

The extended design of Experiment 2 allows us to further elucidate the adaptive flexibility of EP effects. In addition to response conditions (target only vs. Prime + Target), we also manipulate the (positive vs. negative) statistical contingency between prime valence and target valence. Manipulating statistical properties of the list context is a standard instrument for the study of strategic influences on priming (cf. Estes & Jones, 2009). Given a positive contingency—that is, most primes are followed by targets of the same valence—an adaptive strategy is to exhibit a congruity bias. In contrast, if the contingency in the list context is negative, presenting mostly incongruent prime–target pairs, a strategic bias should reduce, eliminate, or even reverse the standard congruity effect.

An intriguing question is how the prime elimination effect in the Prime + Target condition influences the use of contingencies in EP. As argued previously valence congruity within trials and contingency across the list represent two competing predictive cues. In Experiments 1a–1c, the absence of contingencies enhanced the congruity cue. If we eliminate the valence congruity cue and introduce contingencies in the stimulus list, we expect to create ideal conditions for the strategic use of the contingency cue.

If this prediction is correct, it also precludes that prime valence is irreversibly corrected, discounted,

excluded, or blocked via attribution, so that it will be no longer available for contingency-based use. Rather, we believe that a flexible cue-utilization process simply switches from using valence as a local congruity cue to using valence as a more global, contingency-based cue. In addition, active responding to primes should facilitate contingency assessment. Thus, when the default congruity cue is suspended in the Prime + Target condition, we expect strong influences of the contingency cue, whereas the congruity cue should gain more influence in the Target-Only condition.

Method

Participants and Design Seventy-five male and female Heidelberg students participated either for course credit or for payment (4.50 €). They were randomly allocated to five contingency conditions. Unlike in Experiments 1a–1c, response conditions were manipulated within participants; the Target-Only condition always preceded the Prime + Target condition. Reversing this order would have been strange, because a strategy learned in the first stage can hardly be undone in the second stage. As usual, prime valence and target valence were manipulated within participants. For some analyses, we included an additional factor—trial blocks—to examine temporal changes or learning effects across the first and second half of trials within both stages.

Materials and Procedure The stimulus materials and the basic procedure (time parameters, instructions, and dependent measures) were the same as in the first experiment. The only difference consisted in the statistical distribution of positive and negative primes and targets. Unlike in Experiment 1, in which prime valence did not predict target valence, contingencies varied markedly, from $r = -.50$ to $-.33$, $.00$, $+.33$, and $+.50$, across five experimental groups. Table 1 shows the distributions of Prime + Target prime and target valence combinations used to construct these contingencies, which were held within each of four 24-trial blocks. A new random sequence of stimuli, drawn with replacement from the respective set of primes and targets, was constructed for each participant.

The instructions for the first stage were identical to those used for the Target-Only condition of Experiment 1. Then, new instructions told participants that a new stimulus series would be presented after a brief break. This time, they were told to make two evaluative judgments on every trial, one for the prime and one for the target, using the same text as in the Prime + Target condition of Experiment 1. Upon completion of the second series, participants were thanked and debriefed. Overall, the two experimental runs took about 30 min.

Results and discussion

Data preparation was identical to that in Experiment 1. We first considered the basic latency and accuracy findings for the Target-Only condition in the first phase. Then, we analyzed the results from the Prime + Target condition in the second phase, and, finally, we compared performance measures from both phases.

Target-Only latencies Mean latencies appear in Table 2 as a function of experimental conditions. The latencies for the Target-Only condition (upper part of Table 2) again reflect a “normal” congruity effect. Pooling across contingency levels, the average latency in the first phase was shorter for congruent ($M_{PP} = 614$ ms; $M_{NN} = 636$ ms) than for incongruent ($M_{PN} = 640$ ms; $M_{NP} = 644$ ms) trials. The congruity advantage is 17 ms. In a three-factorial Prime Valence $\times$ Target Valence $\times$ Contingency Levels mixed ANOVA with repeated measures on the first two factors, these differences yield a significant Prime–Valence $\times$ Target Valence interaction, $F(1, 70) = 11.44$, $p < .005$, $d = 0.81$.

The only other significant result is due to a prime–valence main effect, $F(1, 70) = 8.49$, $p < .01$, $d = 0.70$; positive primes elicited faster target responses than did negative primes. Neither the contingency-level main effect, $F(1, 70) = 1.40$, $p < .24$, nor the Contingency-Level $\times$ Prime–Valence $\times$ Target–Valence interaction, $F(4, 70) = 1.84$, $p < .13$, were significant. The right-most column in Table 2 shows that the contingency advantage (i.e., mean latency difference for incongruent minus congruent trials) increases only slightly with increasing contingencies.

Table 1 Distribution of trials involving different combinations of positive and negative primes and targets, resulting in different contingency levels (experiment 2)

Contingency level	Positive Primes		Negative Primes	
	Positive Targets	Negative Targets	Positive Targets	Negative Targets
$r = -.50$	12	36	36	12
$r = -.33$	16	32	32	16
$r = .00$	24	24	24	24
$r = +.33$	32	16	16	32
$r = +.50$	36	12	12	36

Table 2 Average target latencies (in milliseconds) by conditions of experiment 2

Contingency Level	P+		P–		Congruent	Incongruent	Congruity Advantage
	T+	T–	T+	T–			
Target Only (First Phase)							
$r = -.50$	640	648	634	638	639	641	2
$r = -.33$	583	602	632	590	587	617	30
$r = .00$	624	639	635	649	636	637	1
$r = +.33$	625	656	671	664	645	664	19
$r = +.50$	600	658	648	636	618	653	35
Total	614	640	644	636	625	642	17
Prime + Target (Second Phase)							
$r = -.50$	698	634	644	690	694	639	–55
$r = -.33$	678	646	640	693	686	643	–42
$r = .00$	645	690	642	661	653	666	13
$r = +.33$	630	668	649	656	643	658	15
$r = +.50$	640	701	684	647	643	693	49
Total	658	68	652	69	664	660	–4

Congruity scores calculated as incongruent minus congruent condition

Target-Only accuracies Error rates were generally low (overall 8.0%) but sufficient for systematic accuracy differences to mirror the pattern of latencies (upper part of Table 3). Specifically, an accuracy ANOVA resulted in a Prime-Valence $\times$ Target-Valence interaction, $F(1, 70) = 15.01$, $p < .001$, $d = 0.93$, reflecting higher accuracies for congruent than for incongruent trials. The prime-valence main effect, $F(1, 70) = 8.87$, $p < .01$, $d = 0.71$, and the target-valence main effect, $F(1, 70) = 4.24$, $p < .05$, $d = 0.49$, were also significant. Target responses were more correct when preceding primes were positive rather than negative, and when targets were positive rather than negative. No effects related to contingency level emerged, all $F_s < 1$, nor were there any other significant results (all other $F_s < 1.4$).

Prime + Target latencies Table 2 (lower part) shows the mean latencies for participants who responded to both primes and targets. Pooling across contingency levels, the difference between congruent ($M_{PP} = 658$ ms; $M_{NN} = 669$ ms) and incongruent ($M_{PN} = 668$ ms; $M_{NP} = 652$ ms) trials is again eliminated as in Experiments 1a–1c. The average difference between incongruent and congruent trials has fallen from 17 ms to –3 ms, precluding a Prime-Valence $\times$ Target-Valence interaction, $F < 1$. A target valence main effect, $F(1, 70) = 5.80$, $p < .05$, $d = 0.58$, reflects somewhat faster responding to positive than to negative targets.

However, as expected, a priming effect reappears in a strong three-way interaction involving Contingency Levels $\times$ Prime Valence $\times$ Target Valence, $F(4, 70) = 15.84$, $p < .001$. A marked congruity advantage arises ($M_{PP} = 642$ ms; $M_{NN} = 652$ ms; $M_{PN} = 666$ ms; $M_{NP} = 691$ ms) when prime and

target valence correlate positively (i.e., $r = +.33$ or $+ .50$), but an equally strong reverse incongruity effect arises ($M_{PP} = 688$ ms; $M_{NN} = 684$ ms; $M_{PN} = 635$ ms; $M_{NP} = 640$ ms) when the correlation is negative ($r = -.33$ or $-.50$). The italicized means in the right-most column of Table 2 display this pattern. For $r = 0$, there was a small unpredicted congruity advantage (13 ms) that may have been due to chance, given that there were only 15 participants per condition.

Latencies of prime responses (slightly above 700 ms) were somewhat slower than target latencies (below 700 ms). No systematic differences between prime latencies were obtained as a function of contingency levels (all $F_s < 1.4$).

Prime + Target accuracies Finally, an examination of the target accuracy data in the Prime + Target condition reveals not only an elimination of the congruity effect across all five contingency levels, but also a reversal. A Prime-Valence $\times$ Target-Valence interaction, $F(1, 70) = 10.22$, $p < .01$, $d = 0.76$, is due to generally lower accuracy scores for congruent trials ($M_{PP} = .88$; $M_{NN} = .89$) than for incongruent trials ($M_{PN} = .88$; $M_{NP} = .90$).

However, this general incongruity trend is moderated by contingency levels in a similar way as the latency results (see bottom part of Table 3). Given negative correlations between prime and target valence, a slight accuracy advantage emerges for incongruent trials ($M_{PP} = .91$; $M_{NN} = .90$ vs. $M_{PN} = .94$; $M_{NP} = .93$). In contrast, given a positive correlation, there is a relative congruity advantage ($M_{PP} = .94$; $M_{NN} = .93$ vs. $M_{PN} = .87$; $M_{NP} = .93$). The corresponding three-way interaction amounts to $F(4, 70) = 5.55$, $p < .001$. The difference for the $r = 0$ group was

Table 3 Average accuracies of target responses by conditions of Experiment 2

Contingency Level	P+		P–		Congruent	Incongruent	Congruity Advantage
	T+	T–	T+	T–			
Target Only (First Phase)							
$r = -.50$	.91	.95	.91	.97	.94	.93	.01
$r = -.33$	.94	.93	.83	.95	.94	.88	.06
$r = .00$	.98	.93	.90	.91	.94	.91	.03
$r = +.33$	.95	.93	.88	.93	.94	.90	.04
$r = +.50$	.95	.92	.84	.90	.93	.88	.04
Total	.94	.93	.87	.93	.94	.90	.04
Prime + Target (Second Phase)							
$r = -.50$	.86	.97	.94	.91	.88	.95	–.07
$r = -.33$	.88	.94	.94	.84	.86	.94	–.08
$r = .00$	.93	.95	.96	.91	.92	.96	–.04
$r = +.33$	.95	.94	.92	.94	.94	.93	.01
$r = +.50$	.95	.91	.91	.92	.94	.91	.03
Total	.91	.94	.94	.90	.91	.94	–.03

Congruity scores calculated as congruent minus incongruent condition

negligible (–0.04). These accuracy findings cannot reflect a speed–accuracy trade-off. The basic congruity effect in the first stage was apparent in both faster latencies and higher accuracy scores. Responding to primes eliminated both performance differences at once. Moreover, when the default congruity cue is eliminated, both accuracy and latency data reflect the same facilitation of trials that match the prevailing contingency.

The accuracy of prime reactions was generally high (i.e., over 80%). There were no significant differences in prime accuracy between experimental conditions.

Longitudinal analyses To test the significance of the prime elimination effect, we included the comparison of the first and second stages in the analysis. For ease of presentation, we computed congruity scores (i.e., average latency of incongruent minus congruent trials) separately for the Target-Only and the Prime + Target condition. As is evident from Table 2, this congruity score was clearly positive for the Target-Only condition ($M = 17$ ms), but not for the Prime + Target condition ($M = -4$ ms), yielding a significant main effect in a Response Mode $\times$ Sign of Contingency ANOVA, $F(1, 70) = 9.58$, $p < .01$, $d = 0.74$. The interaction was also significant, reflecting the appearance of contingency effects in the Prime + Target stage, $F(4, 70) = 7.08$, $p < .001$.

The same pattern was obtained for accuracies, reflecting a response mode main effect, $F(1, 70) = 26.91$, $p < .001$, $d = 1.23$, and a Response Conditions $\times$ Contingency Levels interaction, $F(4, 70) = 3.27$, $p < .05$.

Finally, we tackled the problem of the constant order of the two response conditions. The Prime + Target condition

always followed the Target-Only condition, and this factor is therefore confounded with any learning progress from the first to the second phase. Because the learning of contingencies between prime valence and target valence takes time, it may not be fully apparent during the first stage. Note, however, that the impact of a typical group learning curve should be continuous and most pronounced during the early stage. An analysis of the time course across all four trial blocks (two each within the Target-Only and the Prime + Target stage) is inconsistent with such an account. It is, however, consistent with a contingency effect introduced after the introduction of the prime-reaction task.

Figure 2 portrays the change of the congruity scores across the four trial blocks, separately for the two positive (solid curve) and the two negative contingency conditions (dashed

Fig. 2 Mean congruity score (latency difference for incongruent minus congruent trials) (in milliseconds) as a function of trial blocks and contingency levels in Experiment 2. Positive (solid line) and negative (dashed line) contingency levels are collapsed over moderate and strong contingency conditions ($|r| = .33$ and $.50$). Blocks 1 and 2 represent the Target-Only condition, Blocks 3 and 4 represent the Prime + Target condition (24 trials per block)

curve). As is evident in the sudden divergence of the two curves after the second block, the sensitization to contingencies took place from the second to the third block, when the response mode switched from Target-Only to Prime + Target. There are no contingency effects in the first half (i.e., first two blocks), during which learning should be most apparent. There was also little change between the third and fourth block.

Separate ANOVAs with block transitions as a repeated-measures factor and contingency levels as a between-subjects factor corroborate this interpretation. The Blocks $\times$ Contingency-Level interaction is not significant for the transition from the first to the second block, $F_s < 1$. It is clearly significant for the transition between the second and third block, $F(4, 70) = 6.52, p < .001$, and $F(4, 70) = 5.14, p < .01$, for latencies and accuracies, respectively. But it disappears again from the third to the fourth block, $F(4, 70) = 1.70, ns$, and $F(4, 70) = 2.67, p < .05$, for latencies and accuracies, respectively.

Discussion

We found a standard EP effect when participants reacted to targets only; contingencies between prime and target valence did not moderate this effect. Yet, when participants actively responded to the primes, separating the prime from the target and drawing attention to existing contingencies, we found a marked interaction of contingency, prime valence, and target valence. Although the congruity cue was used in the Target-Only condition, the contingency cue dominated in the Prime + Target condition.

General discussion

The present research was guided by the functionalist idea that adaptive priming must be not only automatic (i.e., efficient and robust) but also flexible (i.e., malleable and strategic). The reported results speak to both assumptions. Supporting the robustness of the basic phenomenon, we provided systematic evidence that EP effects extend regularly to SOAs of 750 ms to 1,450 ms. These findings disconfirm the belief that EP is restricted to a very short time window—too short to account for many real-life behaviors.

However, having established robust and replicable EP effects as a premise, our major research goal was to study their adaptive flexibility. If priming is to prepare the organism for quick and efficient responding in an uncertain environment, it cannot be bound to the rigid execution of automatically determined prime–response sequences. Adaptive priming must be malleable and open to flexible strategies. It must be possible, first, to eliminate priming effects and, secondly, to utilize primes flexibly, as a function of changing environments.

From a functionalist perspective, the standard congruity effect itself may be sensibly conceived as a default strategy, based on the autocorrelation of adjacent observations, rather than a consequence of spreading activation or response interference. Given the random sequence and distinct trial boundaries that characterize most priming experiments, the valence of the prime affords a useful proxy for predicting the same valence of the target belonging to the same local trial (especially at short SOAs). However, this default strategy may be inappropriate and inapplicable in reality, when an individual is exposed to a stream of stimulus input that is not segmented into distinct trials and that involves more than one potential prime. Depending on how the stream of information is segmented into functional units, antecedent primes can be either associated with or dissociated from the target. Depending on the contingency assessed in the stimulus context, positive primes may predict either positive or negative targets.

The reported results were consistent with such a flexible cue-utilization approach. Experiments 1a–1c confirmed the prediction that otherwise reliable EP effects can be eliminated by active prime responses, which can be assumed to separate primes from targets. In the Prime + Target response condition, the “normal” congruity effect disappeared regardless of whether the same keystrokes were used to evaluate primes and targets (Experiment 1a) or prime evaluations were provided vocally (Experiment 1b). Such independence of the specific response mode rules out a response-interference account of prime elimination.

Even irrelevant judgments of the primes’ grammatical gender eliminated the default congruity effect (Experiment 1c), suggesting that the prime’s specific evaluative content cannot play a critical causal role either. We can also discard mental overload or unspecific impairment as a viable explanation, for speed and accuracy were not reduced in the Prime + Target condition (cf. Fig. 1). Moreover, the demanding double-reaction task renders any explanation in terms of mindful correction processes (i.e., consciously deciding not to use a blatant prime) highly implausible. If anything, there would have been more time and resources for voluntary correction in the Target-Only condition, given the long SOA. Deliberate correction processes are resource demanding and time consuming and should have slowed down response times considerably, which was, however, not the case.

We believe instead that the simple notion of segmentation offers a plausible account for the evidence collected so far. Categorizing the prime as positive or negative, or else as male or female, gives closure to a priming episode and introduces a segment boundary between prime and target. As a consequence, the prime is unlikely to intrude into judgments of the target, from which it is separated. Without any loss of generality, the separation hypothesis can be integrated in more refined models in future research (Estes

& Jones, 2009; Fiedler, 2003; Huber et al., 2001; Ratcliff & McKoone, 1988). Manipulations that divide primes and targets into separate segments should be good candidates for interventions that work against local congruity (at the individual trial level) as a priming strategy.

The segmentation hypothesis fits nicely into a functionalist account that emphasizes flexibility and strategic influences on EP. The valence of a functionally separated prime is not lost irreversibly; it is actually experienced vividly through explicit prime reactions. It can be utilized readily when the stimulus context enables a contingency-based strategy, as in [Experiment 2](#). Although active prime responses eliminated the default congruity effect pooled across all contingency levels, as in all other experiments, the statistical contingency between prime valence and target valence was extracted and utilized strategically. When the contingency was positive, so that most primes preceded congruent targets, EP produced a congruity effect. In contrast, when the contingency was negative, with most primes preceding incongruent targets, an equally strong incongruity effect was obtained. The influence of the contingency cue was most apparent in the Prime + Target condition, when prime responses eliminated the local congruity cue and presumably facilitated contingency assessment.

The present findings do not offer ultimate answers to all open questions. We do not know precisely how general the prime elimination effect is. We do not expect that each and every prime reaction task is equally effective. However, the evidence gathered so far suggests that the Zeigarnik-like influence is quite general. It not only generalizes over response modes and response types applied to the primes themselves. In a recent study (Fiedler, 2010), it was even found that completing an unrelated secondary task between prime and target onset of a primary task reduced the priming effect on the primary task. Conversely, treatments that can be assumed to keep the prime episode open rather than closed (e.g., degraded presentation, failure to verify a prime attribute, generative prime task) were shown to increase the strength of priming effects (Alexopoulos, Fiedler, & Freytag 2010; Fiedler et al., 2005).

If the contingency cue is salient, it may also be used in the absence of explicit prime responses, as already shown by Spruyt et al. (2007). Nevertheless, it makes sense, theoretically, that the impact of the contingency cue is more clearly visible when the local congruity cue is eliminated or reduced.

We do not believe that there is only one way to suspend or regulate priming effects, nor do we believe that adaptive strategies are sensitive only to contingencies. Other recent evidence shows that EP can be regulated through explicit instructions (Degner, 2009; Klauer & Teige-Mocigemba, 2007; Teige-Mocigemba & Klauer, 2008). A study by Freytag, Bluemke, and Fiedler (*in press*) revealed that EP is also sensitive to base rate-driven strategies in a paradigm called “pseudocontingencies” (cf. Fiedler, Freytag, & Meiser 2009). Although this growing evidence for alternative strategies and interventions is quite in the spirit of our flexible cue-utilization approach, the focus of the present research was on the interplay of two generic cues that are potentially relevant to any EP setting. First, local contiguity suggests that the meaning and valence of adjacent stimuli (e.g., prime and target within the same trial) are likely to be congruent. Second, the list context can provide statistical information about the valence contingency that can be more useful than the congruity within single trials.

Any comprehensive theory of priming that incorporates both sources of information cannot be based on inflexible constraints of spreading activation or response interference processes. If a theory of priming is to account for newly learned strategies, context influences, and online interventions, it has to deal with cognitive–ecological information exchange that can take place only in working memory rather than in semantic long-term memory or in the sensorimotor system (Estes & Jones, 2009; Ratcliff & McKoon, 1981, 1988). Working memory is the site of contingency assessment, executive control processes, cue substitution, segmentation, and active integration processes that are crucial to the adaptive functions of EP and other priming phenomena.

Appendix

Table 4 Words for prime and target stimuli applied in experiments 1–4

Primes in Experiments 1a, 1b, and 2		Primes (Including Gender) in Experiment 1c		Targets Across all Experiments	
Positive	Negative	Positive	Negative	Positive	Negative
MUT (courage)	WUT (fury)	KUSS (m.) (kiss)	MORD (m.) (murder)	frei (free)	blöd (foolish)
LUST (delight)	LEID (sorrow)	IDEE (f.) (idea)	LÜGE (f.) (lie)	klug (savvy)	dumm (stupid)
GLÜCK (happiness)	ÄRGER (anger)	LIEBE (f.) (love)	ANGST (f.) (anxiety)	treu (faithful)	fies (mean)
LIEBE (love)	ANGST (anxiety)	HUMOR (m.) (humor)	PANIK (f.) (panic)	gesund (healthy)	brutal (violent)

Table 4 (continued)

Primes in Experiments 1a, 1b, and 2		Primes (Including Gender) in Experiment 1c		Targets Across all Experiments	
SPASS (fun)	TRAUER (mourning)	SPASS (m.) (fun)	UNDANK (m.) (ingratitude)	beliebt (popular)	boshaft (wicked)
FREUDE (joy)	FURCHT (dread)	FREUND (m.) (friend)	SKLAVE (m.) (slave)	fleißig (industrious)	grausam (atrocious)
		CHANCE (f.) (chance)	VERRAT (m.) (treason)	ehrlich (honest)	korrupt (corrupt)
		VERSTAND (m.) (intellect)	LEICHE (f.) (corpse)	geduldig (patient)	gehässig (nasty)
		WAHRHEIT (f.) (truth)	SCHADEN (m.) (damage)	herzlich (sincere)	neidisch (envious)
		ERFAHRUNG (f.) (experience)	KRANKHEIT (f.) (disease)	zärtlich (affectionate)	peinlich (embarrassing)
				friedlich (peaceful)	ungerecht (unjust)
				humorvoll (humorous)	widerlich (disgusting)

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