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The Architecture of Intuition: Fluency and Affect Determine Intuitive Judgments of Semantic and Visual Coherence and Judgments of Grammaticality in Artificial Grammar Learning

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People can intuitively detect whether a word triad has a common remote associate (coherent) or does not have one (incoherent) before and independently of actually retrieving the common associate. The authors argue that semantic coherence increases the processing fluency for coherent triads and that this increased fluency triggers a brief and subtle positive affect, which is the experiential basis of these intuitions. In a series of 11 experiments with 3 different fluency manipulations (figure–ground contrast, repeated exposure, and subliminal visual priming) and 3 different affect inductions (short-timed facial feedback, subliminal facial priming, and affect-laden word triads), high fluency and positive affect independently and additively increased the probability that triads would be judged as coherent, irrespective of actual coherence. The authors could equalize and even reverse coherence judgments (i.e., incoherent triads were judged to be coherent more frequently than were coherent triads). When explicitly instructed, participants were unable to correct their judgments for the influence of affect, although they were aware of the manipulation. The impact of fluency and affect was also generalized to intuitions of visual coherence and intuitions of grammaticality in an artificial grammar learning paradigm.

Keywords: intuition, processing fluency, remote associates, artificial grammar learning, visual coherence

In modern psychology, there is an ever-increasing interest in intuitive processes, that is, information processes that occur with little awareness of the process itself (e.g., Deutsch & Strack, 2008; Hammond, 1996; Lieberman, 2000; Wilson, Lindsey, & Schooler, 2000), that are fast and effortless (e.g., Epstein, 1991; Gigerenzer, Todd & The ABC Research Group, 1999; Hamm, 2008; Hogarth, 2001; Kahneman & Frederick, 2002; Stanovich & West, 2000), that are independent from intention (e.g., Betsch, 2008; Epstein, 1991, 1994; Hogarth, 2001; Topolinski & Strack, 2008), and that generate certain internal cues, such as an intuitive hunch or gut feeling (e.g., called messages from within: Bless & Forgas, 2000; vibe: Epstein, 1991, 1994, 2008; cognitive feeling: Kahneman & Frederick, 2002; Loewenstein, Weber, Hsee, & Welch, 2001; or understanding by feeling: Bastick, 1982).

Researchers have learned a lot about intuition (for a recent, extensive review, see Plessner, Betsch, & Betsch, 2008), its power in integrating vast amounts of complex information (e.g., Betsch, Plessner, Schwieren, & Gütig 2001; Dijksterhuis, 2004), its flexible efficiency (e.g., Gigerenzer et al., 1999), its foresight in guiding the problem-solver (e.g., Bowers, Regehrs, Balthazard, & Parker, 1990; Metcalfe, 1986), its deep connection to affect (e.g., Baumann and Kuhl, 2002; Bolte, Goschke, & Kuhl, 2003), and its shortcomings (e.g., Kahneman & Frederick, 2002; Tversky and Kahneman, 1973). However, there is little known about the underlying cognitive and affective processes that lead to intuitive hunches, which prompted Catty and Halberstadt (2008, p. 295) to state that intuition is still the “black box of modern psychology.”

Take, for example, the following intuitive competence: When people are confronted with word triads that either share a common remote associate (e.g., *salt, deep, foam* imply *sea*; Mednick, 1962; Mednick & Mednick, 1967) or are only random word triads (e.g., *dream, ball, book*), they can intuitively feel the semantic coherence before and independently of actually retrieving this common associate (Baumann & Kuhl, 2002; Bolte et al., 2003; Bowers et al., 1990). Moreover, people can discriminate between coherent and incoherent word triads above chance in less than 2,000 ms (Bolte & Goschke, 2005). This is an astonishing faculty because participants feel the existence of something that they do not know or, as Epstein (2008) put it, they know without knowing how they know—and neither do we researchers know how they know it. Although researchers have learned that coherent word triads automatically activate their common remote associate (Beeman et al., 1994; Shames, 1994; Topolinski & Strack, 2008) and that coherence intuitions are more diagnostic under positive mood than under negative mood (Baumann & Kuhl, 2002; Bolte et al., 2003), the mechanisms producing these intuitions remain inscrutable.

Most recently, we opened this black box and connected fairly well-known mechanisms to keep track of this intuitive trace (Topolinski & Strack, in press-b). In a fine-grained analysis of the underlying processes, we traced processing fluency and positive

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affect as possible mechanisms generating these intuitions. The present work systematically tests this fluency–affect account, which is outlined in the following section.

The fluency–Affect Account for Intuitive Judgments of Semantic coherence

In Topolinski & Strack (in press-b), we have proposed an explanation how coherence intuitions may work. Because in that work we have thoroughly developed our account based on an extensive review of affect and fluency literature, we will now present the model in a nutshell. Please also consult Figure 1 for an overview.

We use the terminology of the reflective–impulsive model (RIM, Strack & Deutsch, 2004) to describe the processes. The reflective–impulsive model describes the interactions of an impulsive system that is endowed with an associative semantic network and that produces fast and efficient internal cues, such as feelings, which may be used by a second system, the reflective system, which transforms this input into a propositional format to generate explicit judgments (cf. Deutsch & Strack, 2008). Within the impulsive system, we assume a chain of semantic and affective processing steps that finally generate the intuitive hunch that is then used by the reflective system. Specifically, reading a given coherent word triad causes its three concepts to be sequentially processed in the associative store, in which activation spreads in a fast and parallel fashion to related concepts that are associatively linked to the word. Because the three words of a coherent triad converge on a single common associate, this common concept is activated (Topolinski & Strack, 2008). After reading the first and second words, the partial activation of the common associate facilitates, in turn, the processing of the third word (because the common associate and the third word are also remotely associated), which is thus more fluently processed.[1]

The fluency in processing the third word of a coherent word triad is unexpectedly high (cf., Hansen, Dechêne, & Wänke, 2008; Hansen & Wänke, 2008; Reber, Wurtz, & Zimmerman, 2004; Whittlesea & Williams, 1998, 2000, 2001a, 2001b) because individuals are not used to semantically primed concepts in an apparently random word sequence (cf., Whittlesea, 1993, Experiments 2–5). The unexpectedly high fluency triggers a subtle and brief positive affect (see Reber, Schwarz, & Winkielman, 2004; Winkielman & Cacioppo, 2001; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). That this is actually the case in semantic coherence tasks was demonstrated by Topolinski, Likowski, Weyers and Strack (in press). They presented coherent and incoherent word triads to participants who were ignorant of the underlying semantic structures, and assessed automatic facial activity via electromyography. It turned out that participants showed incipient smiles and reduced frowning for coherent, as compared with incoherent, triads although they did not consciously detect the coherence of some of the triads.

This fluency-triggered positive affect is experienced (Topolinski & Strack, in press-a; cf., Winkielman, Zajonc, & Schwarz, 1997) as a cognitive feeling of ease (cf., Clore et al., 2001; for reviews see Schwarz & Clore, 2007; Jacoby, Kelley, & Dywan, 1989; Unkelbach, 2004) and may then be used as an internal cue (Deutsch & Strack, 2008) by the reflective system, which is responsible for generating explicit judgments and decisions. Asked for the coherence of a word triad, individuals do not have any external criterion (cf., judgments under uncertainty, Kahneman, 2003; Kahneman & Frederick, 2002) and therefore use the internal cue of a positive feeling for their judgment. In processing an incoherent word triad, fluency is not unexpectedly high and does not trigger any change in the affective state; the intuitive chain does not start up and the triad is judged to be incoherent.

This use of an emerging intuitive hunch in a reflective judgment is often mentioned in the intuition literature (e.g., understanding by feeling: Bastick, 1982; messages from within: Bless & Forgas, 2000; vibes: Epstein, 1991, 1994, 2008; intuition as the feeling of physiological discriminations: Perrig & Wippich, 1995, p. 23). Thus far, however, no one has described or tested the manner in which this intuition comes about.

In previous studies (Topolinski & Strack, in press-a, in press-b), we assessed the outputs of the intuitive chain. We demonstrated that coherent triads are processed faster than are incoherent triads in a lexical decision task (high fluency), that the processing of coherent triads inhibited the execution of subsequent negative evaluations (positive affect), and that coherent triads were liked more than were incoherent triads (the use of the emerging feeling in an explicit judgment). It is important to note that none of the participants knew about the underlying semantic structure of the triads and that coherent and incoherent triads did not differ in any dimension that would influence either fluency (e.g., word length) or affect (word valences). Finally, we demonstrated that it is the fluency-triggered positive feeling that is the actual cue used in intuitive judgments: We invalidated the informational value of participants' gut feelings toward the triads (cf., Fazendeiro, Winkielman, Luo, & Lorah, 2005, Experiment 4; Schwarz, Sanna, Skurnik, & Yoon, 2007; Winkielman, Zajonc, & Schwarz, 1997, Experiment 2) by providing an irrelevant source for their affective reactions toward the triads (i.e., background music). As a consequence, participants lost their ability to intuitively discriminate between coherent and incoherent triads (Topolinski & Strack, in press-a, in press-b).

The present research is grounded in these findings and systematically manipulates fluency and affect. Our central hypothesis is the following. We expect that fluency and affect will vary independently of each other on relative levels (cf., Russell, 2003; Russell & Feldman-Barrett, 1999; Whittlesea & Williams, 2001a, 2001b) but will feed jointly and additively into the resulting intuitive hunch. Thus, any manipulation of one of the links in the intuitive chain would alter intuitions, and a joint manipulation of both would also jointly influence intuitions.

Overview of the Present Research

We conducted 11 experiments in which each link of the proposed intuitive chain was systematically manipulated and its impact on intuitions was assessed (please also consult Figure 1 for an overview). In Experiments 1–3, we used three different fluency

[1] The more parsimonious explanation that in a coherent word triad the two preceding words simply semantically prime the third triad word cannot be accepted any longer since Bolte and Goschke (2005) found that the constituents do not differ in their semantic interrelatedness between coherent and incoherent word triads. Hence, the preceding two constituents prime the third constituent to the same extent in coherent and incoherent triads.

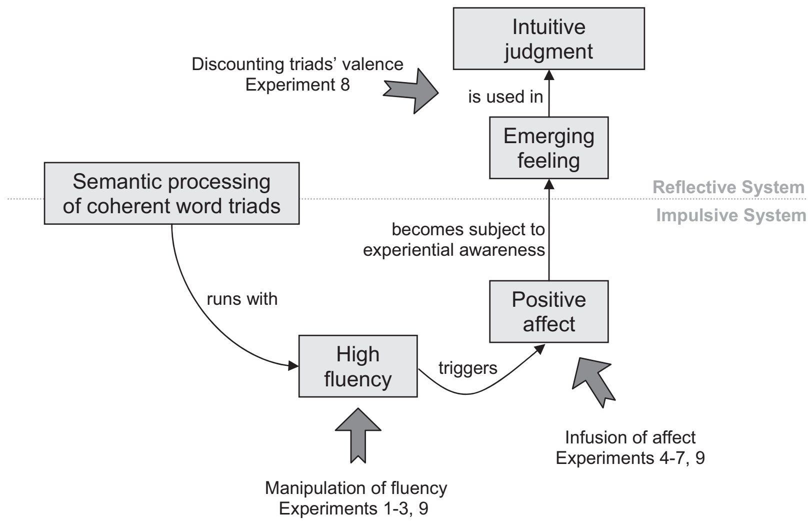

Figure 1. Overview of the fluency–affect account for semantic coherence intuitions and the present experiments.

manipulations, namely figure–ground contrast, repeated exposure, and subliminal visual priming. In Experiments 4–8, we used three different inductions of phasic affect, namely short-term facial feedback, subliminal facial primes, and affect-laden word triads. Finally, in Experiments 9–11, we manipulated fluency and affect jointly and generalized the intuitive chain as to judgments of visual coherence and intuitions of grammaticality in an implicit grammar learning paradigm. Since the paradigm was similar for all experiments, we first outline the general experimental procedure.

General Procedure

Materials

In most of the experiments (except Experiments 8–11), 36 coherent and incoherent German word triads were used from the stimulus pool of Bolte and Goschke (2005; see also Bolte et al., 2003; Topolinski & Strack, 2008). It is important to note that coherent and incoherent word triads do not differ in word length; frequency in everyday language; number of nouns, verbs, or adjectives contained; or affective valence of the contained words (Topolinski and Strack, in press-b).

Procedure

Prior to the experimental block, participants practiced to react in a time-window (similar to Bolte & Goschke, 2005). Specifically, an exclamation mark appeared on the right or left half of the personal computer (PC) screen and participants were asked to react within 500 ms with the appropriate right or left response key. The participants received feedback only if they failed to respond within the time window ("Too slow!" appearing on the screen). After 50 successful trials in succession, the practice block was ended.

In the experimental block, participants were first introduced to the rationale of coherent and incoherent word triads with computer-based instructions that included examples of coherent and incoherent triads that were easy or difficult to solve. These examples were taken from a different stimulus set by Beeman et al. (1994), and they did not reoccur in the later task. To use colloquial language for the participants and to reduce the belief that incoherence is merely seen as the negation of coherence (which is more thoroughly discussed in Experiment 6), we labeled coherent triads as interrelated (German *zusammenhängend*) and labeled incoherent triads as mixed (German *zusammengewürfelt*; see also the General Discussion for the issue of acquiescence). In the experimental block, each trial started with an exclamation mark placed in the center of the screen for 1,000 ms, followed by the word triad presented for 1,500 ms. The words were presented in a stacked format in which each word was written horizontally and the second word placed in the center of the screen. The word triads were 4 cm high and 3–5 cm wide, and the distance between the screen and participants' eyes was approximately 70 cm. After the presentation of the triad, a question mark appeared in the center of the screen and the words *interrelated* and *mixed* appeared on the right and left sides of the screen, depending on which key was assigned to each option (the assignment of response categories was counterbalanced across participants). If a participant did not respond within 500 ms after the onset of the response request, the sentence "Too slow!" appeared on the screen for 300 ms, and the next trial started. In this case, the participant was not asked to type in a possible solution candidate for the triad. If participants succeeded in reacting within the response time window, they were prompted to type in a solution word candidate for the present triad or an *x* if no solution word came to their mind. To generate a word, participants were given 5 s, and then the next trial started. Coherent and incoherent triads were randomly chosen and rerandomized anew for each participant. At the end of the experimental block, a computer-directed debriefing followed in which the participants were asked to type in any anomalies or suspicions. The entire experimental session lasted 15 min to 20 min.

Part 1: Manipulation of Processing fluency

The hypothesis that processing fluency might be a cue for intuitive judgments was already proposed by Wippich and colleagues (Perrig & Wippich, 1995; Perrig, Wippich, & Perrig-Chielo, 1993; also see, for converging assumptions concerning intuitions of prototypicality in artificial grammar learning, Kinder, Shanks, Cock, & Tunney, 2003; Pothos, 2007; Reber, Schwarz, & Winkielman, 2004) and was demonstrated to be used for judgments of visual coherence (Wippich, Mecklenbräuker, & Krisch, 1994). When visually incoherent pictures were presented before the actual intuitive task, thus increasing the fluency for processing these pictures when they reoccurred in the intuitive task, this increased the likelihood that these incoherent pictures would be judged to be coherent when compared with pictures that were not shown before (Wippich, 1994). Although this effect was restricted to incoherent stimuli, it provided pioneering evidence for the present approach. In the first three experiments, we manipulated intuitions of semantic coherence with three different fluency manipulations.

Experiment 1

Many fluency manipulations are reported in the literature, for example, repeated exposure of a stimulus (e.g., Bornstein & D'Agostino, 1994; Jacoby, Kelley, & Dywan, 1989) or duration of stimulus presentation (e.g., Reber, Winkielman, & Schwarz, 1998; Winkielman & Cacioppo, 2001). As a first demonstration, we chose to change the contrast of the color of the font in which the words were presented. Reber and Schwarz (1999, see also Unkelbach, 2006; Werth & Strack, 2003) used this fluency manipulation successfully to affect truth ratings. Specifically, statements presented in a high contrast were judged to be true more frequently than were statements printed in a low contrast. Applied to the present paradigm, we assumed that word triads presented in a high contrast would more likely be judged to be coherent than would triads presented in a low contrast.

Method

Participants. Thirty (15 female, 15 male) non-psychology students participated for a payment of EUR 2 (approximately U.S.$2.50 at the time).

Material and procedure. The general procedure was run; however, the colors in which word triads were presented were manipulated. Specifically, we used Unkelbach's (2007) method of changing the RGB (red, green, blue) component of the colors blue, red, green, and yellow to obtain a variety of dark and light shades of each color (for details, see Unkelbach, 2007). The dark colors had a high figure–ground contrast against the white background, and the light colors had a low contrast, enabling a high processing fluency and a low processing fluency, respectively. Half the coherent triads and half the incoherent triads were randomly chosen and presented with a high contrast of a randomly selected color, and the other half was presented with a low contrast. The assignment of triads to contrasts as well as the sequence of triads was rerandomized for each participant. Instead of asking for optical anomalies, participants were asked whether they were able to read all of the triads without problems (see next paragraph).

Debriefing. It was necessary to rule out the possibility that some of the low contrast triads may have been indecipherable, such that participants would have judged them incoherent only because they were unable to process the words appropriately. For this purpose, participants were asked whether they could easily read the triads or whether there had been words that they were unable to decipher. No participant reported having missed a word.

Results

Missed responses. For all experiments, all analyses were performed with an alpha level of .05 (two-tailed). Partial eta-squared (η_p^2) indicates effect size for omnibus tests, and Cohen's *d* indicates effect size for *t* tests. Following Bolte and Goschke's (2005) data preparation, all trials were discarded in which the response was not generated within the given time window of 500 ms after the offset of the triad, which true for 647 (of 2,160; 30%). Table 1 shows how many of these missed responses came from (in)coherent and (non)fluent trials. As a check for any effect of fluency on the frequency of these missed responses, a 2 (coherence: coherent triads vs. incoherent triads) $\times$ 2 (fluency: high contrast vs. low contrast) analysis of variance (ANOVA) was conducted in which both factors were treated as within-subjects factors, which yielded no effects, $Fs(1, 646) < 1.2$. In fact, across all studies, we found no systematic impact of our experimental manipulations on the frequency of missed responses. Although the number of missed responses for all experiments and conditions are displayed in Tables 1 and 2, we report analyses within the *Results* sections only when there were significant differences in numbers of missed responses between conditions.

Solved triads. If a participant had generated the correct solution word, a synonym, or a different but acceptable solution word after the semantic coherence judgment (which was collectively decided by two raters who were ignorant with regard to the conditions), then this trial was considered solved (cf., Bolte & Goschke, 2005). Solved trials were discarded from further analyses because the participant most likely had not judged intuitively but had judged on the basis of on an explicit retrieval of the solution word. Because the participants were not asked to type in a solution candidate after they had missed responding in the given time window, the solved trials do not overlap with the missed responses. The number of solved trials as a function of experimental condition is shown in Table 1 for Experiments 1–8. We found no difference in the number of solved triads between fluent and nonfluent trials in this experiment, $t(64) < .03$.

Coherence judgments. The proportion of coherent responses in the remaining trials was analyzed in a 2 (coherence: coherent triads vs. incoherent triads) $\times$ 2 (fluency: high contrasts vs. low contrasts) repeated measures ANOVA. We found a main effect for coherence, $F(1, 29) = 26.84$, $p < .0001$, $\eta_p^2 = .48$, as well as for fluency, $F(1, 29) = 15.21$, $p < .001$, $\eta_p^2 = .34$, but no interaction ($F < 0.01$). Planned comparisons revealed that within the coherent triads, triads presented in a high contrast against the background were more likely to be judged coherent ($M = .36$, $SE = .03$) than were triads presented in a low contrast ($M = .25$, $SE = .03$), $t(29) = 2.48$, $p < .02$, and within the incoherent triads, triads presented in a high contrast were also judged coherent more often ($M = .2$, $SE = .04$) than were triads presented in a low contrast ($M = .10$, $SE = .03$), $t(29) = 3.00$, $p < .005$. However, there was no reliable difference between coherent triads presented in a low contrast and incoherent triads presented in a high contrast ($t < 1.2$).

Table 1
Number of Missed Responses and Solved Coherent Triads as A Function of Experimental Condition for Experiments 1–8

Experiment	Missed responses										Solved trials			
	Coherent				Incoherent									
	Fluent	Positive	Nonfluent	Negative	Fluent	Positive	Nonfluent	Negative	Overall	%	Fluent	Positive	Nonfluent	Negative
					fluency manipulated									
Experiment 1 (2,160 trials)	175		160		162		150		647	30	32		33	
Experiment 2 (2,376 trials)	190		194		188		135		707	30	74		47	
Experiment 3 (2,232 trials)	130		141		133		154		558	25	49		40	
					Affect manipulated									
Experiment 4 (3,600 trials)		189		234		181		152	756	21		83		43
Experiment 5 (2,160 trials)		169		210		158		153	690	32		13		27
Experiment 6 (1,620 trials)		189		156		85		87	517	32		18		29
Experiment 7 (2,160 trials)		180		195		177		190	742	34		16		25
Experiment 8 (3,360 trials)		186		156		168		158	668	20				52

Note. For solved trials, by definition, only coherent triads can be solved. Overall percentages are proportions of all missed responses compared to all trials. For Experiment 6, there are 36 coherent triads, but only 18 incoherent triads were presented for each participant.

Discussion

Using figure–ground contrast to alter fluency in this study, we investigated the impact of processing fluency on intuitions of semantic coherence. Not surprisingly, coherent triads were judged to be coherent more often than were incoherent triads. It is more interesting to note that a triad was more likely to be judged as coherent if it was fluently processed, irrespective of whether it was coherent. This additive effect of coherence and fluency strongly suggests that processing fluency determines intuitive judgments of semantic coherence. As expected, no impact of fluency was found on the likelihood of solving the triad or on the response times.

An important alternative explanation should be ruled out at this point. It is conceivable that fluency increased the probability for judgments of coherence via guessing of solution candidates. First, it is possible that high fluency triggered a more heuristic processing style (cf., Alter, Oppenheimer, Epley, & Eyre, 2007) and increased the overall frequency of guessing solution candidates after the triad was read (cf., Harkins, 2006; Topolinski & Strack, 2008). Second, and independently of the first process, high fluency could have increased participants' confidence in a retrieved solution candidate, since we know that high fluency in the retrieval of any memory content increases the confidence in that memory content (e.g., Kelley & Lindsay, 1993). Both increased guessing of solution candidates and increased confidence in guessed solution candidates may in turn have increased the probability of judging the given triad as coherent.

The present paradigm offers a measure of solution guessing, namely whether the participant had or had not typed in a possible solution candidate (which was used before to identify whether coherent trials were solved). Although this measure is not a matter of assessing initial guessing after reading a triad and before judging the coherence (which would itself be a highly complicated methodological challenge), it is an indicator whether participants had guessed at all in the current trial. If fluency had exerted its impact on the intuitive judgments via increased guessing, the impact of fluency should not be detected in those trials in which participants did not submit a solution candidate, that is, in trials in which they did not guess at all. To test this, we reran the analysis using only the trials in which no solution candidate was submitted (which was true for 72% of all trials from the former analysis) and obtained again a main effect for coherence, $F(1, 29) = 6.90$, $p < .02$, $\eta_p^2 = .19$, as well as for fluency, $F(1, 29) = 4.58$, $p < .05$, $\eta_p^2 = .14$. To generalize the present pattern of findings, the pattern should be replicated with another fluency manipulation.

Experiment 2

Another means of manipulating fluency is repeated exposure, since repeated stimuli are more fluently processed than are novel stimuli (e.g., Bornstein & D'Agostino, 1994; Jacoby & Dallas, 1981). In the literature, this manipulation affected a broad range of evaluative and metacognitive judgments, for example, feelings-of-knowing (Koriat & Levy-Sadot, 2001; Metcalfe, Schwartz, & Joaquim, 1993; Reder & Ritter, 1992). Following from the present account, we expected triads that were presented before to be

Table 2
Number of Missed Responses as a Function of Experimental Condition in Experiments 9–11

	coherence: Grammaticality									
	Coherent: Grammatical				Incoherent: Agrammatical					
	Positive		Negative		Positive		Negative			
Experiment	Fluent	Nonfluent	Fluent	Nonfluent	Fluent	Nonfluent	Fluent	Nonfluent	Overall	%
Experiment 9 (1,960 trials)	34	39	32	48	42	22	28	43	288	17
Experiment 10 (1,800 trials)	39	28	26	26	28	22	21	24	214	12
Experiment 11 (1,920 trials)	28	34	36	27	36	44	34	30	269	14

Note. Overall percentages are proportions of all missed responses compared to all trials.

processed faster and thus to be more likely to be judged as coherent.[2]

Method

Participants. Thirty-three (19 female, 14 male) non-psychology students participated for a payment of EUR 2 (approximately U.S.$3 at the time).

Material and procedure. The general procedure was implemented with the normal stimulus pool. However, before the experimental block, participants were asked to merely study a list of words and were presented with 18 coherent and 18 incoherent, randomly chosen triads from the later to-be-judged stimulus set.

Results

Solved triads. The assessment of the actual solution of a coherent triad was similar to Experiment 1 (and was the same in all further studies). Solved trials were again discarded from the following analyses. The number of solved triads for each condition is shown in Table 1. In a planned comparison, it was found that more old triads were solved than were new triads, $t(120) = 2.51$, $p < .013$.

Coherence judgments. A 2 (coherence: coherent vs. incoherent triads) $\times$ 2 (repetition: old triads vs. new triads) repeated measures ANOVA revealed a main effect for coherence, $F(1, 32) = 92.86$, $p < .001$, $\eta_p^2 = .74$, a main effect for repetition, $F(1, 32) = 19.63$, $p < .001$, $\eta_p^2 = .38$, and no interaction ($F < 0.03$). Planned comparisons revealed that within the coherent trials, old triads ($M = .55$, $SE = .04$) were more likely to be judged coherent than were new triads ($M = .45$, $SE = .03$), $t(32) = 3.20$, $p < .003$; and within the incoherent triads, old triads ($M = .27$, $SE = .03$) were also more likely to be judged coherent than were new triads ($M = .28$, $SE = .03$), $t(32) = 4.45$, $p < .001$. The difference between new coherent triads and old incoherent triads also reached significance $t(32) = 4.99$, $p < .001$.

Discussion

Exploiting another fluency manipulation, namely repeated exposure, we obtained the same pattern as in Experiment 1, namely fluency altered coherence judgments, additively and independently of veridical coherence. The finding that recurring coherent triads were solved more often than were nonrecurring triads can be explained by the following mechanism. When the triad is first encountered, semantic activation automatically converges on the common associate, activating the solution word below the threshold (Topolinski & Strack, 2008). When the triad is encountered the second time during the intuitive task, the common associate receives additive converging activation, which renders it more likely that the activation of the common associate is increased above the threshold, and the solution is retrieved.

In the next study, we wanted to replicate the findings from Experiments 1 and 2, using a third fluency induction, namely subliminal visual priming. Furthermore, we wanted to investigate the fluency sensitivity of coherence judgments by implementing the smallest possible manipulation. As was outlined above, we assume that in reading a coherent triad, the processing of the first and second words partially activates the common associate (Beeman et al., 1994; Topolinski & Strack, 2008), which in turn facilitates the processing of the third word. Consequently, we were interested in whether it is sufficient to alter the fluency of only this third word to influence coherence intuitions. Thus, instead of subliminally priming the whole triad, we only primed the third word of a given triad.

Experiment 3

As a last replication, we chose subliminal visual priming as a way to induce processing fluency (cf., Kunst-Wilson & Zajonc, 1980; Reber et al., 1998, Experiment 1; Winkielman & Cacioppo, 2001). Because we assume that the third word of a coherent triad profits the most from prior activation through the preceding associates, only the third word of a given triad was primed. Specifically, the third word was preceded by a visually degraded version of itself or of a nonword, presented for a short duration. This procedure also served to assure the unobtrusiveness of the manipulation because participants were assumed to start reading the triad with the first word, although the prime appeared at the position of the third word (see the *Material and procedure* section). We expected that the higher processing fluency of a triad deriving from this priming would increase the probability that this triad would be judged as coherent.

[2] We thank Colleen Kelly for proposing this experiment.

Method

Participants. Thirty-three (20 female, 13 male) non-psychology students participated for a payment of EUR 2 (approximately U.S.$2 at the time).

Material and procedure. The general procedure was modified as follows. Directly before the presentation of the word triad, a prime was presented for 17 ms (one screen refresh). The prime was either the third word of the following triad, appearing in the same position as it would later appear in the triad, but visually degraded, or a randomly chosen nonword, equal to the triad word in visual width and similarly degraded. Nonwords instead of comparable real words were used to avoid further semantic priming due to the meaning of the prime words. The visual degrading was accomplished with the airbrush function in the Microsoft Paint program; white pixels were airbrushed onto the black (non)words printed on a white background. One research assistant added so many white pixels that she could barely recognize the word and then presented it independently to two other raters who recommended more or less degrading of the stimulus until all three reached the consensus that the word was barely readable. We analyzed the visual properties of these stimuli a posteriori by randomly sampling 30 of them and counting the proportion of erased pixels, which turned out to be 55% on average.

Rerandomized for each participant, one half of the coherent triads and one half of the incoherent triads were preceded by their own degraded third word as prime, and the other half of the coherent triads and the other half of the incoherent triads, respectively, were preceded by a degraded nonword as prime. No blocks of the four conditions were formed; instead, the sequence of all 72 triads was randomly chosen.

Assessment of awareness. At the end of the session, participants were first asked for "any anomalies in the optical presentation of the word triads." Two participants reported having seen a "flicker" or "short errors in the word displays." The data from both these participants were discarded from all further analyses. Second, the participants were asked whether they had seen that "single words appeared shortly before the onset of the word triads." No participant affirmed that. Given these results, our priming procedure can be considered to be subliminal.

Results

Solved triads. The numbers of solved triads for each condition are shown in Table 1. No differences between fluent and nonfluent trials were found, $t(88) < 1.0$.

Coherence judgments. For the remaining responses, the proportion of *coherent* responses was analyzed by means of a 2 (coherence: coherent vs. incoherent triads) × 2 (fluency: matching word prime vs. nonword prime) repeated measures ANOVA. We again found a main effect for both coherence, $F(1, 30) = 27.24$, $p < .0001$, $\eta_p^2 = .48$, and fluency, $F(1, 30) = 10.18$, $p < .003$, $\eta_p^2 = .25$, and no interaction ($F < 0.5$). Post hoc comparisons within the coherent and the incoherent triads revealed that coherent triads were more likely to be judged as coherent when they had been preceded by a visually degraded version of their own third word ($M = .34$, $SE = .04$) than when they had been preceded by a visually degraded version of a nonword ($M = .25$, $SE = .04$), $t(30) = 2.47$, $p < .02$. The same pattern emerged for the incoherent triads: Incoherent triads were marginally more likely to be judged as coherent when they had been preceded by a visually degraded version of their own third word ($M = .20$, $SE = .03$) than when they had been preceded by a visually degraded version of a nonword ($M = .15$, $SE = .02$), $t(30) = 1.98$, $p = .057$. However, a comparison between coherent triads preceded by a degraded nonword and incoherent triads preceded by a degraded version of their own third word yielded no reliable difference ($t < 1.5$).

Discussion

We replicated the findings of Experiments 1 and 2 and generalized them by using a different fluency manipulation, namely subliminal visual priming of the third word. Again, coherence and fluency independently contributed to the likelihood with which a given triad was judged to be coherent.

It was additionally shown that only a minor manipulation was sufficient to alter intuitions, since we only changed the fluency of the third word of each triad. Future research might address whether a selective manipulation of the first and the third word of a triad would differentially influences intuitions. However, this is not within the scope of the present approach.

Conclusions

In the first three studies, we demonstrated that processing fluency determines intuitive judgments of semantic coherence independently of veridical coherence. Moreover, this robust effect did not depend on a particular method of inducing fluency but rather did generalize across different inductions. In the next set of studies, we leave the first link of the intuitive chain and move on to investigating the role of the affective link in judgments of semantic coherence.

Part 2: Experimentally Manipulating Core Affect

The next experiments focus on an important mediating link in the intuitive chain, which is phasic positive affect triggered by fluency. This sudden variation in core affect (Russell, 2003) is a free-floating, undedicated (Murphy & Zajonc, 1993; Zajonc, 1994), or diffuse affective state (Russell & Feldman-Barrett, 1999; Stapel, Koomen, & Ruys, 2002;) that is not necessarily a part of experiential awareness but that can be if the affect is very intense or changes rapidly (Russell, 2003). In such cases, core affect emerges as a feeling of which individuals may become aware (cf., Winkielman, Zajonc, & Schwarz, 1997). In the case of reading a coherent word triad, this fluency-triggered experience resembles a subtle, brief, and positive feeling of ease (e.g., Clore et al., 2001; Topolinski & Strack, in press-a).

One way to manipulate core affect, then, would be to induce positive or negative moods in participants and to compare the coherence judgments of both of these groups. In fact, this was already done by Baumann and Kuhl (2002) as well as by Bolte et al. (2003), who found that intuitive discrimination between coherent and incoherent triads improved in positive mood states and decreased to chance performance in negative mood states. However, the moods induced in those studies were longer lasting, mild affective states (cf., Russell, 2003; Scherer, 2005; Winkielman, Knutson, Paulus, & Tujillo, 2007) that were consciously experienced by the participants (reflected in mood self-ratings) and whose origin (the experimental mood induction) was known to the participants. It is thus unlikely that this persistently experienced affective state was used as an internal cue for intuitive judgments of coherence (cf., Neumann, Seibt, & Strack, 2001). Rather, it seems that the difference in intuitive discrimination as a function of mood states was due to changed cognitive styles (e.g., Fiedler, 1988) or a changed type of semantic processing (e.g., Kuhl, 2000; Niedenthal, 1990). Furthermore, the induced moods had differential effects on judgments of coherent and incoherent triads. For example, positive mood increased *coherent* responses for coherent triads but decreased *coherent* responses for incoherent triads. Thus, it is implausible that the induced mood changed the core affect that was phasically triggered by a given triad, because if that were the case, then positive mood would have had the same effect on judgments for both coherent and incoherent triads. The relation between mood and intuition is discussed more thoroughly in later sections.

To demonstrate that a subtle and brief positive change of core affect that is evoked during or shortly after processing a coherent triad may serve as an internal cue for judgments of semantic coherence, a short-term and much more flexible affect induction should be implemented. This was attempted with unobtrusive short-term facial feedback (Experiment 4), affective facial priming (Experiments 5–7), and affect-laden word triads (Experiment 8). With these procedures, short positive and negative affective changes should be triggered within the same experimental session and even without participants' awareness.

Experiment 4

As a first induction, we manipulated the facial expressions of participants in an unobtrusive way, following the classical facial-feedback approach by Strack, Martin, and Stepper (1988; Niedenthal, 2007), which maintains that manipulations of the face may induce affective states. From Topolinski et al. (in press), we know that coherence activates the smiling muscle, zygomaticus major (which is related to positive affect, Cacioppo, Petty, Losch, & Kim, 1986; Scherer & Ellgring, 2007), and inhibits the frowning muscle, corrugator supercilii (which is related to negative affect, e.g., Cacioppo et al., 1986; Ekman, 1973). Accordingly, to induce positive affect, we used the original pen manipulation by Strack et al. (1988), who found that participants rated comics as funnier when holding a pen between the teeth than when holding a pen between the lips. Holding a pen between the teeth activates the zygomaticus, which triggers positive affect. To induce negative affect, we used the unobtrusive facial manipulation introduced by Larsen, Kasimatis, and Frey (1992), who affixed golf tees to the inside of participants' eyebrows and asked them to bring the ends of the golf tees together, which results in a contraction of the corrugator frowning muscle and induces negative affect (Niedenthal, 2007; see also Phaf & Rotteveel, 2005; Strack & Neumann, 2000; Stepper and Strack, 1993). To obtain short-term affective changes and to manipulate affect orthogonally to coherence within each participant, zygomaticus and corrugator contractions were altered from trial to trial, which is an innovative way to obtain phasic facial feedback. Following our fluency–affect account, we predicted that irrespective of their actual coherence, word triads read under zygomaticus contraction would be more frequently judged as coherent than would triads read under corrugator contraction.

Method

Participants. Fifty (28 female, 22 male) non-psychology students participated for a reward of EUR 2 (approximately U.S.$2.50 at the time).

Material and procedure. The general procedure was modified as follows. Participants were told that the experiment was concerned with muscular tension in the shoulders and neck and its relation to office work and that the experiment would be used for investigating new ways to develop more ergonomic office furniture. They were additionally told that they were in the control condition for which tension would be induced in the face, instead of in the shoulders and neck. For the zygomaticus manipulation, participants were asked to hold a pen in the mouth between the teeth and the lips. They were asked to lift their lips off of the pen whenever the signal word *MOUTH* appeared on the PC screen. By lifting the lips, the pen was held solely by the teeth, resulting in the classical zygomaticus contracting manipulation (Strack et al., 1988). For the corrugator manipulation, golf tees were affixed to the inside end of participants' eyebrows. They were asked to bring the ends of the golf tees together whenever the signal word *BROWS* appeared on the PC screen. This action led to an activation of the corrugator. First, the experimenter explained the to-be-made actions. Then, in 20 trials, participants practiced executing both of these facial responses whenever the word *MOUTH* or *BROWS* appeared on the screen and relaxed their faces whenever the word *RELAX* appeared, 2 s after the signal word *MOUTH* or *BROWS*. The experimenters were well trained in avoiding any affective connotations concerning the facial manipulations. While explaining and training, the facial responses were labeled not with valences (e.g., frowning or smiling) but rather with technical expressions. Even the signal words *MOUTH* and *BROWS* did not contain any affective implications.

Within the actual experimental block, the word *MOUTH* or *BROWS* appeared for 500 ms before the word triad, prompting the participants to execute the corresponding facial response. Then, the word triad followed for 1,500 ms and for the response time window of 500 ms, for the eventual coherence judgment. Only after this response time window, that is, after the participants had made their judgments, the word *RELAX* appeared on the screen for 500 ms, prompting the participants to relax their faces. Then, following the general procedure, the participants were asked to guess a possible solution word. In half the trials, the word *MOUTH* was presented, and in the other half, the word *BROWS* was presented for both coherent and incoherent trials, respectively. The assignment of triads to facial condition was randomized anew for each participant, and so was the sequence of all trials.

Debriefing. In a computer-directed debriefing, participants were asked for their speculations concerning the aim of the experiment. No participant voiced a relevant suspicion.

Results

Solved triads. A planned comparison showed that more triads were solved in the zygomaticus contraction condition than in the corrugator contraction condition, $t(125) = 3.74$, $p < .001$ (see Table 1).

Coherence judgments. We conducted a 2 (coherence: coherent vs. incoherent triads) × 2 (muscle: zygomaticus vs. corrugator contraction) repeated measures ANOVA. We found strong main effects for both coherence, $F(1, 49) = 130.59$, $p < .0001$, $\eta_p^2 = .73$, and muscle, $F(1, 49) = 82.66$, $p < .0001$, $\eta_p^2 = .63$, and no interaction ($F < 2$). Post hoc tests within coherent and incoherent triads revealed that coherent triads were more likely to be judged as coherent under zygomaticus contraction ($M = .39$, $SE = .02$) than under corrugator contraction ($M = .27$, $SE = .02$), $t(49) = 6.17$, $p < .0001$, and incoherent triads were also more likely to be judged as coherent under zygomaticus contraction ($M = .22$, $SE = .02$) than under corrugator contraction ($M = .13$, $SE = .01$), $t(49) = 11.26$, $p < .0001$. The difference between coherent triads under corrugator contraction and incoherent triads under zygomaticus contraction was still reliable, $t(49) = 2.48$, $p < .02$.

Guessing a solution candidate as confounding factor. At this point, as was done before for the fluency manipulation in Experiment 1, one should rule out the possible alternative explanation that positive affect prompted participants to judge the current triad as coherent via increasing the frequency of guessing any solution candidate or via increasing the confidence in a retrieved solution candidate. We reran the above analysis, only including trials in which participants did not submit a solution candidate (which was true for 79% of the trials in the above analysis) and still found main effects for coherence $F(1, 49) = 6.26$, $p < .02$, $\eta_p^2 = .11$, and muscle, $F(1, 49) = 5.13$, $p < .03$, $\eta_p^2 = .10$.

Discussion

Using phasic facial feedback while processing the word triad and judging the coherence, we could alter intuitive coherence judgments. Adopting a light smile by contracting the zygomaticus increased the probability that a given triad was judged to be coherent. However, producing a frown by contracting the corrugator decreased the probability that a given triad was judged to be coherent. It is important to note that this was the case for both coherent and incoherent triads. We argue that positive affect was induced under zygomaticus contraction and negative affect was induced under corrugator contraction (Larsen et al., 1992; Niedenthal, 2007; Scherer & Ellgring, 2007; Strack et al., 1988), which feeds into the intuitive chain. The induced affect added to the coherence-triggered affect and thus produced the obtained pattern.

The finding that more triads were solved under zygomaticus contraction fits well with the existing literature that indicates that positive affect fosters the explicit retrieval of word triads (there called creative insight, Isen, Daubman, & Nowicky, 1987) and that even body movements related to positive affect can foster solution word retrieval (there called creative cognition, Friedman & Förster, 2002). Agreeing with these authors and a huge body of literature, we explain this effect by facilitated semantic activation spread that could more easily converge onto the common associate to activate it above threshold (see also Bolte et al., 2003; Bolte & Goschke, in press; Topolinski & Strack, 2008).

It has to be emphasized that we altered facial feedback randomly from trial to trial, with the facial induction lasting for only 2,000 ms, which is an innovative technique for inducing phasic facial feedback. The obtained findings demonstrate both the efficiency and the unobtrusiveness of this method. It is efficient in successfully altering intuitive judgments. It is unobtrusive in not interfering with the basic task: Despite the demands of prompted facial responses and the continual change of affective valence, participants did not lose their basic sensitivity to coherence. Phasic facial feedback might be used in future research as a powerful tool to induce short-term affect.

However, although conducted for inducing short-term facial feedback triggering phasic muscle contractions, the present paradigm may not be flexible enough for investigating the influence of affect on intuitive judgments for a more precise time frame. Specifically, we were interested in whether inducing affect shortly before or after the word triad would make a difference to the outcome. Given the already sophisticated task with regard to time pressure, it would have been too demanding for participants to execute the facial response for a shorter period of time before triad onset or between triad offset and eventual judgment. Thus, we wanted to use an affect induction that was shorter and that did not involve additional actions by the participants, so that it could be more flexibly timed. In the following Experiments 5–7, we used an affective facial priming procedure.

Experiment 5

In the present study, we should generalize the facial feedback finding from Experiment 4 and implement an affect induction that can be more flexibly timed. To avoid confounding an affective prime with additional semantic meaning, valenced words could not be used to induce affect. Therefore, we chose pleasant and unpleasant faces as affective primes (e.g., Fazio and Dunton, 1997; Murphy & Zajonc, 1993; Winkielman & Berridge, 2004; Winkielman et al., 1997; Wong & Root, 2003).

An important question was the juncture at which the affect manipulation should be effective, that is, before, during, or after reading a given word triad. In our fluency–affect model of intuition, we assume that subtle changes in core affect are triggered immediately after reading. Therefore, we placed the affective prime immediately after the presentation of the word triad. Because we assumed that the manipulated change in core affect is interpreted to indicate coherence, we expected that a word triad that is followed by a positive affective prime would be more likely to be judged to be coherent than would a triad followed by a negative affective prime, irrespective of its actual coherence.

Method

Participants. Thirty (20 female, 10 male) non-psychology students participated for a reward of EUR 2 (approximately U.S.$2.50 at the time).

Material and procedure. Thirty-six photos of happy faces and 36 photos of sad faces (both from different persons) from Lundqvist, Flykt, and Öhman (1998) were used as facial primes. Thirty-six additional, neutral faces were used as masking stimuli (also from Lundqvist et al., 1998). Participants received the same instructions as in the general procedure. In addition, they were informed that portraits of persons would appear after each triad to indicate that the coherence judgment would be required. Modifying the general procedure, a randomly chosen facial prime (positive or negative) appeared in the center of the screen for 17 ms immediately after the offset of the triad's presentation and was then masked by a randomly chosen neutral face (see Milders, Sahraie, & Logan, 2008, for the problem of awareness of such facial primes). Because it was less likely that the affective information of the primes would enter into coherence judgments if the judgments were required immediately after the prime, the backward masking neutral face lasted for 350 ms before the 500 ms time window for the coherence judgment would begin. The prime stimulus was matched in size with an average triad (i.e., 4 × 4 cm on the screen). Since repetitious priming with the same affective face may have led to habituation and thereby diminished the priming effects (cf., Wong & Root, 2003), a new facial prime was chosen for each triad without repetition. Half of the coherent triads were followed by a positive face; the other half was followed by a negative face. The same was done for incoherent triads. The sequence of all 72 triads was rerandomized for every participant.

Debriefing. In a computer-directed debriefing, participants were first asked whether they had noticed any optical anomalies during the stimulus presentation. Then, they were asked more specifically whether they had seen happy or sad looking faces before the supraliminal portraits. No participant affirmed any of these questions.

Results

Missed responses. The numbers of missed responses within each condition are displayed in Table 1. Whereas no influence of conditions was found in the previous experiments, we found, conducting a 2 (coherence: coherent vs. incoherent triads) × 2 (valence: positive vs. negative facial prime) ANOVA with both factors as repeated measures, a main effect for coherence, $F(1, 689) = 5.25$, $p < .02$, $\eta_p^2 = .01$, but no other effects (other Fs < 1.5). A simple-slope test showed that from all missed responses, 55% were trials containing coherent triads, and 45% were from trials containing incoherent triads, $t(689) = 2.72$, $p < .02$. Because this small main effect of coherence effect was not replicated in the remaining experiments and did not yield any theoretical insight for the present purpose, we do not further interpret it.

Solved triads. We found that more negatively primed triads were solved, $t(39) = 2.33$, $p < .03$ (see Table 1).

Coherence judgments. In a 2 (coherence: coherent vs. incoherent triads) × 2 (valence: positive vs. negative facial prime) ANOVA with both measures repeated, we found main effects for both coherence, $F(1, 29) = 26.49$, $p < .0001$, $\eta_p^2 = .48$, and valence, $F(1, 29) = 12.79$, $p < .001$, $\eta_p^2 = .31$, but no interaction ($F < 0.2$). Post hoc tests within the coherent and incoherent triads revealed that positively primed coherent triads were judged coherent more often ($M = .34$, $SE = .03$) than were negatively primed coherent triads ($M = .26$, $SE = .03$), $t(29) = 2.54$, $p < .018$, and that positively primed incoherent triads were judged coherent more often ($M = .20$, $SE = .03$) than were negatively primed incoherent triads ($M = .10$, $SE = .02$), $t(29) = 3.62$, $p < .001$. The difference between negatively primed coherent and positively primed incoherent triads was not significant ($t < 1.4$).

Discussion

In this study, we manipulated participants' core affect by affective facial priming immediately after the processing of a word triad. Above and beyond the actual coherence of a triad, the prime valence influenced coherence judgments in the same direction as in Experiment 4. That is, positively primed triads were more frequently judged coherent than negatively primed triads. The finding that negatively primed coherent triads were solved more frequently than were positively primed triads was replicated in Experiments 5 and 6 and is discussed in the General Discussion.

One might object that the brief affect induction—although outside of awareness—did not induce a subtle change in affect that was used in the coherence judgment but rather did serve as a coherence-unspecific go signal for the participants. Let us elaborate on this idea: As can be seen in all previous experiments, participants chose the *coherent* option in the minority of trials, although it was known by participants that half the presented triads were coherent and half were incoherent. Even in the fluent or positive coherent conditions, the proportion of *coherent* responses fell below 50% (which would occur if a participant was randomly guessing). This indicates a conservative response bias (Snodgrass & Corwin, 1988). Given this, the response *coherent* can be seen as a risky choice that participants only chose when they were quite certain.

What does the literature indicate regarding the relations among mood, certainty, and risk? Happiness is related to certainty in judgments (e.g., Bodenhausen, Kramer, & Süsser, 1994; Smith & Ellsworth, 1985) and more liberal processing (e.g., Bless, Bohner, Schwarz, & Strack, 1990; Murray, Surjan, Hirt, & Surjan, 1990; Schwarz, 2002a), whereas sadness is related to uncertainty (e.g., Smith & Ellsworth, 1985; Tiedens & Linton, 2001) and more conservative processing (e.g., Bodenhausen, Sheppard, & Kramer, 1994). Furthermore, happiness decreases frequency ratings for risky events (Johnson & Tversky, 1983), risk perception (Lerner & Keltner, 2000), and risk assessment (Lerner & Keltner, 2001). Even more important, there is evidence that positive mood increases risk-taking tendencies (Forgas, 1995; Loewenstein, Weber, Hsee, & Welch, 2001), whereas sad mood reduces the tendency to take risks (e.g., Allen & Badcock, 2003; Chou, Lee, & Ho, 2007; Forgas, 1995; Jorgensen, 1998; Yuen & Lee, 2003). Given this abundant evidence, one might argue that triggering positive affect shortly before the judgment may have induced a more liberal response criterion in the participants, and inducing negative affect may have made the participants even more conservative—independently of the to-be-judged dimension of coherence. Experiment 6 should eliminate this possibility by making the *coherent* option the less risky choice.

Experiment 6

The intuitive coherence judgments that participants are asked to make seem to be a risky choice since participants show a conservative response bias by choosing the risky *coherent* option in fewer cases than the *mixed* option. Therefore, it is possible that positive affect has not entered judgments as information but may have led participants to dare the riskier *coherent* option (cf., Chou et al., 2007), irrespective of semantic coherence.

To rule out this interpretation, we made *coherent* the less risky option by reducing the number of incoherent triads and informing participants about that fact. Furthermore, we prompted participants to choose the *coherent* option by default by rewarding hits and punishing misses. If the affective prime only altered the choice behavior, positive primes should now increase the frequency of *mixed* responses (the risky response), whereas negative primes would increase the frequency of the dominant *coherent* responses. In contrast, our model predicts the same pattern as in the previous study, that is, an overall increase in judgments of coherence.

Method

Participants. Thirty (12 female, 18 male) non-psychology students participated for a reward of EUR 2 (approximately U.S.$2.50 at the time).

Material and procedure. Experiment 5 was replicated with the following modifications: Instead of presenting 36 coherent and 36 incoherent triads during the session, 36 coherent and 18 incoherent triads were randomly chosen from the triad pool, leading to a 2:1 ratio between coherent and incoherent trials. Participants were informed about that ratio. Furthermore, they were additionally told that they could gather points during the intuitive task to receive candy as extra compensation. They were told that they would earn 1 point each time they detected a coherent triad, however, they would lose 1 point whenever they missed a coherent triad. This instruction should prompt participants to press the *coherent* button by default, thus making this response the dominant and less risky one. After the experiment, every participant was told that he or she had gathered enough points and was given extra candy.

Debriefing. Again, no participant reported having detected any emotional faces.

Results

Solved triads. A planned comparison found that again, marginally more negatively primed triads were solved than positively primed triads, $t(66) = 1.63$, $p = .11$ (see Table 1).

Coherence judgments. Two participants were excluded from these analyses because they chose the *coherent* response in all trials. They obviously extracted the most rational rule for decisions because false alarms were not punished.

First, it was checked whether the information that more coherent than incoherent triads were presented did, in fact, increase participants' general tendency to judge a triad as coherent. For that purpose, the overall proportion of *coherent* judgments was compared with the overall proportion in Experiment 5. As expected, the overall proportion of *coherent* responses was reliably increased in this study ($M = .53$, $SE = .02$), as compared with Experiment 5 ($M = .23$, $SE = .02$), $t(58) = 10.37$, $p < .001$.

Although participants responded with *coherent* in more than half of the trials, we replicated both main effects, for coherence, $F(1, 29) = 12.92$, $p < .001$, $\eta_p^2 = .31$, and for valence, $F(1, 29) = 22.82$, $p < .001$, $\eta_p^2 = .44$, and again, failed to obtain an interaction ($F < 2$). Positively primed coherent triads were judged coherent more often ($M = .68$, $SE = .03$) than were negatively primed coherent triads ($M = .52$, $SE = .03$), $t(29) = 4.69$, $p < .001$, and positively primed incoherent triads were more likely to be judged coherent ($M = .48$, $SE = .04$) than were negatively primed incoherent triads ($M = .40$, $SE = .05$), $t(29) = 2.26$, $p < .031$. The difference between negatively primed coherent and positively primed incoherent triads was not significant ($t < 1$).

Discussion

The present experiment should rule out the alternative explanation that in Experiments 4 and 5, positive primes may have made participants more inclined to choose the more risky *coherent* option for a given triad (cf., Yuen & Lee, 2003). Reversing this possible response bias, we have turned the option *mixed* into the more risky option by presenting more coherent triads than incoherent triads and by rewarding hits and punishing misses. Nevertheless, positively primed triads were judged coherent more often than were negatively primed triads.

The subliminal priming paradigm used in Experiments 5 and 6 allows for the closer investigation of the relation between affective states (short-term affect as well as longer lasting mood, cf., Russell, 2003) and intuition. We manipulated the affective state after the semantic processing of a triad because our model predicts that at this juncture in the intuitive chain, affect comes into play. This approach is different from earlier conceptions about mood and intuition in which the impact of mood on semantic spread was analyzed (e.g., Baumann & Kuhl, 2002). There, affect comes first and has an impact on semantic processing. In the next study, we tried to relate both approaches by simply priming affect before a triad was read.

Experiment 7

This study addressed the interplay between affect and intuition by relating our fluency–affect account of intuition to the earlier affect-modulation hypothesis by Kuhl (2000). In the studies by Baumann and Kuhl (2002) and Bolte et al. (2003), the intuitive discrimination between coherent and incoherent word triads was increased by inducing positive mood and was decreased by inducing negative mood. The authors explained both findings with the affect-modulation hypothesis by Kuhl (2000), which states that positive mood promotes the spread of semantic activation in associative networks, whereas negative mood restricts the spread of semantic activation. In the case of negative mood, "remote associates are not sufficiently activated to guide intuitive coherence judgments" (Kuhl, 2000, p. 420). From the perspective of our account, this would mean that in a negative mood, semantic spread does not partially activate the common associate. Thus, the fluency in reading the triad is not increased, and no subtle positive affect is triggered.

In the experiments that we have presented so far, the affect manipulation took place after the semantic processing of the triad, that is, after the activation had spread and eventually converged onto the common associate. This undermines the interpretation that the affect induction may have altered the activation spread itself. Therefore, the affect-modulation hypothesis (Kuhl, 2000) does not account for the present effects (see the General Discussion for a thorough integration of these arguments).

However, by manipulating affect before the semantic processing of a triad, we wanted to test the influence of affect on semantic spread that is predicted by the affect-modulation hypothesis. This simple experimental modification also allowed us to relate our model to the affect-modulation hypothesis. Specifically, Kuhl's (2000; see also Baumann & Kuhl, 2002) notion assumes that positive affect enhances semantic spread so that the common associate receives higher converging activations. Recently, this was actually shown by Bolte and Goschke (2008). In the case of coherent triads, this implies that positive affect would increase the frequency of *coherent* responses, whereas negative affect would decrease such responses because the common associate of coherent triads is more activated under positive affect than under negative affect. However, in the case of incoherent triads, there is no common associate to be activated. Although activation spread would be enhanced under positive affect and would be restricted under negative affect, the semantic activation would not converge on a common associate. As a consequence, the positive affect induction would have no impact on the coherence judgments for incoherent triads. In contrast, we argue that the induced affect is used for both coherent and incoherent triads. Thus, an affect induction before processing the triad would contribute to coherence judgments for both coherent and incoherent triads.

Method

Participants. Thirty (19 female, 11 male) non-psychology students participated for a reward of EUR 2 (approximately U.S.$2 at the time).

Material and procedure. We replicated Experiment 5, except that facial primes and masks occurred not after, but rather immediately before, the word triad.

Debriefing. Again, no participant identified the affective primes.

Results

Solved triads. Again, marginally more negatively primed triads were solved than positively primed triads, $t(40) = 1.42$, $p = .16$.

Coherence judgments. We replicated the main effects for coherence, $F(1, 29) = 7.45$, $p < .011$, $\eta_p^2 = .20$, and valence, $F(1, 29) = 14.70$, $p < .001$, $\eta_p^2 = .34$, but there was no interaction ($F < 0.4$). Post hoc comparisons within the coherent and incoherent trials revealed that positively primed coherent triads were judged coherent more often ($M = .30$, $SE = .03$) than were negatively primed coherent triads ($M = .21$, $SE = .03$), $t(29) = 3.23$, $p < .003$, and that positively primed incoherent triads were judged coherent more often ($M = .21$, $SE = .02$) than were negatively primed incoherent triads ($M = .15$, $SE = .02$), $t(29) = 3.18$, $p < .004$. Again, the difference between negatively primed coherent and positively primed incoherent triads was not significant ($t < .01$).

Discussion

By inducing a short positive or negative core affect before the semantic processing of a word triad, we were able to test whether this affect manipulation influences judgments via altering semantic spread onto the common associate or via changing the affective basis of the judgment itself. If the affect manipulation would have had no impact on incoherent triads or would have had at least a smaller impact, this would favor the interpretation of the affect-modulation hypothesis (Kuhl, 2000), which states that affect alters the semantic spread onto the common associate. Because no common associate exists for incoherent triads, affect cannot change coherence judgments for these triads. On the contrary, we found a similar influence of affect in coherent and incoherent triads, which was predicted by the fluency–affect account. That is, the experimentally induced affect added to the fluency-triggered affect, whether or not the given triad was coherent.

To be clear, we do not claim that the affect-modulation hypothesis is wrong; rather we point out that it cannot account for our results. Because these findings have strong implications for our understanding of the interplay between affective states and intuition, we discuss this in more detail in the General Discussion.

Experiment 8

Thus far, we have demonstrated that both phasic facial feedback and affective stimuli influence intuition by feeding affective information into the coherence judgment. In the present experiment, we wanted to generalize these findings by using a third technique of affect manipulation, which additionally allowed us to test whether individuals are able to correct for the induced affect.

Specifically, we wondered whether the induced affect would also alter coherence judgments if the (mis)leading affective information arose not from an external source (facial feedback or an interjected prime) but rather from the triad itself. In other words, what would happen if the words of a given triad were themselves affectively charged? Would a coherent triad that is made up of negative words be judged as coherent (due to the fluency-derived positive affect its coherence elicits) or as incoherent (because of the negative affect that its constituents evoke)?

To address this question, word valence and triad coherence were orthogonally varied. Affectively valenced words were already shown to alter fluency-based judgments: Phaf and Rotteveel (2005) found that words surrounded by positively valenced context words were judged to be familiar more frequently than were words surrounded by negatively valenced context words. Given this, it was expected that independent of their semantic coherence, triads consisting of positive words would more likely be judged to be coherent than would triads consisting of negative words.

Furthermore, we wanted to test whether individuals are able to discount the affective content of triads' words in their coherence judgments. For this purpose, one group of participants (noncorrecting control group) was instructed only to intuitively judge the coherence of the presented triads. However, another group (correcting group) was explicitly informed that positive and negative words were randomly distributed over coherent and incoherent triads and were instructed to only judge coherence but to correct for the affective content of the triads. From earlier works on judgmental correction, it is known that individuals are able to eliminate or even counteract intrusive influences that are not relevant for the judgment at hand (e.g., Jacoby & Whitehouse, 1989; Martin, Seta, & Crelia, 1990; Murphy & Zajonc, 1993; Strack, Schwarz, Bless, Kubler, & Wänke, 1993; Wilson & Brekke, 1994; but see also Payne, Cheng, Govorun, & Stewart, 2005; Winkielman et al., 1997). As a consequence, we hypothesized that the impact of triads' valences should be weaker in the correcting group than in the control group.

Method

Participants. Sixty (38 female, 22 male) non-psychology students participated for a reward of EUR 1 (approximately U.S.$1 at that time).

Material. A pool of 14 positive and 14 negative coherent word triads was created containing valenced words, ensuring that the valence of the implied solution concept did not substantially differ between positive and negative triads. Because valenced clues were likely to encircle targets of the same valence (*WHITE, TURKEY, GIFT* converges on *CHRISTMAS*), we used two compensatory ways to create the triads: One was to create a positive and a negative triad for the same neutral common denominator (e.g., *WATER* is implied by *FRESH, HOLY, LIQUID* as well as by *SALT, DROWN, RAIN*). Another way was to find triads that implied a target of the opposite valence (e.g., the positive triad *SURVIVE, RESCUE, CAR* converges on the negative target *ACCIDENT*, the negative triad *BURN, GLASSES, DAZZLE,* converges on the positive target *SUN*). To control for repeating effects of single words, each triad constituent was only used once.[3]

To obtain explicit ratings of the valence of these triads, a questionnaire containing all 84 triad words and 28 target words in a random order was compiled. The questionnaire was handed out to 25 undergraduate psychology students who were asked to spontaneously rate the valence of each single word on a 7-point Likert scale ranging from *very negative* (−3) to *very positive* (+3). A planned comparison of mean ratings revealed that the word constituents of positive coherent triads were rated as more positive ($M = 1.7$, $SE = .32$) than were the constituents of negative triads ($M = -0.30$, $SE = .25$), $t(24) = 7.21$, $p < .0001$, whereas the ratings for the targets did not differ reliably between positive and negative triads ($t < 1.6$).

Positive incoherent word triads were derived from the positive coherent triads by simply intermixing the constituents and assuring that no new associative coherences emerged, as was also done with the negative coherent triads to obtain negative incoherent triads. To control for possible new solution words for these incoherent triads, we let four groups of five raters each generate solution candidates for all incoherent triads. No solution was found that received the consent of all group members.

Moreover, it was important to assure that coherent and incoherent triads did not differ in the interrelatedness among the triad constituents, since this could be an alternative cue for coherence (cf., Bolte & Goschke, 2005). Furthermore, positive and negative triads should also not differ in their interrelatedness, since this could be confounded with the affect manipulation. Thus, 20 undergraduate students judged the pairwise relatedness among the three constituents of all 56 triads on a 5-point scale ranging from 1 (*not related at all*) to 5 (*highly related*); see Bolte & Goschke, 2005). Thus, three relatedness judgments were obtained and averaged for each triad. The means of these averaged ratings were 2.38 ($SD = 0.70$) for coherent, 2.29 ($SD = 0.88$) for incoherent, 2.42 ($SD = 0.65$) for positive, and 2.44 ($SD = 0.79$) for negative triads, across which were no reliable differences (ts < 0.5).

Procedure. The general procedure was replicated, except for the use of valenced triads instead of neutral triads. In the control group, the valence of triads was not mentioned in the instructions. In the correcting group, the following instructions were added:

> Please note that positive and negative words are randomly interspersed in the following triads. Thus, the appearance of positive or negative words is entirely unrelated to the coherence of a given triad. Please try to judge the coherence of the triads independently of their emotional meaning!

Results

Solved triads. No effect on the number of solved trials was found, $t(99) < 0.40$ (see Table 1).

Coherence judgments. Over the remaining trials, we conducted a 2 (judgment group: noncorrecting control instruction vs. correcting instruction) × (coherence: coherent vs. incoherent triads) × 2 (valence: positive vs. negative triads) ANOVA, with the first factor as a between-subjects factor. We found two strong main effects for coherence, $F(1, 58) = 105.95$, $p < .001$, $\eta_p^2 = .65$, and for valence, $F(1, 58) = 189.24$, $p < .001$, $\eta_p^2 = .77$. We also found an interaction between coherence and valence, $F(1, 58) = 27.05$, $p < .001$, $\eta_p^2 = .32$. No effect of judgment group was found, and no further interactions were found (Fs < 2). Post hoc comparisons indicated that valence exerted its influence for both coherent and incoherent triads. Positive coherent triads were judged to be coherent more often ($M = .55$, $SE = .03$) than were negative coherent triads ($M = .23$, $SE = .02$), $t(59) = 11.20$, $p < .0001$, and positive incoherent triads were judged to be coherent more often ($M = .25$, $SE = .02$) than were negative incoherent triads ($M = .11$, $SE = .01$), $t(59) = 7.36$, $p < .0001$. To test whether the discrimination of coherence was affected by valence, we also tested the differences between coherent and incoherent triads within each valence, which were also highly significant both for positive trials, $t(59) = 9.09$, $p < .0001$, and negative trials, $t(59) = 6.31$, $p < .0001$. The difference between negative coherent and positive incoherent triads did not reach significance ($t < 1.11$). This overall pattern shows that the interaction between coherence and valence is due to an even more highly increased impact of affect for coherent triads.

Discussion

We replicated the impact of affective information on intuitions of coherence by using affect-laden word triads in coherence judgments. That is, positive word triads were judged to be coherent more frequently than were negative word triads, independent of their actual coherence. This time, the impact of valence even exceeded the impact of coherence.

Throughout studies 1–7, we found no statistical difference between detrimentally manipulated coherent triads and advantageously manipulated incoherent triads (e.g., negatively primed or nonfluent coherent and positively primed or fluent incoherent triads). Therefore, we could not conclusively interpret these findings because descriptively, the coherent triads were still judged to be coherent more frequently than were the incoherent ones, and the absence of a significant difference could be due to insufficient power. However, in this study, descriptively, positive incoherent triads were judged to be coherent more frequently than negative coherent triads. Thus, the claim seems justified that the present manipulation made the probabilities to be judged as coherent equal for both types of triads. We disrupted the intuitive chain since participants seem to have lost their ability to intuitively discriminate between coherent and incoherent triads.

The finding that the influence of affect was more pronounced in coherent triads may be explained with the affective modulation of

[3] Because incoherent triads were constituted from the same words (see below), each word actually occurred twice during the experimental session.

semantic spread (Kuhl, 2000; Storbeck & Clore, 2005). Although we ruled out an influence of phasic affect on semantic spread for the affect manipulation of subliminal facial priming in Experiment 7, the affect manipulation of triad constituents' valence may have been strong enough not only to feed affect into the intuitive chain but also to alter the semantic processing of the triad. This seems plausible since affect-laden triads obtained an effect size of $\eta_p^2 = .77$ in the present experiment, whereas the subliminal facial priming methods only yielded the maximal effect size of $\eta_p^2 = .44$ (Experiment 6). Thus, the induction of positive affect fostered semantic spread (c.f. Bolte et al., 2003; Isen et al., 1987) and increased coherence detection for triads with positive valence, compared with triads with negative valence.

Surprisingly, participants in the correcting group were unable to correct their coherence judgments for the affective content of the triads. Although participants were explicitly instructed to discount the valence, it continued to influence their judgments above and beyond the actual coherence. To determine the strength of this robust effect, we computed Cohen's effect size by subtracting the proportion of *coherent* judgments for positive triads from the proportion of *coherent* judgments for negative triads and dividing that difference by the pooled standard deviation. Whereas an effect size of 0.80 or greater is conventionally considered to be large, the effect size for incoherent triads was 1.17, and the effect size for coherent triads was even 1.54. This finding resembles the inability of participants in Payne et al. (2005, Experiments 1 and 2) to correct for the influence of affect-laden pictorial stimuli that were presented shortly before the evaluation of a neutral Chinese ideograph.

The final support for our fluency–affect account for coherence intuitions would be whether our manipulations could actually reverse the judgments and cause the incoherent triads to be judged to be coherent more frequently than are coherent triads. For this purpose, the next experiment pits fluency and affect against coherence in order to ultimately invert the output of the intuitive chain.

Experiment 9

In this experiment, we wanted to manipulate both automatic links in the intuitive chain, that is, fluency and affect. Our account assumes that fluency and affect both vary independently on relative levels (cf., Russell, 2003; Russell & Feldman-Barrett, 1999; Whittlesea, 1993) but jointly feed into the eventual intuition. This assumption is supported by a recent finding by Phaf and Rotteveel (2005) who found a joint impact of fluency and affect on familiarity ratings. If this finding also applies to intuition, then a joint manipulation of fluency and affect should influence coherence judgments in an additive fashion (cf., e.g., Whittlesea, 1993, Experiment 5, for an additive impact of different fluency sources). This means that a manipulation of affect, although the affective link is assumed to procedurally follow the fluency link, would add to the fluency impact, but would not override it.

To test these assumptions, we combined two effective manipulations of fluency and affect from the previous experiments in applying different figure–ground contrasts with lighter and darker colors (Experiment 1) on affect-laden word triads (Experiment 8). We expected coherence, valence, and fluency to independently but jointly contribute to coherence judgments.

Method

Participants. Thirty-five (22 female, 13 male) non-psychology students participated for a reward of EUR 1 (approximately U.S.$1).

Material and procedure. Experiment 8 was replicated with affect-laden word triads and the explicit instruction to discount the valence from coherence judgments. Half the triads were presented in low figure–ground contrast; the other half was presented in high figure–ground contrast (using the fluency manipulation from Experiment 1). The triads' assignment to contrast and sequence of triad presentation was rerandomized for each participant.

Results

Missed responses. The numbers of missed responses are shown in Table 2. Running a 2 (coherence: coherent vs. incoherent triads) × 2 (fluency: high vs. low contrast) × 2 (valence: positive vs. negative triads) repeated measures ANOVA yielded an interaction between fluency and valence, $F(1, 287) = 6.62$, $p < .02$, $\eta_p^2 = .02$, but no other effects (other Fs < 2.6). Because this effect was small and not replicated and the pattern cannot provide an alternative explanation for the aligned effects of fluency and valence on intuitions (see below), we do not further interpret this effect.

Solved triads. The number of solved trials per condition are shown in Table 3. A 2 (fluency: high vs. low contrast) × 2 (valence: positive vs. negative word triads) repeated-measures ANOVA that was conducted over the individual 67 trials in which a triad was correctly solved revealed no effects (Fs < 0.4).

Coherence judgments. A 2 (coherence: coherent vs. incoherent triads) × 2 (fluency: high vs. low contrast) × 2 (valence: positive vs. negative word triads) repeated measures ANOVA revealed three strong main effects: for coherence, $F(1, 34) = 72.17$, $p < .0001$, $\eta_p^2 = .68$, for fluency, $F(1, 34) = 18.92$, $p < .0001$, $\eta_p^2 = .36$, and for triad valence, $F(1, 34) = 78.74$, $p < .0001$, $\eta_p^2 = .70$. This time, a marginal interaction was found between coherence and valence, $F(1, 34) = 2.39$, $p < .13$. As can be seen in Table 4, this interaction implies that the effect of valence was less pronounced for incoherent triads, probably due to a floor effect. Much more important, a planned comparison revealed that positive incoherent triads presented in a high figure–ground contrast were more likely to be judged coherent ($M = .34$, $SE = .03$) than were negative coherent triads presented in a low figure–ground contrast ($M = .24$, $SE = .03$), $t(34) = 3.35$, $p < .002$).

Table 3
Number of Solved Items as a Function of Experimental Condition for Experiments 9–10

Experiment	Positive		Negative	
	Fluent	Nonfluent	Fluent	Nonfluent
Experiment 9 (1,960 trials)	19	15	17	16
Experiment 10 (1,800 trials)	16	23	18	6

Table 4
Probability of Being Judged Coherent (Grammatical) as a Function of Veridical coherence (Grammaticality), fluency, and Affect In Experiments 9–11

	coherence: Grammaticality															
	Coherent/Grammatical								Incoherent/Agrammatical							
	Positive				Negative				Positive				Negative			
	Fluent		Nonfluent		Fluent		Nonfluent		Fluent		Nonfluent		Fluent		Nonfluent	
Experiment	Probability	*SD*	Probability	*SD*	Probability	*SD*	Probability	*SD*	Probability	*SD*	Probability	*SD*	Probability	*SD*	Probability	*SD*
Experiment 9	.58	.24	.47	.28	.33	.22	.24	.18	.34	.17	.25	.19	.14	.17	.10	.12
Experiment 10	.55	.25	.49	.21	.50	.18	.49	.32	.43	.26	.34	.17	.38	.29	.21	.20
Experiment 11	.63	.23	.56	.25	.55	.23	.48	.27	.53	.15	.36	.13	.45	.26	.33	.22

Discussion

This study addressed the joint effect of fluency and affect on intuitive judgments of semantic coherence by manipulating figure–ground contrast and affective content of the triads simultaneously. As expected, the fluency of reading a triad, its affective content, and its actual coherence additively contributed to the eventual coherence judgment.

Finally, we were able to sabotage the intuitive chain by pitting fluency and affect against the triads' actual coherence, thus generating an illusion of coherence (cf., for memory and truth illusions, Begg, Anas, Farinacci, 1992; Jacoby & Whitehouse, 1989; Reber & Schwarz, 1999; Whittlesea, Jacoby, & Girard, 1990). Not only did people did not only lose their ability to practice intuitive discrimination but also their intuitions became completely misguided. That is, incoherent triads that were positively laden and fluently processed were judged to be coherent more frequently than were coherent triads that were negatively laden and nonfluently processed. The next two experiments should extend the present approach to two types of intuitive judgments in other domains, namely intuitions concerning visual coherence and implicit grammaticality.

Experiment 10

This experiment should generalize the present approach to intuitions in another domain, namely intuitions of visual coherence (Bowers et al., 1990). In their pioneering work, Bowers et al. (1990) developed a gestalt closure task in which they used pictures of everyday objects that were visually degraded and fragmented to such a degree that the objects could only rarely be identified (yet the visual gestalt was coherent). Nevertheless, when participants were confronted with these blurred, yet gestalt-like pictures together with pictures that only contained random visual information and no gestalt-like objects at all (incoherent), they detected the pictures depicting blurred but real objects above chance, independently of actually identifying the depicted objects (see, for a replications, Volz & von Cramon, 2006; Wippich, 1994).

We wanted to manipulate these intuitions using fluency and affect. A first approach to this was already made by Wippich (1994), exploiting fluency induced by repeated exposure. In the study phase of that experiment, participants were exposed to either some coherent drawings or some incoherent drawings. Then, they had to watch pairs of coherent and incoherent drawings (both previously presented and new stimuli) and were asked to make a forced-choice decision about which of the two drawings represented a real object (discarding trials in which the coherent objects were correctly identified; cf., Bowers et al., 1990). The result was that incoherent drawings were more likely to be selected as coherent when they had been presented before. However, fluency did not exert any influence on coherent drawings.

Let us briefly speculate about why this occurred. In the preexposure phase, participants had to study each drawing for 5,000 ms, and they were asked to produce free associations to each drawing, which is likely to establish an explicit memory of the drawings. Later in the intuitive task, when confronted again with the preexposed stimuli, participants may have recognized the stimuli from the study list. Because we know from different domains that coherent stimuli are memorized better than are incoherent stimuli (Miller, 1958; Topolinski & Strack, 2008; Zajonc & Burnstein, 1965), it is likely that preexposed coherent drawings were more often recognized than were preexposed incoherent drawings. Given earlier research on attribution processes and memory (e.g., Jacoby, Kelley, Brown, & Jasechko, 1989), it is likely that participants who recognized that the current stimulus was repeated reattributed their fluency experiences to the earlier encounter, and discounted fluency from their intuitive judgments. Thus, predominantly for coherent drawings, participants reattributed fluency to an earlier exposure, rendering fluency ineffective. The present study should avoid recognition of preexposed pictorial stimuli by decreasing preexposure time. Additionally, it should implement the subliminal facial priming as an affect induction.

Method

Pilot study. First, we developed and tested a set of pictorial stimuli that were useful for intuitive judgments because they were so degraded that they could only rarely be visually recognized (Bower et al., 1990). We used 30 black-and-white drawings of everyday objects randomly chosen from the inventory by Snodgrass and Vanderwart (1980), with the only constraint being that depicted objects were visually not too simple (e.g., a circle). Following Volz and von Cramon (2006), these stimuli were visually degraded by a filter that masked the black picture on the white background by increasing the white pixels by 75%. These pictures were the object condition (Volz & von Cramon, 2006) since they depicted visually degraded real objects. Then, these pictures were divided into nine equal rectangles (3 × 3); and these rectangles were randomly rotated within the picture (Volz & von Cramon, 2006; cf., Bower et al., 1990; Wippich, 1994). Thus, these pictures contained the same pixel information as in the object condition and even contained local collinearities (Volz & von Cramon, 2006), but the picture as a whole depicted a physically impossible and thus meaningless object. These pictures were used in the nonobject condition.

The 30 object and 30 nonobject pictures were printed on a paper questionnaire containing six pictures per page and a blank line beneath each picture. These questionnaires were delivered to 40 undergraduate students who were asked to try to identify the depicted objects for course credit. The task was self-paced. It turned out that participants identified the pictures correctly in 42 of the cases (of course, only for object pictures), which was 3.5% of the object items. Since this proportion is similar to the percentage of solved word triads in the previous experiments (consult Table 1), the stimulus set seemed blurred enough to be suitable for an intuitive task.

Participants. Thirty (22 female, 8 male) non-psychology students participated for a payment of EUR 4 (approximately U.S.$6 at the time).

Material and procedure. Experiment 7 was replicated (the general procedure applying subliminal facial primes directly before the onset of the target pictures), except for three modifications. First, the 30 object and 30 nonobject pictures were used instead of word triads. Second, half the pictures were presented to participants before the intuitive task. They were told that this would be a relaxation phase to familiarize them with the laboratory and were asked to simply watch the appearing pictures, which were presented for 250 ms each with an interstimulus interval of 250 ms, which was intended to reduce the likelihood that participants would recognize the pictures later in the intuitive task. The pictures were randomly chosen for each participant. Third, during the intuitive task, the pictures were shown for 1,000 ms (instead of 1,500 ms for the triads) since visual perception of a picture occurs more quickly than reading three words (Palmer, 1999).

Results

Identified pictures. The numbers of trials with object stimuli that were identified are shown in Table 3. With a 2 (fluency: old pictures vs. new pictures) × 2 (valence: positive vs. negative facial primes) repeated measures ANOVA, we detected a marginal main effect of valence, $F(1, 63) = 3.72$, $p = .058$, and an interaction between fluency and valence, $F(1, 63) = 6.20$, $p < .015$, $\eta_p^2 = .09$. Although interesting, this pattern cannot account for the aligned effects of fluency and valence in intuitions (see below; see also the discussion concerning item selection below).

Visual coherence judgments. For participants' judgments regarding whether the presented picture depicted a real object, a 2 (visual coherence: object vs. nonobject pictures) × 2 (fluency: old pictures vs. new pictures) × 2 (valence: positive vs. negative facial primes) repeated measures ANOVA was run. We found main effects of visual coherence, $F(1, 29) = 37.97$, $p < .001$, $\eta_p^2 = .57$, fluency, $F(1, 29) = 13.07$, $p < .001$, $\eta_p^2 = .31$, and valence $F(1, 29) = 8.99$, $p < .01$, $\eta_p^2 = .24$, and no interactions (Fs < 2.1). Means for all conditions are shown in Table 4.

Discussion

We extended the present fluency–affect approach to intuitions of visual coherence (Bowers et al., 1990). Replicating the pattern from Experiment 9, we found that in addition to participants' sensitivity to veridical visual coherence, increased fluency of pictures induced by repeated exposure and phasic positive affect while perceiving the pictures reliably increased the likelihood that the pictures would be judged to be visually coherent. Finally, the present fluency–affect approach should be applied to yet another domain of intuitive judgments, namely, hunches in implicit grammar learning.

Experiment 11

As a final generalization of the present fluency–affect account of intuition, we addressed what is surely the most classical domain of intuitive judgments, namely, intuitions concerning implicit artificial grammars (Reber, 1967). In these tasks, targets are letter strings that either conform to a complex, artificial finite state grammar or do not (Reber, 1967, 1993). In a study phase, participants are exposed to grammatical strings. In a subsequent test phase, they receive novel strings that either conform to the underlying grammar from the study set or do not and are asked to intuitively judge the grammatical correctness. It has been repeatedly shown that individuals are able to detect grammaticality above chance without being able to verbally report the rules underlying the grammar (please see Pothos, 2007, for a recent review).

It is plausible that the fluency–affect link also applies to this intuitive faculty because of the following empirical hints. First, grammatical strings are memorized better (Miller, 1958) and processed faster (Buchner, 1994) than agrammatical strings. Second, grammatical strings are liked more than agrammatical strings in preference judgments (Gordon & Holyoak, 1983; Newell & Bright, 2001). These findings imply that grammaticality increases fluency and positive affect, which may be the internal cues for intuitively judging grammaticality (see Reber et al., 2004, for an extensive discussion of this; see also Servan-Schreiber & Anderson, 1990; but also see Perruchet & Pacteau, 1990; and Vokey & Brooks, 1992, for the influence of explicit recognition). Thus, it is likely that a manipulation of fluency and affect can also alter grammaticality judgments.

A step in that direction was recently taken by Kinder et al. (2003). They let participants quickly memorize a set of grammatical strings in a study phase. Later, they presented novel (a)grammatical letter strings in a test phase in which participants were to indicate the grammaticality of each string. The perceptual fluency of these test strings was experimentally altered by a visual clarification paradigm in which white pixels on a white background started to turn into blue pixels at random positions at a constant rate, so that a blue letter string became more and more visible. Most important, the color change rate was faster for one group of items (fluent) than for the other (nonfluent). As a result, although not reliably for all conditions, faster clarifying items were in general judged to be grammatical more often than were slower clarifying items, which implies a causal impact of fluency on intuitions of grammaticality.

The present study should generalize this finding by implementing a different fluency manipulation (figure-ground contrast) and should extend it by additively manipulating affect (via subliminal facial primes).

Method

Participants. Thirty (22 female, 8 male) non-psychology students participated for a payment of EUR 4 (approximately U.S.$6 at the time).

Material and procedure. The stimulus set published in Vokey and Brooks (1992) was used (which was also implemented by Kinder et al., 2003). The training items consisted of 16 grammatical strings. The test items consisted of 32 different grammatical and 32 agrammatical letter strings. The length of strings varied between three and seven letters. The strings were displayed in the center of the PC screen in letters 1.5 cm high.

The study phase was described as a memory experiment to participants. Each training item was presented for 3,000 ms. Following offset of the letter string, participants were asked to type in the string on the keyboard. If they succeeded in reproducing the item correctly, the next training item followed. If they failed, the current item was repeated until they succeeded. All training items were presented three times in a random order (note that this procedure is similar to the study phase in Kinder et al., 2003, except that they showed the training items four times).

Then, the test phase started in which participants were informed that the study items had conformed to a hidden rule and that they had to judge new items concerning whether these also conformed to the rule or were random. Then, 32 novel grammatical and 32 novel agrammatical strings were presented in a random order.[4] These items were presented in either a high figure–ground contrast or a low figure–ground contrast (like the fluency manipulations in Experiments 1 and 9) and were preceded by either a positive subliminal facial prime or a negative subliminal facial prime (like the affect manipulation in Experiment 7). Each trial started with a fixation cross for 1,500 ms, followed by the affective facial prime for 17 ms, which was masked with a neutral face for 350 ms. Then the letter string appeared, and participants had to judge grammaticality by striking the appropriate key. No response time window was implemented; the response was self-paced. They were told that the face was a signal that the next letter string was about to appear. The next trial started with a delay of 3,000 ms after the response.

Results

Response latencies were, on average, 1,890 ms long (SD = 1,277). Only responses made within 3,000 ms after letter-string onset were included in the analyses, which was true for 86% (this drop out of 14% of the data is relatively small compared with the previous experiments in which up to 30% of responses were lost due to the response time window technique.[5] Over these judgments, a 2 (grammaticality: grammatical vs. agrammatical letter strings) × 2 (fluency: high vs. low contrast) × 2 (valence: positive vs. negative facial primes) repeated measures ANOVA was conducted. We obtained main effects of grammaticality, $F(1, 29) = 65.54$, $p < .001$, $\eta_p^2 = .69$, fluency, $F(1, 29) = 8.70$, $p < .001$, $\eta_p^2 = .23$, and valence, $F(1, 29) = 5.20$, $p < .04$, $\eta_p^2 = .15$. No interactions were found (Fs < 1.6). Consequently, planned comparisons showed that grammatical items were more likely to be judged grammatical ($M = .55$, $SE = .02$) than were agrammatical items ($M = .41$, $SE = .01$), $t(29) = 8.10$, $p < .001$; items presented in high contrast were more likely to be judged grammatical ($M = .54$, $SE = .02$) than were items presented in low contrast ($M = .43$, $SE = .02$), $t(29) = 2.95$, $p < .01$; and items preceded by positive primes were also more likely to be judged grammatical ($M = .52$, $SE = .02$) than items preceded by negative primes ($M = .45$, $SE = .02$), $t(29) = 2.28$, $p < .04$ (the means for each condition are shown in Table 4). Descriptively, nonfluent and negatively primed grammatical items were judged to be grammatical ($M = .48$, $SE = .05$) less often than were fluent and positively primed agrammatical items ($M = .53$, $SE = .03$); however, this difference was not reliable ($t < 1$).

Discussion

Generalizing the present fluency–affect account to the domain of implicit grammar learning, we systematically influenced judgments of grammaticality by manipulating fluency (cf., Kinder et al., 2003) and phasic affect in perceiving (a)grammatical letter strings. We obtained an even clearer pattern than for coherence intuitions. Although participants were still highly sensitive to the grammaticality of the novel strings, they more often judged letter strings to be grammatical when these were presented in high contrast, as compared with low contrast, and were preceded by a positive prime, as compared with a negative prime. In contrast to Kinder et al. (2003), who did not obtain reliable fluency effects within each condition (especially a lack of effect for new agrammatical strings, see Kinder et al., 2003, Experiments 1–2), the present fluency induction reliably exerted its influence on intuitions additively to actual grammaticality in all conditions (see Table 4).

Item Selection Due to Missed Responses and Solved Trials

Before we go to the General Discussion, an important methodological factor possibly confounding with the present manipulations shall be ruled out, which is item selection. The present data preparation entailed two phases of item selections. First, we first discarded all responses that were not made within the provided response window of 500 ms after offset of the target stimulus (which does not apply to Experiment 11, in which we cut off responses with latencies longer than 3,000 ms). This selection concerned both coherent (grammatical) and incoherent (agrammatical) trials. Second, we discarded all trials in which participants generated the correct solution concept for the given triad or picture

[4] Only novel (a)grammatical strings were shown—no old strings were shown, as was done in Kinder et al., 2003—because we wanted to implement only one systematic manipulation of fluency, that is, the figure–ground contrast. The presentation of old items would have provided no additional theoretical insight for the present claims.

[5] For intuitive judgments made after 3,000 ms, we did not find the congruent effects of fluency and affect as reported for the fast responses. However, we also did not find any effects of grammaticality for those slower responses. This suggests that these slower responses were driven by more deliberate processes that are not sensitive to grammaticality and do not qualify as intuition.

(which does not apply to the letter strings in Experiment 11, in which no solutions can be retrieved), which led to an additional dropout. This second selection concerned only coherent (grammatical) trials. The numbers of trials discarded are presented in Tables 1–3 for each experiment and each condition. By means of these tables, the numbers of trials that remained in the analyses can be calculated. Experiment 5, for example (Table 1), yielded 2,160 trials overall, of which half are coherent, and a quarter are coherent positive trials (540). From these positive coherent trials, 169 trials were discarded because the participant had missed the response time window, and additionally, 13 trials were discarded because the participant had solved the triad. Thus, the condition positive coherent included 358 trials. In the condition negative incoherent (again, 540 overall), 153 trials were missed responses, and no trial was solved (because incoherent triads can by definition not be solved). Thus, the condition negative incoherent included 387 trials.

These selections may be confounded with item difficulty in the following ways. First, we discuss the case of missed responses. Consider the process of reaching a decision concerning coherence (or grammaticality) in the intuitive judgment task. Because incoherence cannot be detected with certainty (there always might be an overlooked solution), trying to verify coherence is a more functional strategy. Thus, it is likely that participants scan for the criterion coherence. The difficulty of items may vary in the time it takes participants to verify that criterion of coherence (cf. Bowden & Jung-Beeman, 2003). Thus, in trials containing items that are easily assessed as coherent (easy items), participants may well reach the decision within the short response time window. However, in trials with stimuli for which coherence is harder to detect (hard items), participants may not come to a decision within time and may thus miss the response. Consequently, trials with missed responses may have contained the more difficult items, which are then excluded by our data preparation. If, for example, in the positive affect condition, participants missed more trials than in the negative condition, more trials remained in the positive condition for which coherence is easy to be detected. Then finding that participants more often indicated coherence in the positive condition than in the negative condition would be a trivial finding. However, across the experiments, we did not find any systematic differences in the number of missed responses between the experimental conditions that can account for the effects on intuition.

Furthermore, the discarding of solved trials may confound with item difficulty in, however, the opposite direction. Word triads for which the common associate is more likely to be retrieved are the easier items (cf., Bowden & Jung-Beeman, 2003); thus, the more triads that are solved and discarded in one condition, the more difficult are the remaining items. Again, we did not find systematic effects of the experimental manipulations on the frequency of solved trials that could explain the present effects. Although Experiments 1, 3, 8, and 9 did not show any differences between conditions, the remaining experiments showed inconsistent patterns. In Experiment 2, more items were solved in the fluent, compared with the nonfluent, condition, leaving more difficult items in the fluent condition. In Experiment 4, more items were solved in the positive, compared with the negative, condition, leaving more difficult items in the positive condition. These effects run against the found effect that triads in fluent and positive conditions were more likely to be judged coherent. In Experiments 5–7, marginally more items were solved in the negative, compared with the positive, condition, leaving more difficult items in the negative condition. These differences are the only confound candidates we identified. However, consider that discarded solved trials cannot appear in incoherent triads, since only coherent triads can be solved. If the valence effects on intuitions in Experiment 5–7 would have occurred because the negative conditions contained more difficult items due to the discarding of solved trials, then this could only apply to coherent triads. Nevertheless, we also found reliable differences within incoherent triads in all three experiments, which renders this alternative explanation unlikely.

General Discussion

In the present work, we investigated the processes underlying intuitive judgments, predominantly for the case of hidden semantic coherence (Bowers et al., 1990). As we have proposed earlier, high processing fluency in reading coherent word triads triggers a subtle and brief positive core affect that emerges as a feeling of ease and is used as the basis for the eventual coherence judgment (Topolinski & Strack, in press-a, in press-b). We experimentally manipulated these assumed semantic and affective links in the intuitive chain and were able to switch off and even mislead intuition.

Before we discuss the conceptual implications, let us review the present findings. In Experiments 1–3 we used three different fluency manipulations (figure–ground contrast, repeated exposure, and subliminal visual priming) and showed that irrespective of their actual coherence, more fluently processed word triads were judged to be coherent more frequently than were nonfluent triads. In Experiment 4, we used an innovative technique of short-term facial feedback that either induced phasic zygomaticus or corrugator contraction, which ought to trigger short-term positive and negative affect, respectively. It was found that triads processed under zygomaticus contraction (the smiling muscle, e.g., Scherer & Ellgring, 2007) were more likely to be judged as coherent than were triads processed under corrugator contraction (the frowning muscle, e.g., Cacioppo et al., 1986), again, independent of their actual coherence. Furthermore, in Experiments 5–7, we used a subliminal affective facial priming paradigm and found that positively primed triads were judged as coherent more often than were negatively primes triads, regardless of their veridical coherence. The obtained effects were not due to the fact that affect induced a more liberal response criterion in participants (Experiment 6) or increased the spread of semantic activation (because we manipulated affect after the semantic processing, Experiment 5). In Experiment 8, we used affect-laden word triads and again obtained a very strong and robust effect of affective valence in the same direction. The impact of affect even exceeded the impact of coherence so that negative coherent triads and positive incoherent triads were judged to be coherent equally often. Even instructing participants to correct their judgments for the valence of the triads did not prevent them from using their contaminated gut feelings.

Furthermore, in Experiment 9, we manipulated fluency and affect jointly and obtained an additive impact of both factors on intuition (a pattern that was less pronounced in incoherent triads, probably due to a floor effect). By letting fluency and affect run counter to the actual coherence of a word triad, we could even reverse the default pattern: In these conditions, incoherent triads were judged to be coherent more often than were coherent triads.

The joint impact of fluency and affect completely misguided intuition. Finally, we replicated the same pattern for intuitions of visual coherence (Bowers et al., 1990; Volz & von Cramon, 2006) in Experiment 10 and for intuitions concerning grammaticality in implicit grammar learning (Reber, 1967; Kinder et al., 2003) in Experiment 11.

Taken together, this body of evidence supports our view that a fluency-derived brief positive affect serves as the judgmental basis for intuitions of semantic coherence and also for other well-established intuitive faculties in the literature. The data are especially convincing against the background of our previous findings that coherence in triads does indeed elicit more fluent processing of triads (Topolinski & Strack, in press-a, in press-b) as well as positive affect (Topolinski et al., in press). The present research did not implement artificial manipulations that coincidentally influence coherence judgments but did use the effects that semantic coherence itself triggers. By experimentally reversing intuition, we are in good company with other research that deploys processing fluency for reversing meta-cognitive judgments, such as judgments of confidence (Epley & Norwick, 2006), judgments of truth (Unkelbach, 2007), or judgments of prototypicality in artificial grammar learning (Kinder et al. 2003). However, we integrate both fluency and fluency-triggered affect in our approach. In the domain of intuition, we do not know of any study that so exhaustively traces back the cognitive and affective mechanisms of intuition as the fluency–affect microanalysis that we pursued here.

In the remainder, we first discuss alternative explanations of the present findings and then address the important theoretical implications of our approach.

Alternative Explanations

In surveying the patterns of results across all of our experiments, one might come up with some general objections that question our interpretations; for example, the issues of the acquiescence tendency, processing style, and underlying semantic processing. These are addressed in the following.

The present manipulations only influenced participants' acquiescence tendency. One might object that we only manipulated the participants' tendency to affirm the question asked (i.e., the acquiescence tendency, which is the content-independent tendency to agree to a given proposition, e.g., McGee, 1967; Ray, 1983). Confronted with the question "Is this triad coherent?" and set under time pressure, participants could not reflectively reconsider the given item (Knowles & Condon, 1999); that is, they could not elaborately test the hypothesis of coherence but rather may have shown an automatic bias to uncritically accept the affirmative response of *coherent* (cf., Gilbert, 1991; Knowles & Condon, 1999; see also Deutsch, Gawronski, & Strack. 2006). We may have only increased this agreeing response set (McGee, 1967) with fluent processing and positive affect manipulations.

This interpretation is implausible, however, for three reasons: (a) Participants did not show an automatic acceptance bias (Knowles & Condon, 1999), agreeing to the affirmation that a given triad is coherent but rather did show a conservative response bias (Snodgrass & Corwin, 1988), in the opposite direction, throughout the experiments; (b) Experiment 6 specifically showed that affect induction does not alter the general response tendency of participants (negative affect did not make participants generally more conservative; positive affect did not make participants generally more liberal in judging coherence) but rather does differentially contribute to coherence judgments (negative affect contributed to *incoherent* responses and positive affect contributed to *coherent* responses); (c) Most important to note is that we did not ask for the affirmed criterion *coherent* and its negation *incoherent* but rather did implement the two affirmed options *interrelated* and *mixed*. The above interpretation may well be applied to most of the earlier work on fluency manipulations, in which the response alternative was the negation of the to-be-judged criterion (e.g., "true" vs. or "not true," Reber & Schwarz, 1999; Unkelbach, 2007; "very pretty" vs. "not at all pretty," Reber et al., 1998; "grammatical" vs. "agrammatical," Gordon & Holyoak, 1983). However, we let participants decide between two affirmative options, thus ruling out the possibility of a pure acquiescence effect.

The present manipulations only altered participants' processing styles. Cognitive tuning literature convincingly shows that positive mood is related to heuristic processing strategies (e.g., Bless, 2001; Kuhl, 2000; Rotteveel & Phaf, 2007; Schwarz, 2002b; Whittlesea & Price, 2001), which is less controlled processing that relies on fast and effortless internal cues (cf., Alter, Oppenheimer, Epley, & Eyre, 2007; Deutsch & Strack, 2008; Simmons & Nelson, 2006; Strack & Deutsch, 2004). To give some examples, Bodenhausen, Kramer, and Süsser (1994) found that people in happy moods rely on stereotypes in person perception more than do people in sad moods; Bless et al. (1996) showed that people in happy moods rely on general knowledge structures more than do people in sad moods; and Ruder and Bless (2003) found that positive mood increases the reliance on the ease-of-retrieval heuristic. Consequently, it was theorized and demonstrated that positive affect fosters intuition, whereas negative affect impairs intuition (Baumann & Kuhl, 2002; Bolte et al., 2003). Furthermore, most recently, it was demonstrated that the meta-cognitive experience of (dis)fluency also alters processing styles: Alter et al. (2007) showed that fluency experienced during the process of reasoning is associated with reliance on heuristic processing, and disfluency is associated with reliance on controlled (i.e., more effortful and conscious) processing.

Given these findings, the present results might be interpreted as follows: Inducing high fluency and positive affect let participants rely on internal cues that veridically indicated the coherence, thus increasing the frequency of *coherent* responses. In contrast to that, inducing low fluency and negative affect let participants shift away from an intuitive assessment of coherence to a conscious, effortful analysis of the triads. Since the latter is not an effective way to detect coherence (Topolinski & Strack, 2008), *coherent* responses dropped. However, this interpretation is false: If disfluency and negative affect decreased the overall use of internal cues (in our account, the emerging positive gut feeling) then judgments in disfluent and negative trials should have been less sensitive to the actual coherence, since the internal cue is the veridical signal for coherence. Likewise, if fluency and positive affect fostered the reliance on internal cues and intuitive assessments, the diagnosticity between veridically coherent and incoherent triads should have increased for these trials. In contradistinction to that, we did not find any interactions among coherence detection, fluency, and affect. The induced fluency and affect simply added to the veridical coherence detection, leaving a cognitive tuning interpretation implausible.

The present affect inductions influenced intuitions because they altered underlying semantic processing. It is well known from the literature that positive mood fosters semantic activation spread (Isen, 1999; Isen, Daubman, & Nowicki, 1987; Isen, Johnson, Mertz, & Robinson, 1985; Storbeck & Clore, 2005), also the convergence activation spread in remote associates (Baumann & Kuhl, 2003; Bolte & Goschke, 2008; Bolte et al., 2003). Parallel, recent findings show that negative affect inhibits semantic priming (Storbeck & Clore, 2008; see also Rotteveel & Phaf, 2007). It is thus conceivable that our affect inductions altered semantic spread. This interpretation would arise from both the affect-modulation hypothesis by Kuhl (2000) and the affective-modulation framework by Rotteveel and Phaf (2007) and was already discussed in Experiment 7.

Although we more thoroughly relate our fluency–affect account to the affect-modulation hypotheses below, we should explain at this point why the affect-modulation hypotheses cannot account for Experiments 4–7 (but they may well be applied to Experiment 8, which was discussed there). (a) Affect-modulation of semantic spread would predict that in the negative conditions, discrimination between coherent and incoherent triads would be decreased or even be zero, since, for example, Bolte et al. (2003) showed that under negative mood, intuitive judgments did not differ between coherent and incoherent triads. However, in the absence of any interaction, we found a reliable discrimination between coherent and incoherent triads for negative as well as for positive trials across Experiments 4–7. Even in Experiment 8, in which we found an interaction, judgments were still sensitive to coherence in the negative trials. (b) Affect-modulation cannot explain why positive affect also increased judgments for incoherent triads. Consider the case of incoherent triads: In contrast to coherent triads, in which positive affect facilitates the semantic spread and the eventual convergence of activation on the common associate (Topolinski & Strack, 2008), activation spread of incoherent triads diffuses in all directions and does not converge on a common associate. Whether this semantic spread is fostered by a positive affect induction or inhibited by a negative affect induction, this process would come to nothing for both affect valences. However, we obtained the same robust and strong effect for incoherent triads as we did for coherent triads, which renders an affective modulation unlikely.

The present model assumes fluency to be, procedurally, the first link in the intuitive chain and affect to be its consequence. Although this is in line with the entire body of theories and evidence in the fluency literature (for reviews, see Reber et al., 2004; Winkielman et al., 2003), one could object that perhaps coherence first triggers positive affect, which in turn increases the fluency of processing coherent triads. Let us briefly focus on a recent empirical finding that suggests that the sequence of fluency–affect is more likely than is affect–fluency.

Most recently, Topolinski et al. (in press) demonstrated that spontaneous facial muscle activity was indicative of positive affect when their participants read coherent triads, as compared with incoherent triads. During this task, processing fluency could only vary during the reading of the triads, which took participants less than 1 s (see also Bolte & Goschke, 2005; Topolinski & Strack, 2008). However, positive facial activity began to emerge only after 1.5 s and was full-blown 2–3 s after triad onset, thus, long after fluency variations in reading took place. This suggests that first, fluency varies, and then, fluency triggers affective consequences. Given the above timings, it is implausible that semantic coherence first triggers positive affect and that this affect somehow increases the fluency of reading the triads.

Affect, Semantic Spread, and Intuition

Our work is dedicated to the interplay between affective states and intuition, which was addressed before by Kuhl and colleagues (Baumann & Kuhl, 2002; Bolte et al., 2003), even using the same semantic coherence paradigm. In the following section, we relate both approaches to each other.

First, we consider the differences between both approaches. As we discussed earlier, our results cannot be explained by the affect-modulation hypothesis proposed by Kuhl (2000; cf., Rotteveel and Phaf, 2007), which states that positive mood enhances intuition via the facilitation of semantic activation spread (see, for details, the introduction to Experiments 5–7 and the Discussion section of Experiment 7). Neither can our fluency–affect model account for the results that Kuhl and colleagues (Baumann & Kuhl, 2002; Bolte et al., 2003) found: Given the repeatedly replicated pattern in our results, one would assume that individuals used the induced positive mood as an internal cue for coherence for both coherent and incoherent triads and hence that the diagnosticity of judgments would not be altered by positive (or negative) mood.

To understand the exclusivity of both of these approaches, it is useful to bear in mind the conceptual differences between mood in the affect-modulation hypothesis and core affect in the present fluency–affect account. Mood takes places before and independently of the intuitive chain, alters semantic spread, and is consciously experienced as an experiential state that is independent of the triads to be judged. In contrast, core affect changes are an outcome of the intuitive chain and thus succeed semantic processing, do not alter semantic spread and, if at all, are experienced as internal affective reactions toward the triads to be judged. The latter was convincingly illustrated by the fact that participants could not discount the valence of triad constituents from their intuitions in Experiment 8.

In the present experiments, we induced a very brief, subtle affective change without participants' awareness of that manipulation. Thus, a direct-cue use of the induced affective state was facilitated. Kuhl and colleagues (Baumann & Kuhl, 2002; Bolte et al., 2003), however, induced a longer lasting mood experienced by participants, which was very unlikely to be used as an internal cue for coherence judgments. Hence, in our studies, positive [negative] affect increased [decreased] the likelihood that triads would be judged as coherent for both coherent and incoherent triads, whereas Kuhl's mood induction did not. Furthermore, our affect manipulation had no impact on semantic spread (compare Experiments 5 and 7, but also see Experiment 8), but Kuhl's mood manipulations presumably did (Bolte & Goschke, in press). Given that an enhanced semantic spread generates higher fluency gains in coherent triads, the intuitive chain generates higher core affect changes for coherent triads and thereby enables more diagnostic gut feelings. Hence, in Kuhl's studies, positive [negative] mood increased [eliminated] the diagnosticity between coherent and incoherent triads, whereas our affect induction did not.

After this clarification, we can integrate both lines of evidence. Due to the converging semantic spread onto the common associate, a coherent word triad is more fluently processed than is an incoherent word triad. This higher fluency triggers a brief and subtle positive affect that may emerge as an experienced feeling used in the coherence judgment. The longer lasting affective state of mood does not influence this fluency–affect link (described in our intuitive chain) but rather does alter semantic spread onto the common associate, which changes the primary link of the intuitive chain, namely the processing fluency. From here on, the described processes are executed in the very same fashion under positive and negative moods.

Phasic Affect and Insight

Retrieving the common associate of coherent triads was repeatedly called insight–problem solving in the literature (see Bowden, Jung-Beeman, Fleck, & Kounios, 2005, for an overview). Furthermore, we know from literature that solving insight problems are facilitated by positive affect (e.g., Isen, 1999). Given this background, the mixed results concerning the relationship between affect and retrievals of solution words are a challenge for our understanding. Although Experiment 4 showed that more triads were solved when participants contracted the zygomaticus, compared with contracting the corrugator, in Experiment 5–7, we found that more negatively primed triads than positively primed triads were solved. This evidence is challenging to interpret, given the two a priori assumptions that most authors advocate: (a) the retrieval of the common associate depends on whether the converging semantic spread activates the common associate above threshold (Anderson, 1983; Bolte & Goschke, 2005), and (b) negative affect restricts that very spread (e.g., Baumann & Kuhl, 2002; Bolte & Goschke, 2008; Gick & Lockhart, 1995; Kuhl, 2000; cf. Fiedler, 1998; Isen, 1999; Storbeck & Clore, 2008). To complicate the matter, why did this effect not occur in the more effective affect induction of affect-laden triads (Experiments 8–9), and why did we find the (conceptually more plausible) reversed effect of more solved triads under positive mood induction than under negative mood induction in Experiment 4?

Furthermore, cognitive neuroscience also agrees with the assumption that the solving of a word triad—there called insight—is hampered by negative affect (e.g., Bowden, Jung-Beeman, Fleck, & Kounios, 2005; Bush, Luu, & Posner, 2000; Jung-Beeman, personal communication, June 2007). However, the empirical data are more equivocal than the theories advocated: Whereas Isen, Daubman, and Nowicki (1987) as well as Friedman and Förster (2001) demonstrated that triads are more frequently solved under positive mood, Bolte et al. (2003) did not report an influence of their mood induction on the frequency of solutions for word retrievals (p. 418). Using a brief facial priming paradigm instead of a mood induction, we found the opposite pattern. These inconsistencies clearly inspire further research: How do different affective states (brief and subtle affect, longer lasting mood, or even strong emotions) differentially influence semantic spread in remote associate problems? As we cannot come up with a proper interpretation of our result, we strongly recommend further analyses.

Conclusion

The present fluency–affect approach regarding intuitions of semantic coherence, visual coherence, and implicit grammaticality provides a complete procedural account for the inner workings of intuitive judgments. We identify fluency and fluency-triggered positive affect as the determinants of intuitions.

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