A fluency-affect intuition model

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Meinem Vater in Erinnerung meiner Mutter.

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Table of contents

The appendix contains a reproduction of an original paper:

Topolinski, S., & Strack, F., (2009). The architecture of intuition: Fluency and affect determine intuitive judgments of semantic and visual coherence, and of grammaticality in artificial grammar learning. *Journal of Experimental Psychology: General, 138 (1)*, 39-63.

Introduction

Various domains in psychological research address intuitive judgments, namely judgments in which individuals express knowledge they cannot analytically justify, or –as Epstein (2008) put it– exhibit knowing without knowing *how* they know. To give an impression of the diversity of approaches, the most popular examples from various fields shall be mentioned in the following. Although not all of these approaches are explicitly concerned with intuition, their dependent measures clearly qualify as intuitive judgments.

The most classical approaches on intuition are found in studies on artificial grammar learning (Reber, 1967; for a review, see Pothos, 2007), where individuals can detect whether particular stimuli conform to complex rules without being able to verbally report those rules (but see also Knowlton and Squire, 1994, 1996; Perruchet & Pacteau, 1990; Vokey & Brooks, 1992, for analytic contributions to these judgments). Other examples from cognitive psychology are judgments of hidden visual and semantic coherence (e.g., Bowers, Regehr, Balthazard, & Parker, 1990), or hidden covariation detection (Lewicki, 1986a, 1986b; Lewicki, Czyzewska, & Hoffman, 1987; Lewicki, Hill, & Czyzewska, 1992), where individuals also can detect certain stimulus properties without being able to report the basis for their judgment. Another example that even laymen encounter everyday is the *feeling of knowing* (Hart, 1965; see also Koriat, 1993; Koriat & Levy-Sadot, 2001; Yaniv & Meyer, 1987), in which individuals can reliably assess whether they have certain memory contents without currently being able to retrieve these contents, i.e. again knowing without knowing how they know (Epstein, 2008).

Another broad range of research approaches, more predominantly located in social psychology, addresses the use of affective and nonaffective feelings (e.g., “cognitive feelings”, Clore et al., 2001; for a review see Schwarz & Clore, 2007; also called “understanding by feeling”, Bastick, 1982; “messages from within”, Bless & Forgas, 2000), which are also genuinely intuitive judgments. Furthermore, we find fascinating examples of intuitive judgments concerning properties of multiple or very complex stimuli, such as the evaluative aggregation of multiple events (Betsch, Kaufmann, Lindow, Plessner, & Hoffmann, 2006; Betsch, Plessner, Schwieren, & Gütig, 2001), multiple-attribute judgments under suboptimal conditions (Dijksterhuis, 2004), as well as intuitive interactions with complex dynamic systems (Broadbent, 1977; Hayes & Broadbent, 1988).

Moreover, the traditional literature on decision making and bounded rationality provides various classical examples. From this literature, many of the judgments called "heuristics" (Tversky & Kahneman, 1974) are genuine intuitive judgments, for instance, the recognition heuristic (Goldstein & Gigerenzer, 2002), the availability heuristic (e.g., Schwarz et al., 1991), or the representativeness heuristic (Kahneman & Tversky, 1996). Also, judgments in tasks exploring the base-rate fallacy (Cosmides and Toobey, 1996; Epstein, Pacini, Denes-Raj, & Heier, 1996; Koehler, 1996), the conjunction fallacy (e.g., Tversky & Kahneman, 1983), but also anchoring (e.g., Mussweiler & Strack, 1999; Strack & Mussweiler, 1997), and cross-dimensional mapping (e.g., Ganzach & Krantz, 1990; Kahneman, Ritov, & Schkade, 1999; Parducci, 1965) as well as any cognitive illusion (Kahneman & Tversky, 1996) address intuitive judgments.

Finally, even psychiatry and neuroscience recently developed an interest in intuitive judgments, such as research in neuropsychological populations (e.g., Bechara, Damasio, Tranel, & Damasio, 1997; Harrington, Haaland, Yeo, & Marder, 1990; Knowlton, Mangels, & Squire, 1996; Knowlton, Squire et al., 1996), or neuroimaging research (e.g., Ilg et al., 2007; Lieberman, Chang, Chiao, & Knowlton, 2004; Poldrack et al., 2001; Volz & von Cramon, 2006). Even from this only cursory review it becomes apparent that intuitive judgments are object of a multitude of research approaches from various fields. Researchers' interests range from moral judgments (Haidt, 2001) to predicting sport results (e.g., Halberstadt & Levine, 1999; Simmons & Nelson, 2006), or even the weather (Poldrack et al., 2001).

The cause for why intuitive judgments enjoy such a popularity in psychological research is that they reflect two yet unsolved challenges in understanding the human mind, namely the interplay between cognition and affect (Eder, Hommel, & DeHouwer, 2001; Fazio, 2001), as well as the relation between consciousness and rationality in general (Chase et al., 1998; Gigerenzer & Goldstein, 1996; Kahneman, 2003; Kahneman & Tversky, 1996), since their processes work on the "fringe of consciousness" (James, 1890; see also Mangan, 1993, 2000, 2001; Reber & Schwarz, 2001; Reber, Wurtz, & Zimmermann, 2004). Given this, understanding the procedural architecture of intuitive judgments, i.e. the processes that lead up to intuitions, promises unique insights into the currently lively debated issues of cognition, affect, consciousness, and rationality.

Despite this high theoretical relevance, procedural accounts of intuitive judgments are scarce in literature. Often, the research tradition stops after initially demonstrating the basic effect of an intuitive faculty (e.g., Dijksterhuis, 2004; Lewicki et al., 1992), showing some boundary conditions (e.g., Bolte & Goschke, 2005; Gigerenzer & Goldstein, 1996; Goldstein & Gigerenzer, 2002), or relations to other psychological constructs, such as affect (e.g., Bolte, Goschke, & Kuhl, 2003), or personality (e.g., Baumann & Kuhl, 2002; Epstein et al., 1996). As a consequence, the accompanying conceptualizations remain undifferentiated, descriptive, and often lack any procedural notions of how the particular intuitive faculty comes about (e.g., Epstein, 2008; Dijksterhuis & Nordgren, 2006). For instance, Kihlstrom (1999) called the processes underlying intuitions of hidden coherence (see below) simply "implicit thought" without any further assumptions. This situation prompted Catty and Halberstadt (2008) to state that intuition is still the "black box of modern psychology".

Only a few intuitive faculties underwent a more thorough scientific analysis targeting their inner core mechanisms, such as in the fluency-accounts of the feeling of knowing (Koriat & Levy-Sadot, 2001), and implicit grammar learning (Kinder, Shanks, Cock, and Tunney, 2003; Newell & Bright, 2001; for a highly integrative review, see Reber, Schwarz, &

Winkielman, 2004), as well as the long overdue procedural analysis of heuristics (Bröder & Schiffer, 2003; Glöckner & Betsch, 2008; Glöckner, Betsch, & Schindler, submitted; see Newell, 2005, for a succinct review and integration of the research tradition concerning heuristics). These lines of research identified and tested discrete stages of information processing underlying intuition, both elucidating and disenchanting this black box.

The major thrust of the present treatise is to call for such procedural accounts in further investigating intuitive judgments (see also Deutsch & Strack, 2008). The enterprise of dissecting the underlying mechanisms of intuition has only yet started and will bear fascinating insights into the interplay between higher mental processes. Closely related to this procedural view is the notion that intuitive judgments are not exclusively generated by a special "intuitive", "tacit", or "experiential" system, as other accounts maintain (e.g., Epstein, 2008; Hogarth, 2001; Lieberman, 2000), but are rather joint-products of associative and propositional information processing (see below; see also Deutsch & Strack, 2008; see also Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005; Gawronski & Bodenhausen, 2006).

Following a procedural view on intuitions, a procedural account of *coherence intuitions* was developed most recently by Topolinski and Strack (2009b, in press-b). In the following, this procedural account shall be outlined; and evidence shall be reviewed that was gathered most recently to support this account.

The Fluency-Affect Intuition Model

A satisfactory procedural account of an intuitive judgment must address a lot of aspects. It should identify the underlying cognitive and affective processes and the way in which they are triggered by the to-be-judged stimulus or stimulus-related cognitions. It should assess whether these underlying cognitive and affective processes interact with each other and if yes, in which way they interact. Since the key fascination of intuitive judgments is the experience of results of processes running outside of awareness (e.g., Bruner, 1960; Haidt, 2001; Hammond, 1996; Lieberman, 2000), a procedural account should explore which of these processes at which stage of judgment formation enters awareness, and –closely related to this question– which is the actual cue that is experienced and used in the eventual judgment. Furthermore, it should address how cognitively penetrable the various processes are that lead to the judgment.

In the following the author will review several lines of research that have applied such a procedural account to intuitions, mostly in conducting procedural micro-analyses of intuitive judgments. Since the procedural links assumed to generate intuitions in this account are fluency and affect, the author will refer to this approach as the *fluency-affect intuition model* (FAIM, e.g. Topolinski & Strack, 2009b, in press-b). As will be reviewed in the following, the FAIM can empirically account for three of the most classical intuitive tasks in literature, namely judgments of semantic coherence (e.g., Bowers et al., 1990), gestalt intuitions (e.g., Volz & von Cramon, 2006), and intuitions of grammaticality in artificial grammar learning (e.g., Reber, 1967). In the present call for procedural accounts in investigating intuition, the FAIM serves as an exemplary approach to systematically elucidate the architecture of intuitive judgments.

Before reviewing the literature, the phenomenon of semantic coherence intuitions shall be briefly introduced, since most of the reviewed studies were conducted in this domain. When confronted with word triads that either share a common remote associate (e.g, MILK CLOUD RABBIT converging on the solution word WHITE) or not (e.g., DREAM BALL BOOK; cf. Mednick, 1962; Mednick & Mednick, 1967) individuals can detect above chance whether a triad is coherent or not before and independently from actually retrieving the evidence for the coherence, namely the solution word (Baumann & Kuhl, 2002; Bolte et al., 2003; Bowers et al., 1990). Moreover, this intuitive detection is reliable even under severe time pressure (i.e., making the judgment within 2,000 ms; Bolte & Goschke, 2005). This astonishing faculty can be considered a prototypical intuitive judgment (Baumann & Kuhl, 2002; Bolte et al., 2003; Bowers et al., 1990), since individuals feel the existence of something they do not know yet. Epstein's (2008) apt expression that intuition is knowing without knowing *how* one knows applies perfectly to this judgment.

In the following sections, the body of evidence shall be reviewed that was gathered applying the procedural account of the FAIM to these intuitive judgments. The author will review findings concerning 1) the automatic semantic precursors of these intuitions, 2) the inner architecture of its cognitive and affective mechanisms, and 3) the experiential status of these core mechanisms. As the reader will learn, conceptually and operationally highly specified mechanisms that are well-known from cognitive and social psychology constitute this intuitive faculty for which its underlying mechanisms remained enigmatic thus far.

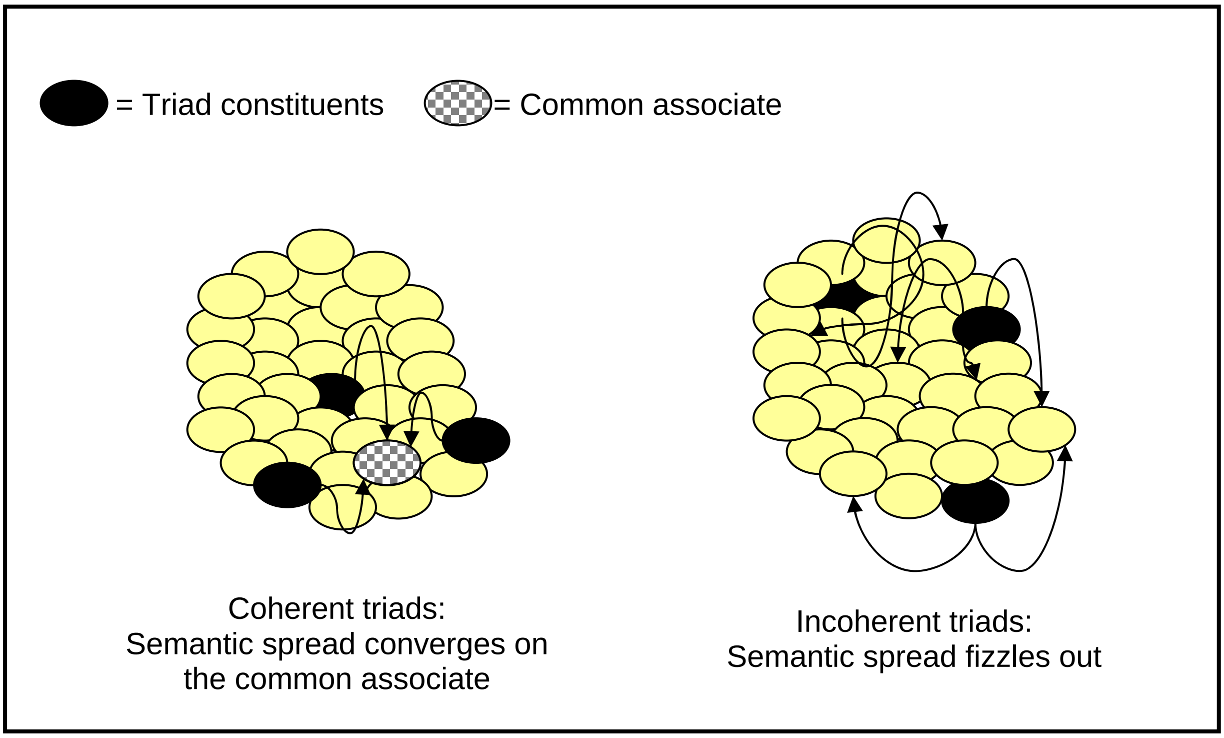

Figure 1

Automatic semantic spread-out for coherent and incoherent word triads

Automatic cognitive precursors of intuition

Since various approaches agree that semantic coherence intuitions are somehow based on the partial semantic activation of the solution word (Bolte & Goschke, in press; Bolte et al., 2003; Bowden, Jung-Beeman, Fleck, & Kounios, 2005; Harkins, 2006; Ilg et al., 2007), Topolinski and Strack (2008) investigated if and under which preconditions the processing of a coherent word triad activates its solution word (cf., Beeman et al., 1994). In Topolinski and Strack (2008, Experiments 1-2), we first investigated whether coherent word triads actually prime their own solution words. Participants received coherent and incoherent word triads that were to be read followed by single target words that were to be judged lexically. The target words were always solution words from coherent triads. Most importantly, participants were kept ignorant about the underlying semantic relationships. Three conditions were implemented. In the *baseline condition*, the solution word was preceded by an incoherent triad. In this condition, semantic activation was assumed to spread only unsystematically since the three words of incoherent triads have no common associate. In the *match condition*, the solution word was preceded by its own coherent triad. Here, semantic activation of the triad's constituents was assumed to converge onto the solution word and thus facilitate the lexical decision of it compared to the baseline (see Figure 1 for an illustration). Finally, in the *mismatch condition*, the solution word was preceded by a different coherent triad. In this case, semantic activation was expected to converge on the coherent triads' solution word, thus systematically steering away from the to-be-identified solution word, which should hamper the lexical decision compared to baseline.

The results confirmed these expectations. It was found that response latencies to lexically judge the solution words were faster than baseline when the solution word was preceded by its own coherent triad, and were slower than baseline when the solution word was preceded by a different coherent triad. This pattern suggests that merely reading a coherent word triad automatically activates its solution word and systematically inhibits other words not implied by the triad.

Converging evidence comes from the field of visual coherence intuitions. Most recently, Bolte and Goschke (in press) presented participants pictures with either fragmented line drawings depicting meaningful objects (coherent fragments) or randomly displaced line segments (incoherent fragments). After each picture, participants were asked for an intuitive judgment under time pressure concerning whether the picture depicted a real object or not. Subsequently, a (non)word was presented for a lexical decision task which was either the name of the object depicted in the fragmented picture or not. It turned out that participants could not only reliably differ between coherent and incoherent fragments without actually recognizing the depicted object (as we know from Bowers et al., 1990; Volz & von Cramon, 2006); but also that response latencies in the lexical decision were faster when a target name and preceding coherent fragment matched in contrast to when they did not match. As the authors concluded, watching degraded pictures of objects automatically activated a semantic representation of that object, even if this activation was not strong enough to enter awareness and to allow participants to consciously recognize the object.

It is noteworthy that Topolinski and Strack (2008, Experiments 1-2) obtained automatic activation of a common associate in participants who were actually ignorant about the underlying semantic relations. This stands in contrast to previous accounts of semantic coherence intuitions which claimed that a problem-solving mind-set, i.e. an intention to search for the solution word, is the condition sine qua non for activating the common associate (e.g. Kihlstrom, 1999; Shames, 1994). To further investigate this claim, the above procedure was replicated with a second group of participants who were informed about the underlying semantic relations and were asked to search for the common associate during the task (Topolinski & Strack, 2008, Experiment 1). For this group, no priming effects were found at all, because –as the authors argued– participants' strategy of selectively testing single triad constituents against possible solution candidates biased the balanced semantic spread that takes place when the triad is merely read (cf. Harkins, 2006). This astonishing result suggests that a problem-solving mind-set is not only unnecessary for the automatic activation of the solution word, but rather hampers it.

In sum, these findings suggest that the mere processing of hidden coherence (both semantic coherence and gestalts) automatically activates a representation of this coherence, which can be compared to the notion of automatic consistency computation (e.g., Glöckner & Betsch, 2008; Kunda & Thagard, 1996). This process runs unintentionally and outside of individuals' awareness (cf. Moors & DeHouwer, 2006) and can thus be considered the cognitive precursor of intuition outside of awareness. The following sections review several microanalyses throwing light on how basic cognitive and affective mechanisms lead from this weak associative representation of coherence to consciously experienced intuitions.

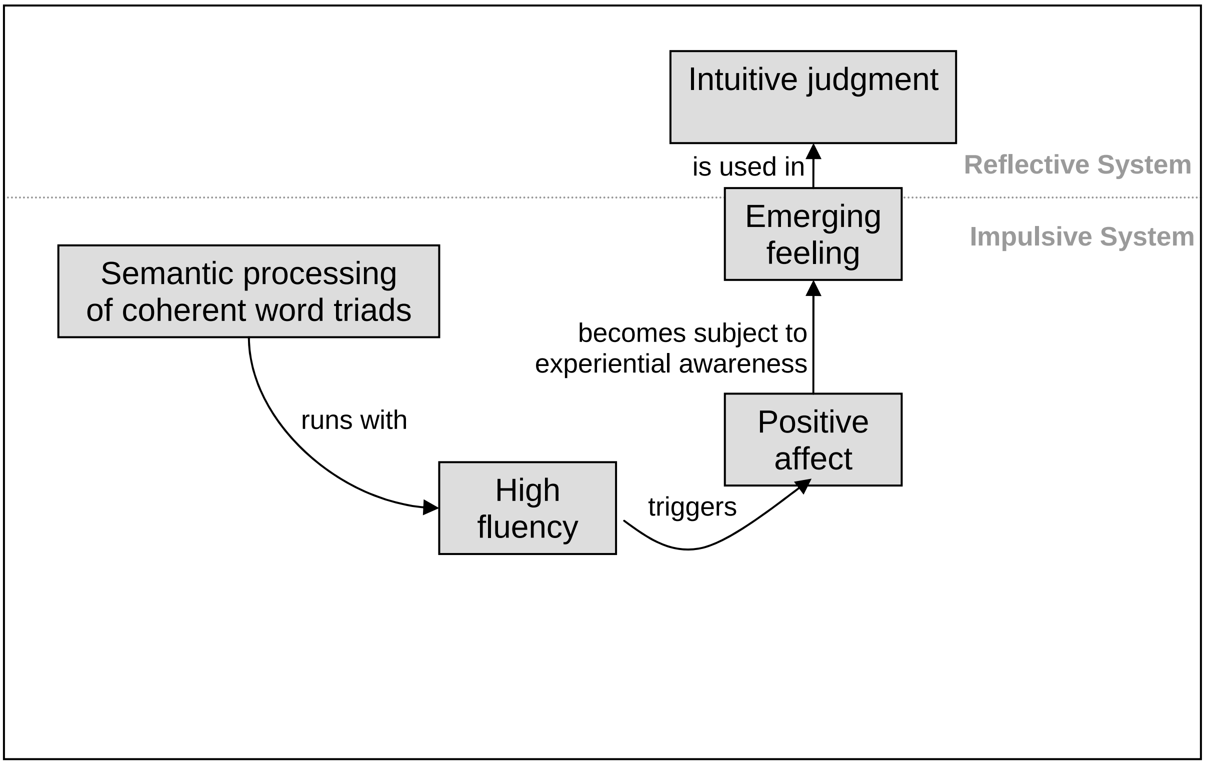

Figure 2

An overview of the intuitive chain in FAIM

The intuitive chain – from unconscious activation to conscious gut feelings

The FAIM conceptualizes a chain of cognitive and affective mechanisms running automatically to generate intuitions. An overview over this chain is provided in Figure 2. According to the first link of this chain, namely the fluency-link, the weak associative representation of the common associate increases the processing fluency, i.e. the general speed and efficiency of processing (Reber et al., 2004), for coherent compared to incoherent word triads. More specifically, it was assumed that in the course of reading a coherent word triad, the processing of the first and second word partially activates the solution word, since they are remote associates. At the time the third word of a given triad is read, the solution word has received enough activation to semantically prime the third word in turn (cf. Topolinski & Strack, 2009b). We know from literature that semantically primed concepts are more fluently, i.e. faster and more efficiently processed (Whittlesea, 1993). Given this, a coherent triad should be processed faster than an incoherent triad.

This was actually shown by Topolinski and Strack (in press-b, Experiment 1) in the following set-up. They presented participants being ignorant about the underlying semantic structure intact coherent and incoherent word triads as well as other word triads in which one of the three clue words was randomly replaced by a pronounceable word-like letter string. Participants should judge the triads lexically, i.e. decide as fast and accurate as possible whether all three words were existing German words or contained a nonword. This task requires semantic processing of all three words of the intact coherent and incoherent triads. It was found that, although participants were not informed about the underlying semantic structure of some of the triads and did not become aware of it, they judged intact coherent triads 57 ms faster than intact incoherent triads. It is important to note that coherent and incoherent triads did not differ in psycholinguistic properties such as the triads' numbers of letters, numbers of syllables, the word classes of contained words (verbs, adjectives, or nouns), repeating word appearances among the triads, or the triad words' frequencies in everyday language. A fluency gain in semantic processing due to hidden semantic coherence was also shown by Topolinski and Strack (in press-a) for participants who only read (in)coherent word triads independently of any lexical decision.

Furthermore, the FAIM predicts genuine affective consequences of these coherence-triggered fluency gains. We know from literature that such an unexpected local fluctuation of processing fluency (cf., Hansen, Dechêne, & Wänke, 2008; Hansen & Wänke, 2008; Whittlesea, 1993; Whittlesea & Williams, 1998, 2000, 2001a, 2001b) triggers a subtle and brief positive affect (Harmon-Jones & Allen, 2001; Topolinski & Strack, 2009a;Winkielman & Cacioppo, 2001; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). Given this, it was predicted that the mere processing of coherent word triads compared to incoherent word triads should trigger positive affect, irrespective of the triads' valence. It is important to note that this affect is a diffuse affective state (Stapel, Koomen, & Ruys, 2002) that is not necessarily object to experiential awareness or introspection (cf., Winkielman & Berridge, 2004) and can exist without being labeled or interpreted (c.f., *core affect*, Russell, 2003; Russell & Feldman-Barrett, 1999). Thus, the immediate affective response to hidden coherence should not only be detectable via self-report but also via more indirect measures assessing affect outside of individuals' awareness (cf. Quirin, 2005; Quirin, Kazén & Kuhl, in prep; Stapel et al., 2002; Berridge & Winkielman, 2004).

This was shown both using a response-time based behavioral and a physiological measure. Topolinski and Strack (in press-b, Experiment 2) used (in)coherent word triads as affective primes in an affective priming paradigm (Fazio, 2001). There, (in)coherent triads were succeeded by either a positive or negative target word that had to be evaluated as fast as possible (Fazio, Sanbonmatsu, Powell, & Kardes, 1986). It turned out that after having read a coherent word triad participants could evaluate positive targets faster than negative targets, independently of whether they were informed of the underlying semantic structure, or were completely ignorant. This finding suggests that hidden semantic coherence triggers a positive affect that is strong enough to interfere with subsequent evaluations.

Moreover, such an immediate coherence-triggered positive affect was also detected via facial electromyography (Friedlund & Cacioppo, 1986). Topolinski, Likowski, Weyers, and Strack (2009) presented coherent and incoherent word triads to participants who were completely ignorant of the underlying semantic triad structure and measured spontaneous muscular activity of the M. zygomaticus major, the smiling muscle being an indicator of positive affect (Cacioppo, Petty, Losch, & Kim, 1986; Scherer & Ellgring, 2007), the M. corrugator supercilii., being an indicator of negative affect (e.g., Cacioppo et al., 1986; Ekman, 1973), and the M. frontalis being the muscle discussed to express surprise (Scherer & Ellgring, 2007). They found that incidentally reading coherent compared to incoherent triads automatically activated the smiling muscle zygomaticus and relaxed the frowning muscle corrugator, indicating an induction of positive affect, and a reduction of negative affect (cf., Harmon-Jones & Allen, 2001; Winkielman & Cacioppo, 2001; Winkielman et al, 2003; using visual fluency, who only found induction of positive affect due to visual fluency, but no reduction of negative affect). Because also the frontalis was relaxed by coherent compared to incoherent word triads, one can even additionally state that participants –without their knowing– were less surprised by hidden semantic coherence compared to random words (see Figure 3 for the results). However, fluency-triggered positive affect can also enter experiential awareness, especially when it exceeds a certain threshold or changes rapidly (Russell, 2003), for instance due to a rapid fluency change (e.g., Whittlesea & Williams, 2001a, 2001b) or fluency gains that come unexpected (e.g., Hansen et al., 2008; Whittlesea & Williams, 1998). Given this, coherence-triggered positive affect may also be detected in explicit self-reports of affective state. In the FAIM, this is the crucial point where underlying cognitive and affective mechanisms may become experiences.

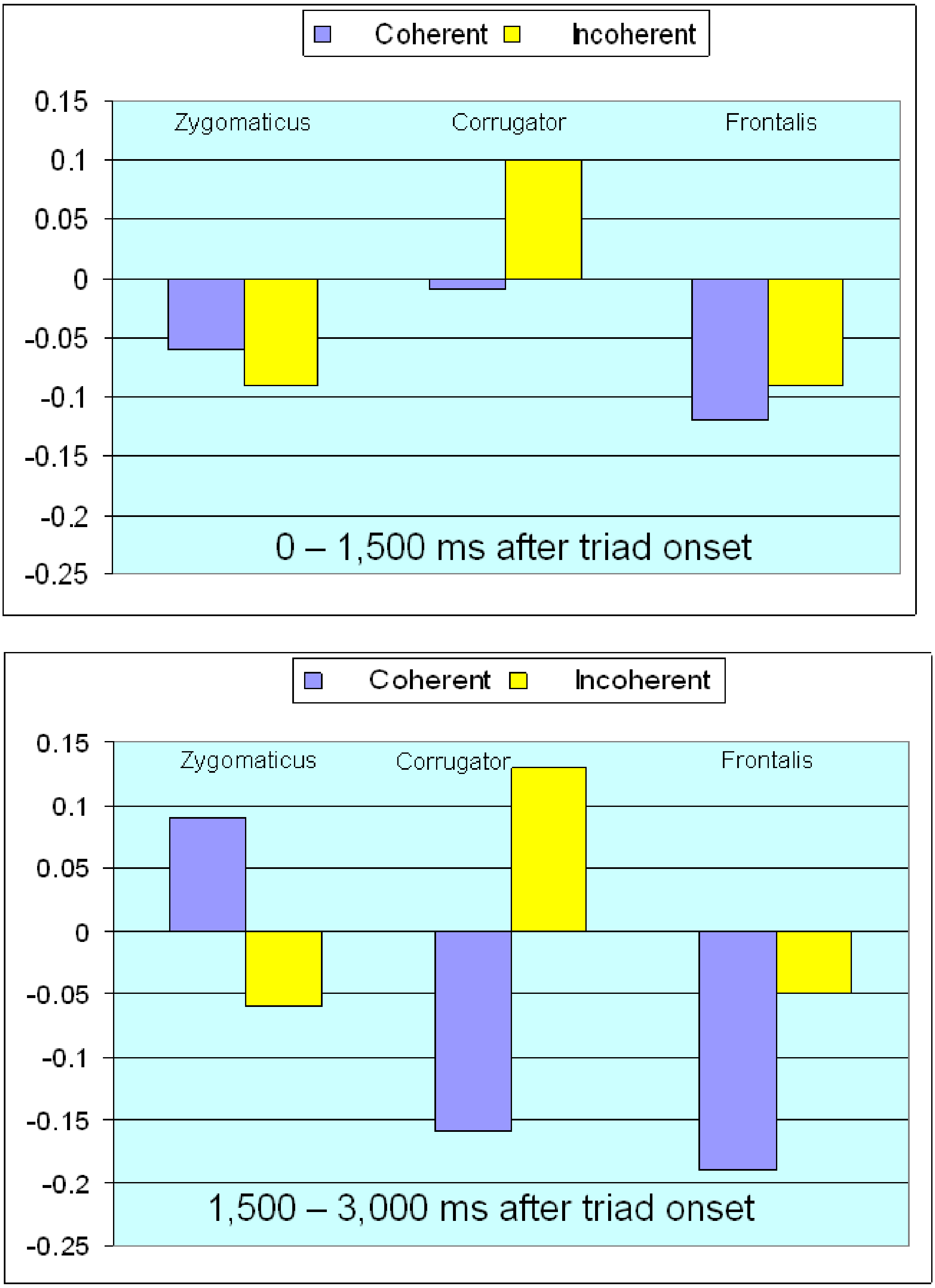

Figure 3

Spontaneous EMG activity reported in Topolinski et al. (2009) for coherent and incoherent word triads plotted separately for zygomaticus, corrugator, and frontalis immediately after triad presentation onset (top panel) and 1,500 ms later (bottom panel).

This transition was actually shown by Topolinski and Strack (in press-a, Experiment 1; in press-b, Experiment 3) who let participants read (in)coherent word triads and indicate their preference. It was found that coherent word triads were liked more than incoherent word triads, indicating that the coherence-induced positive affect can even become object of experiential awareness. It is important to emphasize that coherent and incoherent word triads did not differ in the valence of their constituting words (Topolinski and Strack, in press-b, Experiment 3). This finding also converges with previous findings in the domain of artificial grammar learning, where grammatical strings were also found to be liked more than agrammatical strings (Gordon & Holyoak, 1983), which serves as a hint that the FAIM may also be applied to this domain (see below).

When a fluency-triggered positive affect enters experiential awareness (cf., Winkielman, Zajonc, & Schwarz, 1997), it may not only be experienced as a preference towards the highly fluent stimulus (e.g., Topolinski & Strack, 2009a), but also as a more malleable cognitive feeling (Kahneman & Frederick, 2002; Loewenstein, Weber, Hsee, & Welch, 2001; Schwarz & Clore, 2007; cf. “feelings as informations”, Schwarz, 1990; cognitive feelings, Clore, 1992; Clore et al., 2001; “vibes”, Epstein, 1991, 1994) applicable as an internal cue for any judgment (Deutsch & Strack, 2008). We actually know from literature that fluency-triggered affect is used in a wide variety of judgments, such as loudness (e.g., Jacoby, Allan, Collins, & Larwill, 1988), clarity (e.g., Whittlesea, Jacoby, & Girard, 1990), but also familiarity (e.g., Whittlesea, 1993), or even truth (e.g., Begg, Anas, & Farinacci, 1992; R. Reber & Schwarz, 1999). Applied to word triads, it is thus plausible that positive affect caused by hidden semantic coherence may also influence other judgments than preference. This was shown by Topolinski (submitted) who presented single words to participants in a study phase and then (in)coherent word triads later in a test phase. Crucially, some of the coherent and incoherent triads contained a word that had appeared before in the study phase. Participants’ task was to indicate whether a particular triad contained a word from the study list or not. Additionally to and independently from participants' ability to reliably discriminate between triads containing an old word and triads not containing an old word a strong effect of semantic coherence was found. Coherent triads were more likely to be judged containing an old word than incoherent triads, which suggests that the coherence-triggered cognitive feeling is also used as an internal cue for judgments of familiarity and recognition (Dunn, 2004, 2008; Yonelinas, 2002).

Concerning coherence intuitions, the FAIM predicts that it is the fluency-triggered positive affect that is the actual cue used when judging the criterion of coherence (Topolinski & Strack, 2009b; in press-a, b). 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 their affective reaction. This stage of information processing is also of particular interest concerning a more general claim of the FAIM, namely that intuitive judgments are not exclusively realized by a special "intuitive" or "implicit" system, that generates these judgments in an associative and automatic fashion, as other accounts maintain (e.g., Epstein, 2008; Lieberman, 2000; Hogarth, 2008 "tacit system of thought"). Since intuitive judgments are still judgments (Lieberman, 2000), they also entail controlled information processing. To elaborate this point, the author uses the terminology of the Reflective Impulsive Model (RIM, Strack & Deutsch, 2004), which distinguishes between an impulsive system, representing information in patterns of activation in an associative store, and a reflective system, representing information by connecting several elements from the associative store using relational schemata to which a truth value is attached. At the juncture the emerging positive affect is used as a basis for the eventual judgment, the reflective system incorporates associatively represented information (the affect, see Deutsch & Strack, 2008) into a judgment that has a propositional representational format ("This triad is coherent."). Thus, intuitive judgments are a joint-product of associative and reflective processes (as all judgments and most behavior are, Deutsch & Strack, 2008; see also Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005; Gawronski & Bodenhausen, 2006).

To more thoroughly map this delicate process of transition from associative to propositional information processing, participants were prompted to intuitively judge the coherence of word triads in a short response-time window (cf. Baumann & Kuhl, 2002; Bolte & Goschke, 2005; Bolte et al., 2003; Bowers et al., 1990). Most crucially, we invalidated the informational value of internal judgmental cues for some of the participants by introducing a transient external cause for their subjective states (Schwarz and Clore, 1983). As was shown in a variety of studies, such a manipulation prevents individuals to use internal cues for their judgments because they re-attribute their internal state to the external source (e.g., Jacoby & Whitehouse, 1989; Schwarz et al., 1991; Strack, Schwarz, Bless, Kubler, & Wänke, 1993).

To apply this to semantic coherence intuitions, we played ambiguous background music to participants and told some of them that the music is known to influence individuals' emotional responses to the word triads (cf., Fazendeiro, Winkielman, Luo, & Lorah, 2005, Experiment 4; Winkielman, Zajonc, & Schwarz, 1997, Experiment 2; Schwarz, Sanna, Skurnik, & Yoon, 2007). A reproduction of the results can be found in Figure 4. We found that while participants in a control condition could intuitively discriminate between coherent and incoherent triads, participants re-attributing their affective reactions to the background music completely lost their intuitive ability (Topolinski & Strack, in press-b, Experiment 4; see also Topolinski & Strack, in press-a, Experiment 2). This clear-cut pattern suggests that it is the affective response towards the word triads that serves as the judgmental cue to coherence.

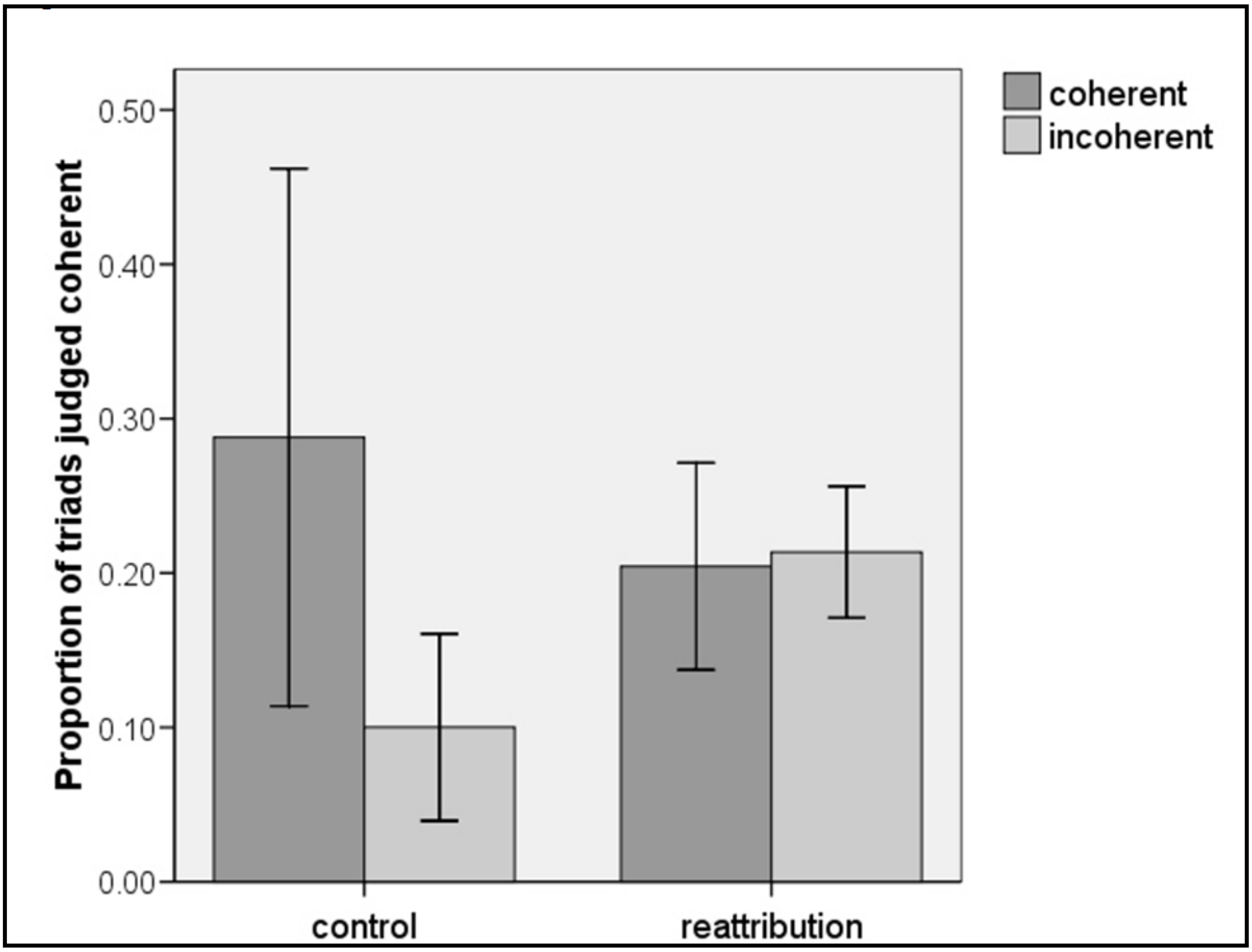

Figure 4

The probability to be judged coherent for coherent and incoherent word triads plotted separately for the control group (left bars) and the re-attribution experimental group (right bars) in Topolinski and Strack (in press-a, Experiment 2).

The notion of a causal chain of high fluency and positive affect producing an internal cue that is eventually used in the reflective coherence judgment was further corroborated by item-based correlational evidence provided by Topolinski and Strack (in press-b, Study 5). They derived item-specific parameters of speed of processing, likeability, and probability of being judged as coherent for each triad stimulus aggregated over up to one-hundred participants in several experiments. They found that, independently of the actual coherence, word triads that were processed faster were also liked more and were more likely to be judged coherent. Most importantly, they found that the relation between liking and probability of being judged as coherent was mediated by the fluency of processing a triad, which illustrates that a fluency-based internal cue is the basis for both the preference and the coherence judgments. Furthermore, also experiments actively manipulating fluency and affect in semantic coherence judgments suggest the chain of mechanisms advocated by the FAIM, which is reviewed in the following.

Manipulating the guts

In Topolinski and Strack (2009b) we systematically addressed each link of the intuitive chain and experimentally manipulated it by altering processing fluency and infusing affect by various means while participants intuitively judged semantic coherence.

As a first demonstration (Experiment 1), the color of the font in which the word triads were presented was changed in such a way that some triads appeared with a higher color contrast against the white background and some appeared with a lower figure-ground contrast (Reber & Schwarz, 1999; Unkelbach, 2007; Werth & Strack, 2003). It turned out that participants could still discriminate intuitively between coherent and incoherent triads. However, both for coherent and incoherent, triads with a higher figure-ground contrast were more likely to be judged as being coherent than triads with a lower figure-ground contrast, suggesting that the perceptual fluency fed into the intuitive chain.

Another classical manipulation of fluency, namely repeated exposure (Bornstein & D'Agostino, 1994; Jacoby & Dallas, 1981; Koriat & Levy-Sadot, 2001; Metcalfe, Schwartz, & Joaquim, 1993; Reder & Ritter, 1992) had the same impact: word triads that were presented before in a study phase were more likely to be judged as coherent than new word triads, which was again true both for coherent and incoherent triads (Topolinski & Strack, 2009b, Experiment 2). Note that this familiarity-coherence path is the reversed direction than in Topolinski (submitted) showing a coherence-familiarity path, which additionally bolsters our claims. Finally, even a very subtle manipulation of fluency, which is subliminal visual priming (cf., Kunst-Wilson & Zajonc, 1980; Reber, Winkielman, & Schwarz, 1998, Experiment 1; Winkielman & Cacioppo, 2001), affected coherence intuitions. Specifically, we manipulated the visual fluency of only the third word of a given triad, since we argue that the third word of a coherent triad profits the most from prior activation through the preceding associates (see above). We achieved this by flashing in a visually degraded version of the third word or of a nonword for only 17 ms briefly before a particular triad was presented, a manipulation participants were not aware of. It turned out that also this manipulation, which is presumably the smallest possible fluency manipulation of a word triad, had a strong impact on coherence intuitions. Both coherent and incoherent word triads that were subliminally primed with their own third word were more frequently judged as being coherent than triads that were primed with a nonword (Topolinski & Strack, 2009b, Experiment 3). To sum up, various manipulations of processing fluency affected intuitive coherence judgments; which strongly suggests that fluency plays a causal role in the intuitive chain.

These findings are also convergent with other fluency manipulations of intuitive judgments, such as the feeling-of-knowing (Hart, 1965; Yaniv & Meyer, 1987), where individuals can intuitively detect the existence of certain memory contents without retrieving these contents. As Koriat and Levy-Sadot (2001) have shown, this intuitive faculty also depends on the fluency of both the mnemonic pointer (the question for the memory content), and the fluency of retrieved contents in memory search, and thus can be affected by fluency manipulations. Furthermore, Kinder and colleagues (2003) have successfully manipulated judgments by changing fluency in yet another intuitive domain, namely in artificial grammar learning (see below). Taken together, these findings across domains suggest that the fluency-link advocated by the FAIM applies not only to semantic coherence, but also to the feeling-of-knowing and intuitions in artificial grammar learning as well.

However, also various manipulations of affect were shown to influence coherence intuitions. Exploiting the logic of facial feedback (Strack, Martin, & Stepper, 1988; see also

Larsen, Kasimatis, and Frey, 1992; Niedenthal, 2007; Strack & Neumann, 2000; Stepper and Strack, 1993) we induced phasic activation of either the zygomaticus, or the corrugator muscle during reading (in)coherent word triads, which should result in the induction of positive, or negative affect, respectively. We found that both coherent and incoherent word triads were more frequently judged coherent under zygomaticus than under corrugator activity (Topolinski & Strack, 2009b, Experiment 4). Again, note that this finding is exactly the inversed causal relation then in Topolinski et al. (2009), where hidden coherence affected exactly these facial muscles. This bi-directionality further corroborates the validity of the FAIM. Also, a much more subtle affect induction, namely subliminal facial priming (Fazio and Dunton, 1997; Milders, Sahraie, & Logan, 2008; Murphy & Zajonc, 1993; Winkielman & Berridge, 2004; Winkielman et al., 1997) influenced coherence intuitions: word triads that were preceded by briefly flashed and masked photos of smiling faces were more likely to be judged coherent than word triads were preceded by photos of sad faces (Topolinski & Strack, 2009b, Experiment 7). Impressively, this subtle affect induction had the same impact even when implemented *after* participants had read the triad and briefly *before* they eventually made the coherence judgment, thus infusing affect directly into the ongoing judgment formation (Experiments 5-6; which rules out phasic affective modulation of semantic spread, Topolinski & Deutsch, submitted).

Finally, we used yet another affect induction by constructing coherent and incoherent word triads that consisted either of positive or negative words, thus exploiting semantically induced affect as a manipulation (cf., Phaf & Rotteveel, 2005). For instance, both the triad FRESH HOLY LIQUID as well as the triad SALT DROWN RAIN converge on the common associate WATER; however the former triad consists of positive words while the latter consists of negative words. In the case of these affectively charged triads, affect and semantic coherence are genuinely entangled (cf., de Wall & Baumeister, 2007). Take, for instance, a coherent triad that is made up of negative words. We wondered whether such a triad would 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). Confirming the previous results, we found again a strong effect of affect that was independent of coherence, rendering positive triads more likely to be judged coherent than negative triads (Topolinski & Strack, 2009b, Experiment 8). To sum up, various experimental infusions of phasic affect effectively influenced coherence judgments; which strongly suggests that affect is an integral part of the intuitive chain.

Finally, we also manipulated both links –fluency and affect– simultaneously by applying the figure-ground contrast manipulation described above to affectively laden word triads. We found that coherence, fluency, and affect jointly but independently from each other influenced coherence intuitions (Topolinski & Strack, 2009b, Experiment 9). Additionally to veridical coherence of word triads, fluency and affect fed into the intuitive chain. Most interestingly, we could even sabotage intuition by pitting both fluency and affect against coherence: incoherent word triads that were highly fluent and positive were more frequently judged as being coherent than coherent triads that were less fluent and negative (see Figure 5).

In infusing affect into intuitive judgments, this approach is in good company with research in other domains also leading intuition up the garden path. Batson, Engle, and Fridell (1999) provided false physiological feedback while participants heard stories in which the values of either freedom or equality were threatened. When later asked to choose which of these values should be selected as a theme for a week-long program of events at their university, participants more frequently chose the value for which they thought they had shown a stronger visceral reaction. Moreover, Wheatley and Haidt (2000) exploited an even more direct affect manipulation in the domain of moral intuitions (see Haidt, 2001). In their work, affective responses of disgust instructed under hypnosis effectively influenced intuitive moral judgments.

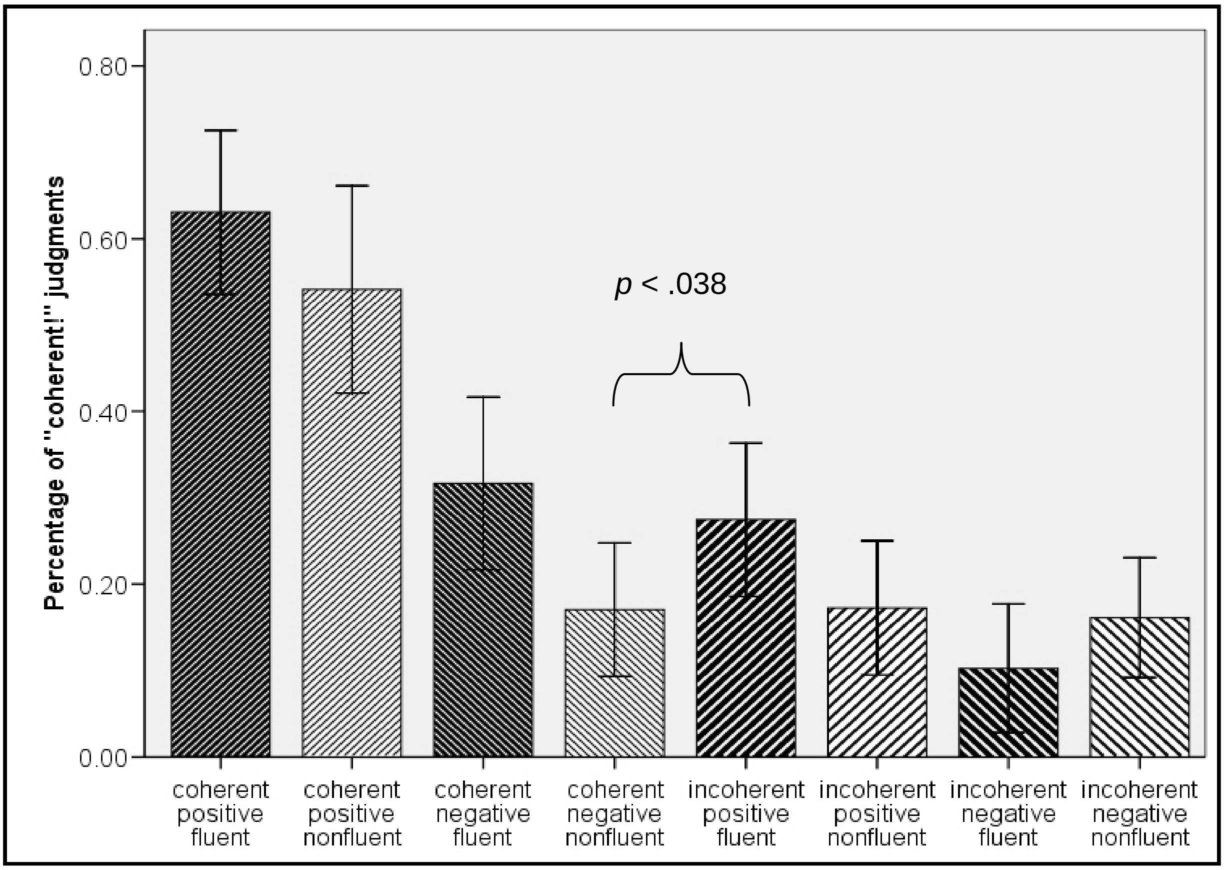

Figure 5

The probabilities to be judged coherent plotted separately for each combination of the orthogonal factors coherence, fluency, and affective valence in Topolinski and Strack (2009-b, Experiment 9).

In sum, this pattern of results provides ample empirical support for the FAIM, in that processing fluency and fluency-triggered affect are the causal precursors of semantic coherence intuitions. Yet, the experiential status of each of the links of the intuitive chain is to be explored, which will be reviewed in the following.

Experiential status

The FAIM not only provides predictions concerning the mechanisms that lead up to intuitive judgments, but also of the experiential status of these mechanisms. This is an important theoretical achievement for a procedural account of intuition since it maps the delicate borderline between processes out and inside of awareness, an aspect that is most vividly discussed in the literature (cf., the phenomenon of insight and its unconscious precursors, e.g., Beeman et al., 1994; Bowden & Beeman, 1998; Bowden et al., 2005) and is elaborated in the following. In contrast to analytic judgments such as a mathematical calculations, intuitions used in intuitive judgments occur with little awareness of the underlying processes (Bechara et al., 1997; Betsch, 2008; Deutsch & Strack, 2008; Epstein, 1991; Hammond, Hamm, Grassia, Pearson, 1987; Hastie, 2001; Hogarth, 2001; Kahneman, 2003; Reber, 1989; Volz & von Cramon, 2006), which was most succinctly expressed by Lieberman (2000, p. 111) in the notion that intuition is "[…]the subjective experience of a mostly nonconscious process." Of course, also analytic judgments entail auxiliary processes outside of awareness (such as concept retrieval from memory, Strack & Deutsch, 2004), however, in intuitive judgments most of the information processing happens outside of awareness and is not cognitively penetrable (e.g., Lieberman, 2000; Deutsch & Strack, 2008). Thus, the puzzling nature of intuition is the transition from processes operating outside of awareness and then entering the individual's experiential awareness; a borderland that was also called *fringe consciousness* (James, 1890; see also Cook, 1999; Dewey, 1925; Mangan, 1993, 2000, 2001; Reber & Schwarz, 2001; Reber, Wurtz, & Zimmermann, 2004).

Concerning the intuitive chain running in intuitive judgments of semantic coherence, it is first of all apparent that the early cognitive precursors in the associative semantic store, i.e. the activation convergence onto the solution word of a coherent triad, remain outside of individuals' awareness and are cognitively impenetrable. This claim is supported by the finding that activation convergence runs unintentionally and without participants' awareness (Topolinski & Strack, 2008; see also above). Actually, the only way in which this process would enter awareness would be the immediate spontaneous retrieval of the solution word after reading a coherent triad, which happens very rarely (Bolte & Goschke, 2005; Topolinski

& Strack, 2009b, in press-b; see also Bowden et al., 2005), and does not qualify as intuition, but rather insight (e.g., Bowden et al., 2005; Metcalf, 1986 a, b; Metcalf & Wiebe, 1987).

Concerning the next links in the intuitive chain, i.e. fluency and affect, it is obvious that affect is indeed experienced, since it can be verbally reported by participants in preference judgments (Topolinski & Strack, in press-b, Experiment 3), is obviously used as internal cue in coherence judgments (Topolinski & Strack, in press-b, Experiment 4), and presumably serves as the cue in judgments of familiarity (Topolinski, submitted). Thus, only the experiential status of fluency remains an object of empirical investigation. From the literature, no precise prediction can be made whether fluency itself is experienced or not. While the fluency of very fast processes such as visual perception is not consciously experienced by individuals (Fazendeiro et al., 2005), the fluency of longer lasting processes, such as memory retrieval, is very well experienced and can readily be reported (Schwarz et al., 1991). The fluency variations of semantic processing, which obviously applies to the present case of word triads, however, are only experienced when exceeding a certain threshold, namely fluctuations of around 100 ms (Hertwig, Herzog, Schooler, Steinmann, & Reimer, 2009). Given that the objective fluency difference in processing coherent compared to incoherent word triads is well below 100 ms (Topolinski & Strack, in press-b, Experiment 1-2, see also above), the experiential status of fluency due to hidden semantic coherence remains an empirical question.

This question was recently addressed in Topolinski and Strack (in press-a) by assessing two different indicators of awareness for both fluency and affect, namely verbal reports (cf. Steven, 1957, 1961; but see also Nisbett & Wilson, 1977), and a misattribution paradigm (e.g. Schwarz & Clore, 2007, see also above). First, we asked participants to read coherent and incoherent word triads and push a key as soon as they had accomplished reading the triad (providing a measure of objective fluency). Then, we asked some of the participants to report how easy and fast they could read the triad; while other participants were asked to report how much they liked the particular triad. Following the FAIM, the former report should map experienced fluency, while the latter experienced affect. It turned out that although objectively participants actually read coherent triads faster than incoherent triads (with a response latency gain of again around 60 ms; see Topolinski & Strack, in press-b, Experiment 1-2), they did not rate their processing of them being more fluent; however, liked them more (Topolinski & Strack, in press-a, Experiment 1). This differential pattern suggests that participants could not detect the coherence-induced fluency, but the fluency-triggered positive affect.

Further evidence was gathered in a subsequent experiment in which we applied the above described misattribution procedure to either fluency or affect. Specifically, we let participants intuitively judge the coherence of (in)coherent word triads, as in the classical set-up (e.g., Bolte & Goschke, 2005), and played an ambiguous piece of background music. Some of the participants were told that the music influences their affective responses to the triads, while other participants were told that the music influences the easiness of reading and recognizing the meaning of a word. Following the logic of the misattribution paradigm (e.g., Fazendeiro et al., 2005; Schwarz et al., 1991; Strack et al., 1993) and the notion that one can only re-attribute what one is consciously experiencing (Winkielman et al., 1997), possible differences in intuitive performance between the experimental groups should be highly informative concerning the experiential status of fluency. And they were: while participants misattributing affect to the external source completely lost their ability to intuitively detect semantic coherence (cf., Topolinski & Strack, in press-b, Experiment 4), the participants misattributing semantic fluency could reliably detect semantic coherence, showing a performance similar to a control group with no re-attribution instruction (Topolinski & Strack, in press-a, Experiment 2). This pattern of findings suggests that participants re-attributed affect but not fluency to the external source, presumably because they did not consciously experience the fluency (Winkielman et al., 1997). This evidence further corroborates the notion that the fluency-triggered positive affect, but not the fluency itself, is experienced in hidden semantic coherence.

To summarize, we can specifically describe the experiential status of the different stages of information processing that lead up to semantic coherence intuitions. While both semantic activation convergence and increased processing fluency stay outside of awareness, thus remain behind the curtain of fringe consciousness (Mangan, 1993; Reber et al., 2004), their affective consequences emerge into experiential awareness, can be reported, used as internal cues, and can even be discounted from a judgment.

Summing up, a body of evidence provides support for the FAIM. The author does not know of any other account that traces back the architecture of intuitive judgments without any explanatory gap, as the FAIM does. Rather than assuming an “intuitive system” en bloc carrying out “implicit thought” (Kihlstrom, 1999), the FAIM identifies, measures and even manipulates specific mechanisms that are well-known from the literature, such as semantic activation spread, processing fluency, and affective consequences of fluency building the inner architecture of the black box of semantic coherence judgments.

Finally, the present fluency-affect account can also be generalized to other intuitions in the literature, which is outlined in the following.

Generalizing the FAIM to other intuitions

The present fluency-affect approach to intuitive judgments can also be generalized to other intuitive faculties that have been connected to fluency in the literature, which are, for instance, gestalt intuitions (Bowers et al., 1990; Bolte & Goschke, in press; Volz & von Cramon, 2006; Wippich, 1994; Wippich & Mecklenbräuker, 1994; Wippich, Mecklenbräuker, & Krisch, 1994), and judgments of grammaticality in artificial grammar learning (Reber, 1967; Kinder et al., 2003). In the following, we will briefly apply the FAIM to these intuitions and will also review empirical evidence supporting our theoretical claims.

Gestalt intuitions. In their classical paper on intuition, Bowers and colleagues (1990) investigated also whether visual coherence can intuitively be detected. They presented participants pictures of black-and-white drawings of everyday objects that were visually degraded to such a degree that the depicted object could only rarely be recognized, although the visual gestalt remained coherent. In addition, they also presented the same degraded pictures, however fragmented and the fragments rotated and intermixed, thus containing the same visual information, but not exhibiting a coherent gestalt. They found that participants could reliably discriminate between blurred, yet gestalt-like pictures and incoherent pictures, independently from actually recognizing the depicted object (see also Volz & von Cramon, 2006; Wippich, 1994; Wippich & Mecklenbräuker, 1994; Wippich et al., 1994).

The FAIM can also account for this intuitive faculty by predicting that the visual coherent stimuli can more easily be processed than visual incoherent stimuli (Reber et al., 2004) and also trigger positive affect that is used in the intuitive judgment. A first empirical hint for this was provided by Wippich (1994) who found that pre-exposed drawings were more likely to be judged visually coherent than new drawings (cf., the above fluency manipulation of repeated exposure). Furthermore, most recently, we demonstrated the impact of both fluency and affect also in these intuitions. In Topolinski and Strack (2009-b, Experiment 10), we pre-exposed coherent and incoherent blurred drawings in a study phase. Later, during an intuitive task in which participants should intuitively detect visual coherence, we presented these old drawings together with new (in)coherent drawings. Furthermore, we flashed masked photos of happy and sad faces briefly before each drawing was presented. As a consequence, we found that veridical visual coherence, exposure-manipulated fluency, and subliminally primed affect each independently influenced intuitive judgments of visual coherence in the way that coherent, pre-exposed, and positively primed drawings were more frequently judged to be coherent than incoherent, new, and negatively primed drawings. This result generalizes the FAIM to gestalt intuitions. It is important to emphasize that this research is also the first to demonstrate a causal role of affect in an allegedly purely visual detection task (see also Topolinski, Likowski, Weyers, & Reber, submitted).

Intuitive judgments of grammaticality. Performance in artificial grammar learning (Reber, 1967; for a recent review, see Pothos, 2007) are surely the most prominent and classical example of empirically investigated intuitions. In this task, participants are exposed to letter strings that are derived from a complex synthetic grammar. Later in a test phase, they receive novel strings that either match the underlying grammar from the study set or not, and are asked to intuitively judge the grammatical correctness. In numerous studies, it was shown that individuals are able to detect grammaticality above chance without being able to verbally report the rules underlying the grammar (Pothos, 2007). Although this phenomenon is not called "intuition" in the literature but rather implicit learning (Schacter, 1987); and research is especially interested in the cognitive mechanisms that are responsible for this type of learning (e.g., Perruchet & Pacteau, 1990; Pothos, 2007), the eventual grammaticality judgment can be called an intuitive one, since participants reliably detect a criterion that they cannot explicitly report (e.g., Epstein, 2008; Metcalf, 1986 a, b; Yanic & Meyer, 1987).

The fluency-affect link may also be applied to these intuitive judgments (see Reber et al., 2004, who first proposed this possibility; see also Servan-Schreiber & Anderson, 1990; but also see Perruchet & Pacteau, 1990; Vokey & Brooks, 1992), because of the following empirical evidence. There are hints that grammaticality increases processing fluency, since grammatical strings are memorized better (Miller, 1954; such as coherent word triads are also memorized better than incoherent word triads, Topolinski & Strack, 2008) and processed faster (Buchner, 1994) than agrammatical strings. Furthermore, there is evidence that grammaticality also induces positive affect, since grammatical strings were found to be preferred to agrammatical strings (Gordon & Holoyak, 1983; Newell & Bright, 2001). Furthermore, manipulating the visual fluency of letter strings was found to affect grammaticality intuitions (Kinder et al., 2003). Finally, most recently, we found that also both figure-ground contrast and subliminal affective primes (as described above) influence grammaticality intuitions independently from veridical grammaticality in the way that grammatical strings with high figure-ground contrast and preceded by a positive affective prime were more frequently judged to be grammatical than agrammatical strings with low figure-ground contrast and preceded by a negative affective prime (Topolinski & Strack, 2009b, Experiment 11). In sum, this body of evidence strongly bolsters that the FAIM can also provide a procedural account of grammaticality intuitions.

Limitations of the FAIM

The present treatise does not claim that a fluency-affect link can be proposed for every intuitive judgment that is found in the literature. For instance, the intuitive stage of performance in the Iowa Gambling Task (Bechara et al., 1997; Damasio, 1994; de Vries, Holland, & Witteman, 2003) or the automatic aggregation of valence in the tasks by Betsch and colleagues (Betsch, Hoffmann, Hoffrage, & Plessner, 2003; Betsch et al., 2001, 2003, 2006) will hardly be connected to processing fluency but rely on evaluative conditioning processes (De Houwer, Thomas, & Baeyens, 2001). The author only used the FAIM as an example of a procedural approach to intuition specifically identifying the involved cognitive and affective mechanisms and their processing features. For other domains of intuitive judgments, applicable procedural accounts shall be developed in future theorizing and tested in future research.

However, in the closing section, it shall be illustrated that the explanatory power of the FAIM does not end with the evidence gathered so far. The author will only cursorily provide some examples of future research questions that can be derived from the FAIM. Furthermore, the author wants to inspire procedural accounts of intuitive judgments in yet other domains by pointing to some urgent questions.

Can Linda make us smile? - Further questions

The presently propagated procedural approach FAIM might trigger a multitude of future research questions, such as the following. Do visually coherent drawings compared to incoherent drawings (Bowers et al., 1990) also induce positive affect? In which other tasks than artificial grammar learning (Pothos, 2007) that have classically been considered to be purely cognitive may affect also play a causal role (Topolinski & Strack, 2009b)? Extending Mangan's (2000) question what feeling the feeling-of-knowing is, does it feel positive or negative? Since a causal role of phasic affect was already shown for moral intuitions (Wheatley and Haidt, 2000), it will be interesting to explore whether this affect is part of experiential awareness and can be discounted from the judgment. In particular, will individuals loose the faculty of moral judgment (Haidt, 2001) in a re-attribution paradigm?

Finally, consider the classical conjunction fallacy (Tversky & Kahneman, 1983), where a young woman is described resembling a feminist, but not a bank teller. Then, participants are asked to consider which of two statements is more likely: (a) Linda is a bank teller or (b) Linda is a bank teller who is active in the feminist movement. Although, from a normative logical perspective, the first proposition is more likely than the second, many people prefer the second over the first (for a review, see Kahneman & Tversky, 1996). Since the person description of Linda is highly semantically convergent on the concept of feminism, it is plausible that fluency and also fluency-triggered affect may play a causal role in this classical fallacy. In particular, can the fallacy be affected by semantic priming? Will it disappear in a re-attribution paradigm? Or, will a feminist Linda make us smile (cf. Topolinski et al., 2009)?

However, procedural accounts shall also be derived for other intuitive judgments that do not draw on a fluency-affect link. For the anchor heuristic, for example, this was already done (Mussweiler & Strack, 1997). Often, the mechanisms underlying the judgment are described, but not tested. For instance, Kahneman & Frederick (2002) described the formation of the intuitive judgment of willingness to pay to save migratory birds from drowning in oil ponds (Desvouges et al., 1993) as follows: “The deaths of numerous birds are first represented by a prototypical instance, perhaps an image of a bird soaked in oil and drowning. The prototype automatically evokes an affective response and the intensity of that emotion is then mapped onto the dollar scale […]” This description alone provides a sketch for a possible procedural account that might specifically investigate the micro-architecture of this intuitive judgment.

There are numerous fields for which such procedural accounts are yet to be developed. For instance, the research on heuristics is merely occupied with simulating individuals' choices by computing various possible ways of cue integration and compares these with actual human choices (e.g., Gigerenzer & Goldstein, 1996); however, such simulation data do not provide any evidence about actual human decision making (Newell, 2005). What are the actual steps of judgment formation and what are the actual experiential cues their participants use in their judgments (see Bröder & Schiffer, 2003, for a first approach to these questions)? To point to other still underspecified phenomena, what are the semantic processes running during “unconscious thought” (Dijksterhuis, 2004), and the processes that enable covariation-detection (Lewicki, 1986, a, b)? What are the actual cues they generate?

Conclusion

In the present treatise, a procedural account of studying intuitive judgments is called for. As an example, the fluency-affect intuition-model by Topolinski and Strack (2008, 2009a, 2009b, in press-a, in press-b) is introduced and evidence is reviewed supporting its empirical validity.

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German Summary - Deutsche Zusammenfassung

In der vorliegenden Abhandlung wird für eine prozedurale Betrachtungsweise bei der psychologischen Erforschung intuitiver Urteile gestritten. Obwohl intuitive Urteile in einer Vielzahl von Bereichen untersucht werden (z.B. Bechara, Damasio, Tranel, & Damasio, 1997; Kahneman & Tversky, 1996; Reber, 1967), sind theoretische Modelle und empirische Arbeiten, die die intuitiven Urteilen zugrunde liegenden Prozesse darstellen, selten (e.g., Koriat & Levy-Sadot, 2001). Anhand des kürzlich entwickelten Fluency-Affekt Intuitionsmodells (FAIM) von Topolinski und Strack (2008, 2009a, 2009b, im Druck-a, im Druck -b) wird exemplarisch ein sozialkognitiver Ansatz dargestellt, der systematisch die Prozesse untersucht, die zu Intuitionen von Kohärenz führen. Bei dieser Art von Intuition erspüren Individuen, ob eine Wortgruppe einen gemeinsamen Assoziaten als Lösungswort hat (z.B. SALZ TIEF GISCHT implizieren MEER), oder nur eine zufällige Wortgruppe ist (z.B. TRAUM BALL BUCH), ohne das Lösungswort abrufen zu können (Bowers, Regehr, Balthazard, & Parker, 1990).

Insbesondere nimmt das FAIM an, daß beim Lesen einer kohärenten Worttriade schrittweise deren Lösungswort semantisch aktiviert wird, was die Verarbeitungsflüssigkeit (Fluency) kohärenter Triade erhöht im Vergleich zu inkohärenten Triaden (vgl. Whittlesea, 1993). Diese erhöhte Verarbeitungsflüssigkeit löst automatisch einen positiven Affekt aus (vgl., Reber, Schwarz, & Winkielman, 2004), der als kognitives Gefühl als Urteilsgrundlage herangezogen wird (vgl. Schwarz & Clore, 2007). Es werden insgesamt 24 Experimente aus 5 veröffentlichten Arbeiten des Autoren und 1 unveröffentlichtes Experiment besprochen, die empirische Hinweise für die Gültigkeit des FAIM geliefert haben.

Wichtige Implikationen für zukünftige Forschung unter einem prozeduralen Fokus auf intuitive Urteile werden besprochen.

APPENDIX

Topolinski, S., & Strack, F., (2009). The architecture of intuition: Fluency and affect determine intuitive judgments of semantic and visual coherence, and of grammaticality in artificial grammar learning. *Journal of Experimental Psychology: General, 138 (1)*, 39-63.

Abstract

People can intuitively detect whether a word triad has a common remote associate (coherent) or not (incoherent) before, and independently from actually retrieving the common associate. We argue that semantic coherence increases the processing fluency for coherent triads, and that this increased fluency triggers brief and subtle positive affect, which is the experiential basis of these intuitions. In a series of 11 experiments using three different fluency manipulations (figure-ground contrast, repeated exposure, and subliminal visual priming) and three 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. We could equalize and even reverse coherence judgments (i.e., incoherent triads were more frequently judged to be coherent than 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.

Key words: intuition, processing fluency, remote associates, artificial grammar learning, judgments, feelings-as-information, visual coherence

The Architecture of Intuition:

Fluency and Affect Determine Intuitive Judgments of Semantic and Visual Coherence, and of Grammaticality in Artificial Grammar Learning

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., Hammond, 1996; Lieberman, 2000; Deutsch & Strack, 2008; Wilson, Lindsey, & Schooler, 2000), that are fast and effortless (e.g., Gigerenzer, Todd & the ABC Research Group, 1999; Epstein, 1991; Hamm, 2008; Hogarth, 2001; Kahneman & Frederick, 2002; Stanovich & West, 2002), 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).

We 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, Todd & the ABC Research Group, 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 also 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) 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 from actually retrieving this common associate (Baumann & Kuhl, 2002; Bolte et al., 2003; Bowers et al., 1990). Moreover, they can discriminate between coherent and incoherent word triads above chance in less than 2,000 ms (Bolte & Goschke, 2005). This is an astonishing faculty, since 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. Although we have learned that coherent word triads automatically activate their common remote associate (Beeman et al., 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 affect as possible mechanisms generating these intuitions. The present work will systematically test this fluency-affect account, which will be 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. Since it that work we 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 RIM describes the interactions between an Impulsive System that is endowed with an associative semantic network and produces fast and efficient internal cues, such as feelings, that may be used by a second system, the Reflective System, that transforms this input into a propositional format in order 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; 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 to 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 yet described or tested the manner in which this intuition comes about.

In previous studies (Topolinski & Strack, in press) we assessed the outputs of the intuitive chain. We demonstrated that coherent triads are processed faster than 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 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; Winkielman, Zajonc, & Schwarz, 1997, Experiment 2; Schwarz, Sanna, Skurnik, & Yoon, 2007) 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, 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). Experiments 1-3 used three different fluency manipulations, namely figure-ground contrast, repeated exposure, and subliminal visual priming. Experiments 4-8 used three different inductions of phasic affect, namely short-term facial feedback, subliminal facial primes, and affect-laden word triads. Finally, Experiments 9-11 manipulated fluency and affect jointly and generalized the intuitive chain also to judgments of visual coherence, and intuitions of grammaticality in an implicit grammar learning paradigm. Since the paradigm was similar for all experiments, we will 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 used in 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/left half of the PC screen and participants were asked to react within 500 ms with the appropriate right/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 did not re-occur 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 will be more thoroughly discussed in Experiment 6), coherent triads were labeled as “interrelated” (German “zusammenhängend”), but incoherent triads were labeled 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 re-randomized 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 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 et al., 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 re-occured in the intuitive task, this increased the likelihood that these incoherent pictures would be judged to be coherent when compared to 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 using 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 (1990, 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 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 triads presented in a low contrast.

Method

Participants. Thirty (15 female) non-psychology students participated for a payment of two Euros (approximately $2.50 US at the time).

Materials and procedure. The general procedure was run with the colors manipulated in which word triads were presented. 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 and a low processing fluency, respectively. Half of the coherent and half of 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 re-randomized 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 as incoherent only because they were unable to process the words appropriately. For this purpose, participants were asked if they could easily read the triads or if 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 using 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 2160, 30 %). Table 1 shows how many of these missed responses came from (in)coherent, and (non)fluent trials, respectively. In order to check for any effect of fluency on the frequency of these missed responses, a 2 (Coherence: coherent triads vs. incoherent triads) X 2 (Fluency: high contrast vs. low contrast) analysis of variance (ANOVA) was conducted treating both factors as within-subjects factors, which yielded no effects, all 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. While the number of missed responses for all experiments and conditions are displayed in Tables 1 and 2, we will 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 based on an explicit retrieval of the solution word. Because the participants were not asked to type in a solution candidate after they had missed to respond 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 of 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 vs. incoherent triads) x 2 (Fluency: high vs. low contrasts) repeated measures analysis of variance (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 as coherent ($M = 0.36$, $SE = 0.03$) than triads presented in a low contrast ($M = 0.25$, $SE = 0.03$), $t(29) = 2.48$, $p < .02$, and within the incoherent triads, triads presented in a high contrast were also more often judged as coherent ($M = 0.2$, $SE = 0.04$) than triads presented in a low contrast ($M = 0.10$, $SE = 0.03$), $t(29) = 3.00$, $p < .005$. However, there was no reliable difference between coherent triads presented in a low contrast and incoherent triads presented in a high contrast, $t < 1.2$.

Discussion

Using figure-ground contrast to alter fluency, this study investigated the impact of processing fluency on intuitions of semantic coherence. Not surprisingly, coherent triads were judged to be coherent more often than incoherent triads. More interestingly, a triad was more likely to be judged as coherent if it was fluently processed, irrespective of whether it was coherent or not. 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 et al., 2007) and increased the overall frequency of guessing solution candidates after having read the triad (cf., Harkins, 2006; Topolinski & Strack, 2008). Second, and independently from 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, 1992). Both increased guessing of solution candidates or increased confidence in guessed solution candidates in turn may 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 typed in a possible solution candidate or not (which was used before to identify whether coherent trials were solved). Although this measure is not 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, i.e. in trials in which they did not guess at all. To test this, we re-ran the analysis only using 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 using another fluency manipulation.

Experiment 2

Another means of manipulating fluency is repeated exposure, since repeated stimuli are more fluently processed than 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 processed faster and thus more likely to be judged as coherent.

Method

Participants. Thirty-three (19 female) non-psychology students participated for a payment of two Euros (approximately $3.00 US at the time).

Materials and procedure. The general procedure was implemented using 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 will be 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 new triads, $t(120) = 2.51$, $p < .013$.

Coherence judgments. A 2 (Coherence: coherent vs. incoherent triads) x 2 (Repetition: old triads vs. new triads) repeated measures analysis of variance (ANOVA) revealed a main effect for Coherence, $F(1,32) = 92.86$, $p < .001$, $\eta_p^2 = .74$, and 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 ($M = 0.55$, $SE = 0.04$) were more likely to be judged as coherent than new triads ($M = 0.45$, $SE = 0.03$), $t(32) = 3.20$, $p < .003$; and within the incoherent triads, old triads ($M = 0.27$, $SE = 0.03$) were also more likely to be judged as coherent than new triads ($M = 0.28$, $SE = 0.03$), $t(32) = 4.45$, $p < .001$. 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 that fluency alters coherence judgments, additively and independently from veridical coherence. The finding that recurring coherent triads were more often solved than 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 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 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 in order 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, Winkielman, & Schwarz, 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 either 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, while the prime appeared at the position of the third word (see the 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.

Method

Participants. Thirty-three (20 female) non-psychology students participated for a payment of two Euros (approximately $2.00 US at the time).

Materials 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 that was equal to the triad word in visual width and that was 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 by the Airbrush function in the Microsoft Paint program by airbrushing white pixels 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.

Re-randomized for each participant, one half of the coherent and one half of the incoherent triads was preceded by their own degraded third word as prime, and the other half of the coherent and incoherent triads, respectively, was preceded by a degraded nonword as prime. No blocks of the four conditions were formed, but rather 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 of 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) x 2 (Fluency: matching word prime vs. nonword prime) repeated measures analysis of variance (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 ($M = 0.34$, $SE = 0.04$) than when they had been preceded by a visually degraded version of a nonword ($M = 0.25$, $SE = 0.04$), $t(30) = 2.47$, $p < .02$. 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 ($M = 0.20$, $SE = 0.03$) than when they had been preceded by a visually degraded version of a nonword ($M = 0.15$, $SE = 0.02$), $t(30) = 1.98$, $p = .057$. 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 from veridical coherence. Moreover, this robust effect did not depend on a particular method of inducing fluency, but rather generalized across different inductions. In the next set of studies, we shall 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 (Stapel, Koomen, & Ruys, 2002; Russell & Feldman-Barrett, 1999) that is not necessarily a part of experiential awareness, but can be if the affect is very intense or changes rapidly (Russell, 2003). In such cases, core affect emerges as a feeling that individuals may become aware of (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 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 was 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 will be 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 by using 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 et al., 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 be able 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 triads read under corrugator contraction.

Method

Participants. Fifty (28 female) non-psychology students participated for a reward of two Euros (approximately $2.50 US 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 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 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' eye brows. 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 words MOUTH or BROWS appeared on the screen, and relaxed their faces whenever the word RELAX appeared, which was shown 2 s after the signal words MOUTH or BROWS had appeared. The experimenters were well trained in avoiding any affective connotations concerning the facial manipulations. While explaining and training, the facial responses were not labeled 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 words 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 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 of 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) x 2 (Muscle: zygomaticus vs. corrugator contraction) repeated measures analysis of variance (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 the coherent and incoherent triads revealed that coherent triads were more likely to be judged as coherent under zygomaticus contraction ($M = 0.39$, $SE = 0.02$) than under corrugator contraction ($M = 0.27$, $SE = 0.02$), $t(49) = 6.17$, $p < .0001$, and incoherent triads were also more likely to be judged as coherent under zygomaticus contraction ($M = 0.22$, $SE = 0.02$) than under corrugator contraction ($M = 0.13$, $SE = 0.01$), $t(49) = 11.26$, $p < .0001$. 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, the possible alternative explanation should be ruled out that positive affect prompted participants to judge the current triad as coherent via increasing the frequency of guessing any solution candidate, or increasing the confidence in a retrieved solution candidate. We re-ran 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 as 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 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 more easily could 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 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

The present study 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, Zajonc, & Schwarz, 1997; Wong & Root, 1999).

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 a triad followed by a negative affective prime, irrespective of its actual coherence.

Method

Participants. Thirty (20 female) non-psychology students participated for a reward of two Euros (approximately $2.50 US 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 Lundquist 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 x 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, 1997), 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 re-randomized 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 if 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) x 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 *F*s < 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 does 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) x 2 (Valence: positive vs. negative facial prime) analysis of variance (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 more often judged as coherent ($M = 0.34$, $SE = 0.03$) than negatively primed coherent triads ($M = 0.26$, $SE = 0.03$), $t(29) = 2.54$, $p < .018$; and that positively primed incoherent triads were more often judged as coherent ($M = 0.20$, $SE = 0.03$) than negatively primed incoherent triads ($M = 0.10$, $SE = 0.02$), $t(29) = 3.62$, $p < .001$. 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 as coherent than negatively primed triads. The finding that negatively primed coherent triads were more frequently solved than positively primed triads was replicated in Experiments 5 and 6 and will be 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 served as a coherence-unspecific "go"-signal for the participants. Let us elaborate upon 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 of 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 between 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 importantly, 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 option "coherent" (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) non-psychology students participated for a reward of two Euros (approximately $2.50 US 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 told that they could additionally gather points during the intuitive task in order to receive candy as extra compensation. They were told that they would earn one point each time they detected a coherent triad, however, they would lose one 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 s/he 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 to the overall proportion in Experiment 5. As expected, the overall proportion of "coherent" responses was reliably increased in this study (*M* = 0.53, *SE* = 0.02) as compared to Experiment 5 (*M* = 0.23, *SE* = 0.02), $t(58) = 10.37$, $p < .001$.

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 more often judged as coherent (*M* = 0.68, *SE* = 0.03) than negatively primed coherent triads (*M* = 0.52, *SE* = 0.03), $t(29) = 4.69$, $p < .001$, and positively primed incoherent triads were more likely to be judged as coherent (*M* = 0.48, *SE* = 0.04) than negatively primed incoherent triads (*M* = 0.40, *SE* = 0.05), $t(29) = 2.26$, $p < .031$. 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 option “coherent” 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 than incoherent triads and by rewarding hits and punishing misses. Nevertheless, positively primed triads were more often judged as coherent than 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 that analyzed the impact of mood on semantic spread (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 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; s.a. 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 (submitted). In the case of coherent triads, this implies that positive affect would increase the frequency of “coherent”-responses, while 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) non-psychology students participated for a reward of two Euros (approximately $2.00 US at the time).

Materials and procedure. We replicated Experiment 5 except that facial primes and masks did not occur 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 more often judged as coherent ($M = 0.30$, $SE = 0.03$) than negatively primed coherent triads ($M = 0.21$, $SE = 0.03$), $t(29) = 3.23$, $p < .003$, and that positively primed incoherent triads were more often judged as coherent ($M = 0.21$, $SE = 0.02$) than negatively primed incoherent triads ($M = 0.15$, $SE = 0.02$), $t(29) = 3.18$, $p < .004$.

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 at least a smaller impact, this would favor the interpretation of the affect-modulation hypothesis (Kuhl, 2002) 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, but rather 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 will 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 allowed us to additionally 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 did not arise 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 themselves were 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 more frequently judged to be familiar than 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 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 only instructed 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) non-psychology students participated for a reward of one Euro (approximately $1.00 US at that time).

Materials. 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.[2]

In order to obtain explicit ratings of the valence of these triads a questionnaire was compiled containing all 84 triad words and the 28 target words in a random order. The questionnaire was handed out to $N = 25$ 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 ($M = 1.7$, $SE = 0.32$) than the constituents of negative triads ($M = -0.30$, $SE = 0.25$), $t(24) = 7.21$, $p < .0001$), 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 pair-wise relatedness between 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 using the valenced triads instead of the 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) x (Coherence: coherent vs. incoherent triads) x 2 (Valence: positive vs. negative triads) ANOVA was run 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, as were no further interactions (all *F*s < 2). Post-hoc comparisons indicated that Valence exerted its influence for both coherent and incoherent triads. Positive coherent triads were more often judged to be coherent ($M = 0.55$, $SE = 0.03$) than negative coherent triads ($M = 0.23$, $SE = 0.02$), $t(59) = 11.20$, $p < .0001$; and positive incoherent triads were more often judged to be coherent ($M = 0.25$, $SE = 0.02$) than negative incoherent triads ($M = 0.11$, $SE = 0.01$), $t(59) = 7.36$, $p < .0001$. 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 more frequently judged to be coherent than 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 more frequently judged to be coherent than 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 more frequently judged to be coherent 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 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 to not only 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 sizeof $\eta_p^2 = .77$ in the present experiment, while 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 to 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. While 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 if our manipulations could actually reverse the judgments and cause the incoherent triads to be more frequently judged to be coherent than 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) non-psychology students participated for a reward of one Euro (approximately $1.00 US).

Materials and procedure. Experiment 8 was replicated using affect-laden word triads and the explicit instruction to discount the valence from coherence judgments. Half of 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 re-randomized for each participant.

Results

Missed responses. The numbers of missed responses are shown in Table 2. Running a 2 (Coherence: coherent vs. incoherent triads) x 2 (Fluency: high vs. low contrast) x 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) x 2 (Valence: positive vs. negative word triads) repeated-measures analysis of variance (ANOVA) that was conducted over the individual 67 trials in which a triad was correctly solved, which revealed no effects (all Fs < 0.4).

Coherence judgments. A 2 (Coherence: coherent vs. incoherent triads) x 2 (Fluency: high vs. low contrast) x 2 (Valence: positive vs. negative word triads) repeated measures analysis of variance (ANOVA) revealed three strong main effects: for Coherence, $F(1,34) = 72.17$, $p < .0001$, $\eta_p^2 = .68$, for Fluency, $F(1,34) = 18.92$, $p < .0001$, $\eta_p^2 = .36$, as well as 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 importantly, a planned comparison revealed that positive incoherent triads presented in a high figure-ground contrast were more likely to be judged as coherent (*M* = 0.34, *SE* = 0.03) than negative coherent triads presented in a low figure-ground contrast (*M* = 0.24, *SE* = 0.03), $t(34) = 3.35$, $p < .002$).

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, as well as 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). People did not only lose their ability to practice intuitive discrimination but rather their intuitions became completely misguided. That is, incoherent triads that were positively laden and fluently processed were more frequently judged to be coherent than coherent triads that were negatively laden and nonfluently processed. The next two experiments should extend the present approach to two types of intuitive jugdments 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 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 pre-exposure phase, participants had to study each drawing for 5,000 ms and were asked to produce free associations to each, which is likely to establish an explicit memory of the drawings. Later in the intuitive task, when confronted again with the pre-exposed stimuli, participants may have recognized the stimuli from the study list. Because we know from different domains that coherent stimuli are memorized better than incoherent stimuli (Miller, 1958; Topolinski & Strack, 2008; Zajonc & Burnstein, 1965), it is likely that pre-exposed coherent drawings were more often recognized than pre-exposed 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 re-attributed their fluency experiences to the earlier encounter, and discounted fluency from their intuitive judgments. Thus, predominantly for coherent drawings, participants re-attributed fluency to an earlier exposure, rendering fluency ineffective. The present study should avoid recognition of pre-exposed pictorial stimuli by decreasing pre-exposure 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 x 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, 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 6 pictures per page and a blank line beneath each picture. These questionnaires were delivered to $N = 40$ 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) non-psychology students participated for a payment of four Euros (approximately $6.00 US at the time).

Materials and procedure. Experiment 7 was replicated (the general procedure applying subliminal facial primes directly before 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 of 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 inter-stimulus 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. A 2 (Fluency: old pictures vs. new pictures) x 2 (Valence: positive vs. negative facial primes) repeated measures ANOVA 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 or not, a 2 (Visual coherence: object vs. nonobject pictures) x 2 (Fluency: old pictures vs. new pictures) x 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 (all 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 the surely 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 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 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, 1954) and processed faster (Buchner, 1994) than agrammatical strings. Second, grammatical strings are liked more than agrammatical strings in preference judgments (Gordon & Holoyak, 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, Shanks, Cock, and Tunney (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 importantly, the color change rate was faster for one group if items (fluent) than for the other (nonfluent). As a result, although not reliably for all conditions, faster-clarifying items were in general more often judged to be grammatical than 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 extend it by additively manipulating affect (via subliminal facial primes).

Method

Participants. Thirty (22 female) non-psychology students participated for a payment of four Euros (approximately $6.00 US at the time).

Materials 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.[3] These items were presented either in a high or low figure-ground contrast (like the fluency manipulations in Experiments 1 and 9) and were either preceded by a positive or 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 rather 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 to the previous experiments in which up to 30 % of responses were lost due to the response time window technique[4]. Over these judgments, a 2 (Grammaticality: grammatical vs. agrammatical letter strings) x 2 (Fluency: high vs. low contrast) x 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 (all *F*s < 1.6). Consequently, planned comparisons showed that grammatical items were more likely to be judged as grammatical ($M = 0.55$, $SE = 0.02$) than agrammatical items ($M = 0.41$, $SE = 0.01$), $t(29) = 8.10$, $p < .001$; items presented in high contrast were more likely to be judged as grammatical ($M = 0.54$, $SE = 0.02$) than items presented in low contrast ($M = 0.43$, $SE = 0.02$), $t(29) = 2.95$, $p < .01$; and items preceded by positive primes were also more likely to be judged as grammatical ($M = 0.52$, $SE = 0.02$) than items preceded by negative primes ($M = 0.45$, $SE = 0.02$), $t(29) = 2.28$, $p < .04$ (the means for each condition are shown in Table 4). Descriptively, nonfluent and negatively primed grammatical items were less often judged to be grammatical ($M = 0.48$, $SE = 0.05$) than fluent and positively primed agrammatical items ($M = 0.53$, $SE = 0.03$), 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 to low contrast, and were preceded by a positive prime as compared to 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 (which does not apply to the letter strings in Experiment 11, where no solutions can be retrieved), which led to an additional drop-out. 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 2160 trials overall, of which a half is coherent, and a quarter is 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 *in*coherence 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 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, also the discarding of solved trials may confound with item difficulty, however, in the opposite direction. Word triads for which the common associate is more likely to be retrieved are the easier items (cf., Bowden & Beeman, 2003), thus, the more triads are solved and discarded in one condition the more difficult are the remaining items. Again, we did not found systematic effects of the experimental manipulations on the frequency of solved trials that could explain the present effects. While 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 to the nonfluent condition, leaving more difficult items in the fluent condition. In Experiment 4, more items were solved in the positive compared to the negative condition, leaving more difficult items in the positive condition. These both effects run *against* the found effect that triads in fluent and positive conditions were more likely to be judged as coherent. In Experiments 5-7, marginally more items were solved in the negative compared to 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 affects 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

The present work investigates 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, 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 more frequently judged to be coherent that 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 triads processed under corrugator contraction (the "frowning muscle," e.g., Cacioppo et al., 1986), again, independent of their actual coherence. Furthermore, Experiments 5-7 used a subliminal affective facial priming paradigm and found that positively primed triads were more often judged as coherent than 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 more often judged to be coherent than 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, 1968; 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 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, 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 rather employed 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, submitted), judgments of truth (Unkelbach, 2007), or judgments of prototypicality in artifical 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 will first discuss alternative explanations of the present findings and will 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 will be 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 may have rather showed 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 showed 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 differentially contributes to coherence judgments (negative affect contributed to "incoherent" responses and positive affect contributed to "coherent" responses); (c) Most importantly, we did not ask for the affirmed criterion "coherent" and its negation "incoherent," but rather implemented the two affirmed options "interrelated" and "mixed." The above interpretation may well be applied to most of the earlier work on fluency manipulations, where 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; Strack & Deutsch, 2004). To give some examples: Bodenhausen, Kramer, and Süsser (1994) found that people in happy moods rely more on stereotypes in person perception that people in sad moods; Bless et al. (1996) showed that people in happy moods rely more on general knowledge structures than 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, 2003; Bolte et al., 2003). Furthermore, most recently it was demonstrated that the metacognitive 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 between 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 et al., 2003; Bolte & Goschke, in press). Parallel, recent findings show that negative affect inhibits semantic priming (Storbeck & Clore, in press; 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). 1) Affect-modulation of semantic spread would predict that in the negative conditions, discrimination between coherent and incoherent triads would be decreased or even 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, where we found an interaction, judgments were still sensitive to coherence in the negative trials. (2) Affect-modulation cannot explain why positive affect also increased judgments for incoherent triads. Consider the case of incoherent triads: In contrast to coherent triads, where 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 Internal Sequence of the Intuitive Chain

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 maybe 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 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 to incoherent triads. During this task, processing fluency could only vary during the reading of the triads, which took participants less than 1 s (s.a. Bolte & Goschke, 2005; Topolinski & Strack, 2008). However, positive facial activity began to emerge only after 1.5 s and was full blown after 2-3 s after triad onset, thus, long after fluency variations in reading took place. This suggests that first fluency varies and then 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, even using the same semantic coherence paradigm (Baumann & Kuhl, 2002; Bolte et al., 2003). In the following section, we will relate both approaches to each other.

First, we shall 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 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 that hence 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 *towards* 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, 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 Experimentw 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 an incoherent word triad. This higher fluency triggers a brief and subtle positive affect which 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 alters 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 is 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. While Experiment 4 showed that more triads were solved when participants contracted the zygomaticus compared to contracting the corrugator, Experiment 5-7 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, submitted; Gick & Lockhart, 1995; Kuhl, 2000; cf. Fiedler, 1998; Isen, 1999; Storbeck & Clore, in press). 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?

Futhermore, 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: While 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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Footnotes

[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.

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

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

[4]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.

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Table 1

Number of Missed Responses and Solved Coherent Triads as a Function of Experimental Condition for Experiments 1-8.

	Missed responses					Solved trials[a]	
Fluency	Coherent		Incoherent		Overall (%)[b]		
manipulated	*Fluent*	*Nonfluent*	*Fluent*	*Nonfluent*		*Fluent*	*Nonfluent*
Experiment 1 (2160 trials)	175	160	162	150	647 (30 %)	32	33
Experiment 2 (2376 trials)	190	194	188	135	707 (30 %)	74	47
Experiment 3 (2232 trials)	130	141	133	154	558 (25 %)	49	40
Affect	Coherent		Incoherent		Overall (%)	Solved trials[a]	

manipulated	*Positive*	*Negative*	*Positive*	*Negative*		*Positive*	*Negative*
Experiment 4 (3600 trials)	189	234	181	152	756 (21 %)	83	43
Experiment 5 (2160 trials)	169	210	158	153	690 (32 %)	13	27
Experiment 6 (1620 trials)[c]	189	156	85	87	517 (32 %)	18	29
Experiment 7 (2160 trials)	180	195	177	190	742 (34 %)	16	25
Experiment 8 (3360 trials)	186	156	168	158	668 (20 %)	52	48

[a]Per definition, only coherent triads can be solved.

[b]Percentages are proportions of all missed responses compared to all trials.

[c]36 coherent, but only 18 incoherent triads were presented for each participant.

Table 2

Number of Missed Responses as a Function of Experimental Condition in Experiments 9-11.

	Coherence (grammaticality)								
	Coherent (grammatical)				Incoherent (agrammatical)				
Affect	Positive		Negative		Positive		Negative		Overall (%)[a]
Fluency	Fluent	Nonfluent	Fluent	Nonfluent	Fluent	Nonfluent	Fluent	Nonfluent	
Experiment 9 (1960 trials)	34	39	32	48	42	22	28	43	288 (17 %)
Experiment 10 (1800 trials)	39	28	26	26	28	22	21	24	214 (12 %)
Experiment 11 (1920 trials)	28	34	36	27	36	44	34	30	269 (14 %)

[a] Percentages are proportions of all missed responses compared to all trials.

Table 3

Number of Solved Items as a Function of Experimental Condition for Experiments 9-10.

Valence	Positive		Negative	
Fluency	*Fluent*	*Nonfluent*	*Fluent*	*Nonfluent*
Experiment 9 (1960 trials)	19	15	17	16
Experiment 10 (1800 trials)	16	23	18	6

Table 4

Probability of Being Judged as Coherent (Grammatical) as a Function of Veridical Coherence (Grammaticality), Fluency, and Affect in Experiments 9-11.

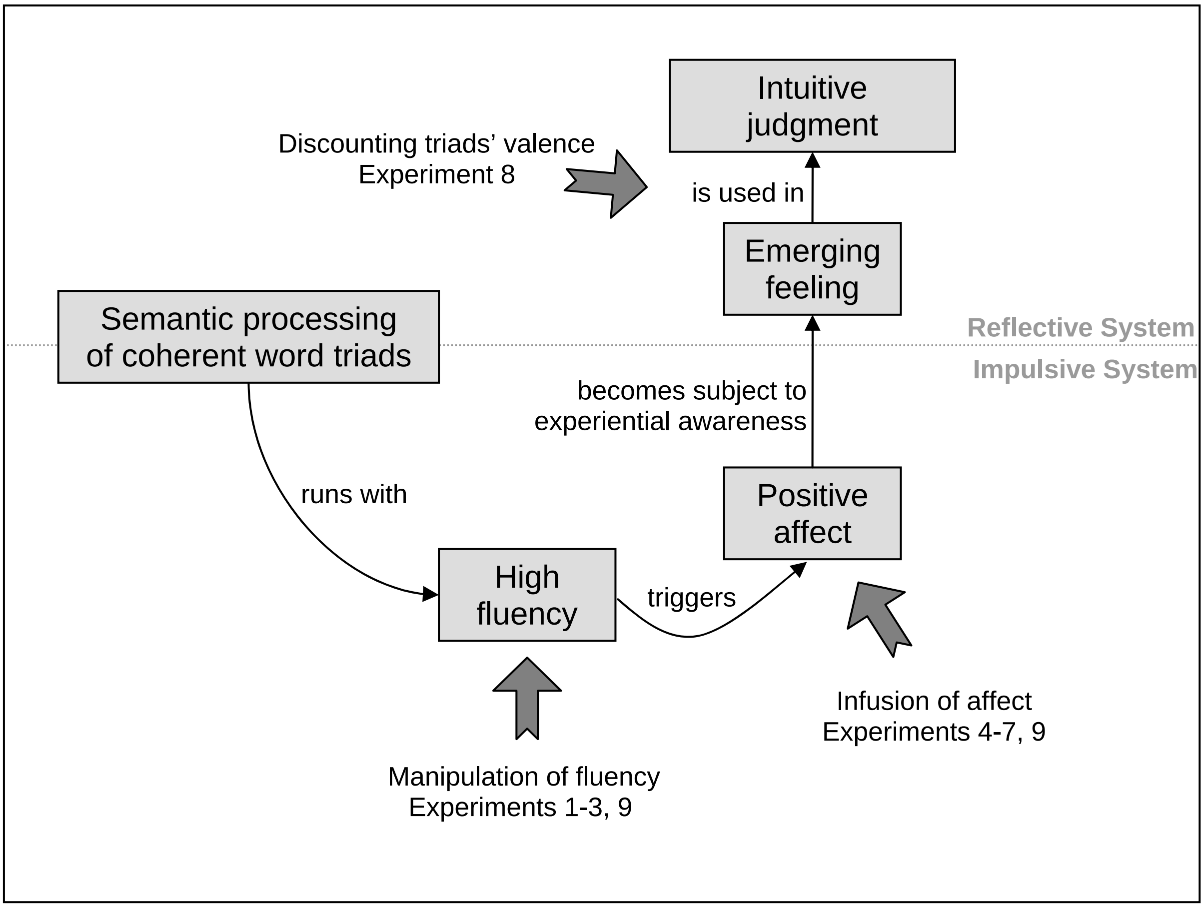
	Coherence (grammaticality)							
	Coherent (grammatical)				Incoherent (agrammatical)			
Affect	Positive		Negative		Positive		Negative	
Fluency	Fluent	Nonfluent	Fluent	Nonfluent	Fluent	Nonfluent	Fluent	Nonfluent
Experiment 9	0.58 (0.24)	0.47 (0.28)	0.33 (0.22)	0.24 (0.18)	0.34 (0.17)	0.25 (0.19)	0.14 (0.17)	0.10 (0.12)
Experiment 10	0.55 (0.25)	0.49 (0.21)	0.50 (0.18)	0.49 (0.32)	0.43 (0.26)	0.34 (0.17)	0.38 (0.29)	0.21 (0.20)
Experiment 11	0.63 (0.23)	0.56 (0.25)	0.55 (0.23)	0.48 (0.27)	0.53 (0.15)	0.36 (0.13)	0.45 (0.26)	0.33 (0.22)

Note. In parentheses standard deviations.

Figure Captions

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

Figure 1


Intuitive judgment
Discounting triads' valence
Experiment 8
is used in
Emerging feeling
Semantic processing of coherent word triads
Reflective System
Impulsive System
becomes subject to experiential awareness
runs with
Positive affect
High fluency
triggers
Infusion of affect
Experiments 4-7, 9
Manipulation of fluency
Experiments 1-3, 9

Erklärung

gemäß §4 Abs. 4 der PromO vom 14.06.2001

Hiermit versichere ich an Eides statt, daß ich die vorliegende Dissertation selbständig angefertigt und ausschließlich die angegebenen Quellen und Hilfsmittel benutzt habe. Ich habe bisher keine akademischen Grade erworben oder zu erwerben versucht. Diese Dissertation ist noch nicht bei einem früheren Prüfungsverfahren eingereicht worden.

Würzburg, den 06.06.2009 ________________________

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Curriculum vitae

Education and degrees

2002	Vordiplom (equivalent to B.A.), Psychology, University of Würzburg
2005	Diploma (equivalent to M. A.), Psychology University of Würzburg
2005-present	Doctoral dissertation

Professional appointments

2005-present	Research and Teaching Assistant Department of Psychology II University of Würzburg

Research Funding

Research Grant: "Intuition and Psychosis" (2007-2008)
GRK 1253 Emotions
Total value: 652.50 € (principal investigator)

Doctoral Fellowship: "Individual differences in the use of cognitive feelings in intuitive judgments of semantic coherence" (2007-present)
Studienstiftung des Deutschen Volkes, Germany
Total value: 34,000 € (principal investigator)

Research Interests

My work investigates several interfaces between affect, cognition, and the body. First, I am interested in the underlying micro-processes of intuitive judgments, investigating the role of processing fluency and affect in intuitions concerning semantic and visual coherence, artificial grammar learning, and insight. Second, I investigate how the body and its covert sensorimotor simulations shape attitudes and memory. Finally, I am interested in very brief, phasic affective states and their power to shape cognition.

.

Courses taught

2006-2007	Fluency, Affect, and Intuition
2007	Intuitions in Visual Coherence Detection
2007-2008	Philosophical and psychological dimensions of the concept of “feeling” (interdisciplinary approach together with philosophers)
2007-2008	Mood (philosophical, psychological, and biological implications) (interdisciplinary approach together with philosophers)
2008	Embodiment and Fluency
2008	The Concept of “Repetition” – In music, psychology, aesthetics, and philosophy (interdisciplinary approach together with musicologists)
2009	Motor-representation

Journal Articles

Topolinski, S. & Strack, F. (in press). Scanning the “fringe” of consciousness: What is felt and what is not felt in intuitions about semantic coherence. *Consciousness and Cognition.*

Topolinski, S. & Strack, F. (in press). The analysis of intuition: Processing fluency and affect in judgements of semantic coherence. *Cognition and Emotion.*

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Other publications

Reber, R. & Topolinski, S. (2009). Einfach + schön = wahr. Gehirn & Geist, January/February*, 20-23*.

Kordts, R. & Topolinski, S. (in press). Meine Neuronen und ich - Wie kann sich der freie Wille am eigenen Schopf aus dem kortikalen Sumpf ziehen? [My neurons and me: How might the free will lift himself up by his own cortical bootstraps?] *Die Idee.*

Topolinski, S. (2005). Der abwesende Verursacher - Das Böse im Film "Der Untergang" [The Absent Initiator - The Evil in the Motion Picture "Downfall"]. *Bad Alchemy, 45,* 75-78.

Invited Talks

Topolinski, S. (2009, March). *What's new, pussycat? Concerning the impossibility of the absolute New*. Invited talk at the Interdisciplinary Workshop on Novelty in Philosophy and Science, Würzburg, Germany.

Topolinski, S. (2009, March). *Embodied implicit memory*. Invited talk at the Department of Social Psychology, University of Basel, Switzerland.

Topolinski, S. (2008, September). *Intuition and Affect*. Invited talk at the Cognitive Neuroscience Group, University of Bergen, Norway.

Topolinski, S. (2008). Verarbeitungsflüssigkeit und ihre Konsequenzen für intuitive Urteile. [Processing fluency and ist consequences for intuitive judgments.] Vortrag gehalten im Institutskolloquium des Max-Planck-Instituts für Neurologische Forschung, Prof. Dr. von Cramon, 05. Mai, 2008, in Köln.

Topolinski, S. (2006). Hinter das eigene Gesicht steigen - Wie die Psychoanalyse die Lüge vom Ich entlarvte und was passiert, wenn man sich seinen Träumen hingibt. [Unmasking the own face - How psychoanalysis showed up the lie of the ego and what happens if you devote yourself to your dreams.] Vortrag gehalten in der Ringvorlesung der Fachschaftsinitiative Psychologie Würzburg, 31. Oktober, 2006, in Würzburg.

Conference presentations

Topolinski, S. & Strack, F. (2009, March). *Motorfluency als die Grundlage des Mere Exposure Phänomens [Motor fluency as the basis of the mere exposure phenomenon]*. Paper presented at the 51. Tagung experimentell arbeitender Psychologen.

Topolinski, S. & Strack, (2008, July). *We cannot force intuition*. Paper presented at the XXIX. International Congress of Psychology (ICP), Berlin, Germany.

Topolinski, S., & Strack, F. (2008, June). *A fluency-affect approach to analyze intuition.* Paper presented at the 15h General Meeting of the European Association of Experimental Social Psychology, Opatija, Croatia.

Topolinski, S., & Strack, F. (2008, June). *A fluency-affect approach to analyze intuition.* Paper presented at the 1th Summer School of Decision Processes, Catholic University of Milan, Italy.

Topolinski, S. & Strack, F. (2007, September). *Kopf oder Bauch? Kopf und Bauch! - Das Nutzen kognitiver Gefühle bei intuitiven Urteilen [Head or gut? Head and gut! The use of cognitive feelings in intuitive judgments]*. Paper presented at the 11. Tagung der Fachgruppe Sozialpsychologie.

Topolinski, S. & Strack, F. (2007, April). *The intuitive chain - On the interplay between cognition and emotion*. Paper presented at the 4. Würzburg Brain and Behaviour Days.

Topolinski, S. & Strack, F. (2007, March). *Was ist Intuition? Die Rolle von Verarbeitungsflüssigkeit und Affekt bei semantischen Kohärenzurteilen [What is intuition? The role of processing fluency and affect in semantic coherence judgments]*. Paper presented at the 49. Tagung experimentell arbeitender Psychologen.

Topolinski, S. & Hertel. G. (2006, September). *Persönlichkeit und Karriere von PsychotherapeutInnen: Zum Zusammenhang von Traits, therapeutischen Schulen und Arbeitszufriedenheit [Personality and careers of psychotherapists: Relations between traits, therapeutic schools, and job satisfaction]*. Paper presented at the 45. Kongress der Deutschen Gesellschaft für Psychologie.

Ad hoc reviews

Cognition and Emotion
Psychological Science