

Fluency of consistency: When thoughts fit nicely and flow smoothly.

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Cognitive Consistency: A Unifying Concept in Social Psychology

Introduction and overview.

Cognition influences affect – sometimes dramatically, as when a crafty political speech rises passions, and moves people to lofty or dangerous endeavors. However, many cognition-affect interactions are subtle. A fuzzy text or a noisy reception triggers annoyance. A harmonious chord or a symmetric design elicits pleasure. Recognizing a familiar face produces a sense of warm glow. There is something “off” in our colleague’s explanation of an event. Our chapter deals with these subtle interactions. Specifically, we address how *everyday evaluative responses* depend on fluency – ease or difficulty of information processing. Further, we show how the mechanisms linking fluency and evaluation can be understood using a combination of psychological experimentation and computer modeling.

The unique aspect of the present contribution, besides offering several theoretical refinements and an empirical update on our respective programs of research, is that we address how the notion of fluency relates to the notion of consistency and related concepts, such as coherence and dissonance. That is, we will explore how fluency and consistency phenomena are similar and different from each other, both conceptually and empirically. We will also show how they can be precisely modeled using a computational framework.

The structure of our contribution is roughly as follows. First, we distinguish various sources of evaluative responses – non-specific processing dynamics and specific feature-based information. This then allows us to address the similarities and differences between the concepts of fluency and consistency. Next, we describe empirical work suggesting that evaluative reactions to fluency can explain several common preference phenomena. Finally, we describe some computational models of fluency and consistency.

Fluency, consistency and related concepts.

Fluency and features. A visitor arrives in Warsaw and sees several faces in the airport's arrival hall. Some she identifies as Polish, some she does not. Some she recognizes, some she does not. Some she likes, some she does not. Why? One obvious source of her reactions is the "what" of processing – the stimulus' specific *features*. For example, detecting a round face with high cheekbones suggests that the person is Polish. Detecting a particular mustache on a waving greeter triggers recognition of the visitor's host. Detecting a smile – "the curve that sets everything straight" – triggers positive affect. In addition, however, there is the "how" of processing – the dynamics of perceptual and conceptual operations on the stimulus. These dynamic parameters include processing speed and processing ease – how much effort does the process require (subjectively and objectively). For example, how fast and effortful was the process of identifying, recognizing, and categorizing the face. These attributes are usually referred to with the general term of "fluency." Fluency is often divided into perceptual fluency, which relates to basic stimulus identification processes, versus conceptual fluency, which relates to higher-order interpretational and reasoning processes (Jacoby, Kelley, & Dywan, 1989).

As we describe shortly, one idea guiding this paper is that fluency is typically associated with positive evaluations. Thus, returning to our initial example, some faces might be easier to recognize, and this ease may trigger positive affect. We will also discuss how fluency links to other experiences and judgments, from familiarity to truth.

It is useful to highlight a few things about the relation between features and fluency. First, both can be available simultaneously, with each contributing to the final reaction. For example, positivity from detecting a "smile" feature can combine with positivity from the ease of face recognition. Second, features and fluency can play off each other. For example, the same

feature, such as symmetry, might create a positive reaction because of its cognitive implications (e.g., health), but also make the face easier to recognize. In other words, a feature might not only create an evaluative reaction directly, but also indirectly, via its influence on fluency.

Fluency and consistency. The relation between the concepts of “fluency” and “consistency” is in some way straightforward. Fluency is about “how” – the speed and ease with which a particular cognitive element, or a set of elements, is processed. Consistency is about “what” – a content *match* between cognitive elements. As such, consistency is one of the relations that may result in fluency. However, what exactly is a “consistent match?” This issue also touches on some of the trickiest problems in psychology. So, before we discuss this, let’s briefly recall how consistency is generally used in psychology.

What is consistency? The idea of “consistency” goes back to the days of Gestalt psychology, which emphasized that perception and cognition tend to organize in a way that achieves “Prägnanz” (a concise, pithy, “good” structure). Heider (1946) proposed that mental organization of social relations uses similar principles. His balance theory mostly deals with evaluative consistency, in which relationships between elements (e.g., people) are balanced when their attitudes (likes, dislikes) towards each other *match* in a relevant respect. For example, Norbert likes Liam, Liam likes Dave, Dave likes Norbert, Norbert and Dave dislike Piotr. If there is a *mismatch* in the structure (e.g., Liam likes Piotr), it is posited to cause some level of psychological discomfort, or at least a motivation to restore balance. Balance theory was famously followed by Festinger’s dissonance theory and various congruity theories, but the basic logic stayed the same (Abelson, 1983). Interestingly, consistency theories were very popular in the 1960s, but they declined in popularity in the 70s and 80s, being replaced by more content-oriented cognitive approaches (Abelson, 1983). Reasons for the decline include difficulties in

defining what constitutes a relevant relation, what exactly constitutes inconsistency/mismatch, and doubts whether people are motivated to resolve inconsistency. Perhaps the most important reason was the growing interest in the “what” of cognition – the actual content, rather than just formal relations between cognitive elements. These problems remain. Interestingly, however, recently there’s been a revival of consistency concepts in psychology in general, and social psychology in particular (e.g., this very book). One example of this revival is the development of constraint-satisfaction models (e.g., neural networks), which have become a major tool for understanding the operation of cognition. These models are now widely used for the modeling of social phenomena in dynamical psychology (Nowak & Vallacher, 1998; Read & Simon, this volume). Similarly, principles of consistency, mutual adjustment, constraint-satisfaction, and synchronization are used in the modeling of social network effects (e.g., contagion effects on obesity, loneliness, etc., Lazer et al., 2009). With all this in mind, here are some essential points about the relation of consistency to fluency.

Consistency with fluency: Regularity. Note that fluency is basically a description of a cognitive and behavioral effect – processing is easier, smoother, faster, more accurate, etc. Nothing more, nothing less. To the extent that fluency is an effect, one needs to ask whether consistency creates fluency effects. To this the answer is certainly “yes.” After all, consistency is about elements being tied together in a relation. Thus, via the basic mechanism of *priming*, in which a presentation of one element can preactivate a related element, consistency breeds co-activation, and thus fluency. Another way to put it is that consistency is about regularity and, as we will discuss shortly, priming is essentially about exploiting regularities.

Some of these regularities are purely structural, some are associative, some are semantic, some are based on predictability, and some are based on high-order relations. For example,

priming that produces perceptual fluency can involve a simple structural “identity” relation – presenting a picture of a polygon facilitates processing of a subsequent polygon and presenting the word “CHAIR” facilitates processing of subsequent word “CHAIR”. A semantic structure underlies a similarity relation between “CHAIR” followed by “FURNITURE.” An experiential structure (co-occurrence in language) underlies an associative relation “CHAIR” followed by “PERSON”, etc. A predictability relation underlies the fluency of “In a waiting room, a helpful man offered an elderly woman a CHAIR.” We will complicate this picture later when discussing phenomena such as overpriming and semantic saturation. But for now we propose that priming – one basis of fluency – is based on basic forms of consistency.

If consistency breeds fluency, then two of them should be confusable to some extent. This leads to an interesting prediction that people will have difficulty noticing conceptually inconsistent information if it is presented smoothly. Song and Schwarz (2008) found just this in their research on the so-called Moses illusion. When people are asked how many animals of each kind Moses took on the ark, they often say ‘two’. This is an error, since Moses comes from the biblical story of tablets, not the flood. Interestingly, participants are less likely to detect the error when the question was written in an easy-to-read font.

Consistency without fluency: Connection and coherence. However, there are consistency relations that fail to produce fluency, and other consistency relations that produce fluency, but not via simple priming-like mechanisms. Several issues are worth mentioning here.

When two elements are said to be “consistent”, it does not mean that they are mechanistically connected in a person’s mind. After all, consistency is about having a relation in some ‘abstract’ way. Thus, the word “physician” may be semantically connected to “syringe”, but these words may nevertheless fail to prime each other (Nelson et al. 1998), or they will prime

each other in one context, such as “hospital”, but not another, such as “heroin” (Kellas et al., 1991). As a consequence, it is difficult for consistency theories to use the abstract notion of a “match” to a priori predict the propositions that will be subjectively represented as consistent and mechanistically work as such. This is true even when one specifies consistency as “psychological consistency” and defines it in an idiosyncratic, individual-specific way. Anecdotally, in everyday life there are often situations when people fail to “put two and two together” – connect two obvious cognitions – either because they don’t think about them at the same time, or because they “fail to see the connection”. In short, specifying consistency on the abstract level must always be accompanied by some mechanistically realistic theory of how the corresponding cognitions are realized with a capacity-constrained and motivation-limited individual mind.

A perhaps more serious issue is that consistency may refer to complex semantic relations. This is easiest to explain with a related concept of “coherence”, which is a type of higher-order consistency, including relations such as logical deduction, compatibility in explanation, causality, etc (Thagard, 2000). Note that, for example, logical coherence does not imply fluency, as it is not directly based on any empirically-encountered regularity. This can be illustrated using syllogistic reasoning. Take the premises: “all fish live in the water” and “salmon live in the water.” Now evaluate whether this conclusion logically follows from the premises: “Therefore, salmon are fish.” This conclusion is incoherent (false), because it does not conform to our logical schema of proper reasoning. However, it is not disfluent. After all, processing the premises does not necessarily make processing of the sentence “salmon are fish” slower or more difficult. In fact, it has been empirically demonstrated that people sometimes find it easier to logically process incoherent syllogisms that have surface similarity as compared to logically true

sylogisms that lack surface similarity (Evans, Barston and Pollard, 1983). In short, logical coherence refers to a particular type of rule-based relation that can cause behavioral fluency in some circumstance (and certainly does over time), although fluency is not a necessary consequence of logical coherence.

Such phenomena are not restricted to complicated propositional logic and can occur with simpler stimuli. Reading 6×6 makes the number 36 fluent (due to associative priming). But reading $323 - 322 = 232$ involves priming and yet it is incoherent by violating the simple rules of subtraction. To get at these issues, some studies placed rule-based coherence and priming in direct opposition. For example, the word “SMOKE” and “FIRE” are associatively related. This associative relation, which leads to simple priming, makes it difficult to notice the falsehood of the statement “SMOKE CAUSES FIRE” (Fenker, Waldmann, & Holyoak, 2005). This distinction between rule-based processes and associative processes is further explored in various “two-system” models (e.g., Strack & Deutsch, 2004). Of course, the issue of distinguishing between associative and ‘rule-based’ processes is complex (Kruglanski & Gigerenzer, 2011). However, for our purposes here, it is only important to highlight that fluency (the “how”) based on association can often run counter to coherence based on content (the ‘what’).

In the above examples, people occasionally make errors when faced with a structurally consistent or fluent, but logically or factually incoherent situation (Song & Schwarz, 2008; Evans et al., 1983; Fenker et al, 2005). However, most of the time people get it right. Therefore, perhaps researchers should focus on coherence of content rather the more structural aspects of consistency? Not at all. We need both – structural consistency and inferential coherence. In fact, the idea that structural consistency relations are meaning-dependent is not a novel point. In the balance theory literature it has long been noted that a relation that is balanced in a friendship

context (Bill likes Hilary, Bill likes Monica, Hilary likes Monica), becomes unbalanced in a sexual-relationship context. Thus, the mechanistic balance and fluency processes operate within a network of relations specified over a meaningful content. In some way, then, modern versions of consistency and coherence theories are extensions of this insight. We will elaborate on these points when we discuss our modeling work using constraint-satisfaction models, and when we go back to some more concrete examples of coherence processes in higher-order reasoning. But for now, let us return to fluency.

How is it going? Linking fluency, consistency, and affect.

Fluency and consistency, or lack thereof, have affective and motivational consequences. It is worth highlighting a few reasons why it should be so. The major explanations focus on the role of fluency and consistency as cues to the quality of the internal state of the organism and the quality of an external stimulus.

Information about quality of internal processing. Affect has many functions, but one is to inform the organism about its own internal state (Carver & Scheier, 1990). When things are in physiological homeostasis we feel good and when they are imbalanced, we feel bad. Similarly, affect us about the current state of cognitive operations. Thus, fluent and consistent processing “feels good” because it indicates an internally coherent structure of beliefs. For example, perceptual fluency indicates good progress towards recognition of the stimulus whereas conceptual fluency indicates progress towards a successful task solution.

Motivational force. Besides informing the organism that processing is going well, positive affect triggered by fluency and consistency may play a motivational function and reinforce successful strategies. On the other hand, disfluency and inconsistency can serve as

signals of cognitive error or incompatibility, and motivate a strategy revision (Fernandez-Duque et al., 2000; Nowak & Vallacher, 1998).

Affective implications of incoherence. These theoretical ideas converge with classic observations from the social psychological literature that mental states characterized by low coherence can often be unpleasant. For example, several studies documented the unpleasantness of cognitive dissonance with self-report as well as physiological measures of affect (Elliot & Devine, 1994; for review see Harmon-Jones, Amodio, & Harmon-Jones, 2009).

It is worth noting that some social psychological explanations for why inconsistency is unpleasant emphasize high-level social implications of holding incompatible beliefs or performing belief-inconsistent actions (e.g., writing a counter-attitudinal essay). For example, some modern social psychological accounts of cognitive dissonance propose that the unpleasantness of inconsistency comes not from the mere dissonance itself, but from the implication of dissonance as a threat to self-image and self-esteem. Accordingly, self-esteem and self-affirmation manipulations help to reduce the consequences of dissonance. Note, however, that all these effects, and interventions (which are largely interchangeable), could be understood as essentially targeting negative affect. Thus, they are consistent with the idea that at the core of dissonance lays a basic affective mechanism (Tesser, 2000).

This idea is consistent with another current social psychological theory that emphasizes the finding that dissonance effects are particularly strong when they involve a mismatch between beliefs and a possible or actual action (Harmon-Jones et al., 2009). On this account, the reason why belief-action mismatch is ‘unpleasant’ and motivating has to do with the fact that it puts the organism into a behavioral conflict (e.g., approach-avoidance conflict), which generates negative affect via basic conflict-detection processes.

Finally, the idea that dissonance-elicitation mechanisms are basic explains why dissonance can occur when high-level social concerns are eliminated or severely reduced. Thus, dissonance effects have been observed in completely private settings and are found in children, amnesic patients, and even monkeys (Egan et al, 2007). As such, it seems doubtful that high level explanations can supersede low-level explanations that focus on basic psychological mechanisms of inconsistency processing.

Information about Quality of External Stimuli. Fluency and consistency do more than just inform the perceiver about their own internal state. Smooth processing can also have affective consequences because it indicates (probabilistically) whether an external stimulus is good or bad. One version of this logic is well-known from research on heuristics and biases. Fluency, or its consequences such as familiarity and recognition, can be a learned, “fast and frugal” heuristic for identifying choices that are likely to be objectively better (Gigerenzer, 2007). Similarly, as we discuss later, fluency offers a cue that indicates the likelihood of other valued properties of external stimuli, such as symmetry, prototypicality, etc.

The heuristics and biases literature assumes that the fluency-judgment link is used strategically, and is subject to naïve-theories and short-term environmental experiences. Later in the chapter we illustrate this point with some empirical examples. But such processes are also automatized, or even partly innate. For example, it’s known, at least since Titchener (1910), that familiar (fluent) stimuli elicit a “warm glow” – an effect that can be especially powerful in infants. Accordingly, illusions of familiarity (oldness) can be produced through unobtrusive inductions of positive affect (Phaf & Roteveel, 2005). One reason for this warmth-familiarity link could be a biological predisposition for caution in encounters with novel, and thus potentially harmful, stimuli (Zajonc, 1998).

Finally, fluency can enter into complex inferences about the external information that can eventually result in affective and motivational consequences. One interesting line of research that is relevant to the question about fluency and consistency explored the effects of fluency on the perception of social truth. As Festinger (1954) observed, we often evaluate truth on the basis of social consensus and infer that there “must be something to it” if many others believe it. Unfortunately, people are bad at tracking how often they heard what from whom and misread the familiarity resulting from repeated exposure as evidence for broad consensus, even if the familiarity merely results from the same single person saying the same thing over and over again (Weaver, Garcia, Miller, & Schwarz, 2007). Experimentally, any variable that increases the fluency with which a statement can be processed also increases the likelihood that the statement is accepted as true – and merely printing the statement in higher figure-ground contrast (Reber & Schwarz, 1999) or a rhyming form (McGlone & Tofiqbakhsh, 2000) is sufficient to enhance its truth value (for a review see Schwarz, Sanna, Skurnik, & Yoon, 2007). In short, information that is presented in a fluent form comes with a higher perceived truth value; it should therefore result in more dissonance when it conflicts with one’s own beliefs. This possibility awaits empirical testing, but is nicely consistent with findings that dissonance depends on the subjective truth value that is assigned to related propositions (Gawronski & Strack, 2004).

Empirical evidence for the role of fluency in evaluation

Next we turn to a brief review of the literature establishing the fluency-affect link (see Winkielman et al, 2003; Reber et al, 2004 for a more comprehensive review). A large number of studies generally support the idea that processing fluency enhances evaluation. Here we will discuss a subset of this literature focusing on five related variables: (i) repetition/mere exposure, (ii) priming, (iii) contrast, clarity, and duration, (iv) symmetry and (v) prototypicality. One

reason for our focus on those five variables is because we want to draw a connection between the empirical work and computer modeling approaches, as discussed shortly. Importantly, many of these variables have also been found to cause other judgmental consequences of fluency (e.g., familiarity, truth, sense of temporal distance, see Schwarz, 2010).

Repetition (mere/exposure). The simplest way of facilitating stimulus processing is repetition. Accordingly, repetition should enhance liking (Bornstein & D'Agostino, 1994; Jacoby, Kelley, & Dywan, 1989; Mandler, Nakamura, & Van Zandt, 1987). This is, of course, the famous mere exposure effect (MEE) -- the observation that simple repetition enhances liking for an initially neutral stimulus (Zajonc, 1968). The MEE has been demonstrated behaviorally, using liking and mood judgments (e.g., Monahan, Murphy, and Zajonc, 2000). It has also been demonstrated physiologically, using facial electromyography (EMG) which relies on the observation that positive affect triggers incipient smiles (EMG activity over the cheek region), whereas negative affective trigger incipient frowns (EMG activity over the brow region). Harmon-Jones and Allen (2001) observed that repeatedly presented stimuli elicited stronger EMG activity over the “smiling”, without changing the activity over the “frowning” region.

Priming. Priming also facilitates processing. Thus, it should result in increased liking, even under conditions of a single exposure. Many studies have now confirmed this. In an early investigation, participants identified and evaluated pictures of everyday objects (e.g., a desk, bird, or plane). Picture processing was facilitated or inhibited processing by prior subliminal presentation of matching or mismatching visual contours. Results showed that pictures preceded by matched contours were identified faster, indicating higher fluency, and were liked more than pictures preceded by mismatched contours (Reber, Winkielman & Schwarz, 1998, Study 1).

Critically, there is physiological evidence for the positivity of reactions caused by priming, gathered using the earlier-mentioned EMG technique (Winkielman and Cacioppo, 2001). High fluency triggers stronger activity over the “smiling” region, but not the “frowning” region. This effect occurs quickly after stimulus presentation, suggesting an automatic link between fluency and positivity.

Contrast, clarity, and duration. High contrast, clarity, and duration facilitate identification. Thus, these features should trigger liking. Indeed, participants like the same stimulus more when it is presented with higher contrast and longer presentation duration (Reber et al., 1998). Again, these manipulations trigger EMG activity specific to the cheek region, suggesting that high fluency elicits positive affect on the physiological level (Winkielman & Cacioppo, 2001).

Symmetry. Humans and non-human animals show a widespread preference for symmetry (Rhodes, 2006). This is often attributed to the biological value of symmetry as a signal of mate quality (e.g., Thornhill & Gangstead, 1993). However, symmetry could be appealing partly because it is fluent. After all, symmetrical stimuli are structurally simpler than non-symmetrical stimuli. This simplicity, and redundancy of information, facilitates identification of stimuli (Palmer, 1990). Support for this comes from studies on preference and fluency of abstract shapes (Reber & Schwarz, 2006). Participants made preference judgments and also same-different judgments for symmetrical and asymmetrical shapes. The results showed that symmetrical shapes are not only more appealing, but also easier to identify than comparable asymmetrical shapes.

Prototypicality. People prefer prototypicality or “averageness” -- in the sense of a stimulus fitting the central tendency of a category (Rhodes, 2006). This applies to living objects,

such as faces, fish, dogs and birds, and also to nonliving objects, such as color patches, furniture, wristwatches and automobiles (Halberstadt, 2006). This preference has often been explained as an evolved predisposition to interpret prototypicality as a cue to mate quality (Symons, 1979). However, there is a more straightforward fluency explanation. Given that prototypes are the most representative members of their categories, they are also fluent, as reflected in accuracy and speed of classification (Posner & Keele, 1968). This raises the possibility that prototypes are liked *because* they are fluent. Winkielman, Halberstadt, Fazendeiro, and Catty (2006) tested this idea. In some studies, participants first learned a category of visual patterns. Then they saw novel patterns varying across different levels of prototypicality. Participants classified these patterns (measure of fluency) and also rated their attractiveness. A close relationship between fluency, attractiveness, and the level of prototypicality was observed. Both fluency and attractiveness increased with prototypicality. Importantly, when fluency was statistically controlled, the relation between prototypicality and attractiveness dropped by half (though it remained significant). This suggests that processing facilitation is an important contributor to the “beauty-in-averageness” effect. Interestingly, prototypical, rather than non-prototypical patterns elicited significantly greater EMG activity, suggesting that categorically fluent stimuli trigger genuine affective reactions.

Contextual moderation: The role of mood and naïve theories in fluency-affect link

Is the reaction to fluent stimuli always positive? On the logic presented earlier, this link appears fixed. However, note that besides affect, fluency can also lead to other subjective experiences, such as familiarity. Further, fluency itself may be subject to different interpretations, depending on the judgmental context. Both processes may have affective and judgmental consequences that may occasionally flip the fluency-positivity link.

Fluency, familiarity, and mood. One prominent fluency-dependent experience is familiarity (Jacoby et al., 1989; Whittlesea, 1993). As we discuss shortly, fluency manipulation robustly change judgments of stimulus ‘oldness’. But the connection between familiarity and positivity is tricky. After all, positivity of the “known and old” depends on one’s current environment. Familiarity is nice in a hazardous environment, but less so in a friendly one. For example, in a strange city a familiar face or food may elicit a warm glow, whereas locally the same items prompt a yawn. Similarly, children cling to the familiar in an unsafe, shaky environment, but explore in a safe, comfortable one.

So, what tells us if the environment is dangerous? One cue is an individuals’ mood. Bad mood signals a problem, whereas good mood suggests a benign environment (Schwarz & Clore, 1996). Thus, the value of familiarity should depend on how people feel. In a recent study, we (De Vries et al., 2010) examined this reasoning by presenting participants with stimuli that were made categorically fluent and familiar. This was done via the prototypicality manipulation described earlier (Winkielman et al., 2006). Then, we measured participants’ emotional and memory responses with stimulus ratings and physiological measures (facial electromyography and skin conductance). Critically, we put some participants in a good mood and some in a bad mood. As predicted, sad participants showed the classic preference for familiar stimuli, including the “beauty-in-averages” effect, and the mere-exposure effect. These reactions were genuinely positive, as reflected by EMG measures of “smiling.” However, happy mood eliminated these preferences. Even the usually highly-liked familiar prototypes were rated low and not smiled to. This occurred, interestingly, in spite the fact that in happiness, prototypes were rated as particularly familiar, and triggered stronger skin conductance responses, consistent with earlier research on familiarity and arousal (Morris, Cleary, & Still, 2008). This latter finding shows that

these results cannot be explained by hedonic adaptation: loss of sensitivity to positive stimuli after the good mood induction (in addition, happy participants' responses were sensitive to objectively prettier and uglier patterns). Thus, our results suggest that happy people experience familiarity, but for them it does not “glow” warmly. Future studies may explore whether focusing participants on the fluency “per se” (rather than familiarity) may restore its positive effects on judgment, consistent with the observation that the meaning of fluent processing is malleable and context sensitive (Schwarz, 2010).

Fluency and naïve theories. A powerful determinant of how any subjective experience, including fluency, translates into judgments is the interpretational process applied to that experience (Schwarz, 2010). After all, the experiences do not mean much by themselves! In fact, there is now plenty of evidence that under some interpretations, the experience of ease can lead to negative judgments, and the experience of difficulty to positive judgments. One early study manipulated retrieval fluency of *neutral* childhood memories via the 4/12 event paradigm (Winkielman & Schwarz, 2001). We found that the *difficulty* of retrieving neutral childhood memories (12 events) led to *more* positive childhood evaluations than the *ease* of retrieval (4 events). This occurred when participants were given a bridging naïve theory which implied that difficulty in recalling childhood means nothing bad had happened. The opposite result was obtained when the naïve theory provided to participants implied that difficulty in recalling memories means that something bad must have happened. Of course, it may not be surprising that the evaluative implications of inferences from fluency may override any hedonic tinges deriving from the fluency itself. Still, it is important to remember that experiences can be fed into various judgmental processes that can override any potential default effects.

A recent study nicely made the above point using manipulations of perceptual fluency. Song and Schwarz (2009) presented participants with names of amusement park rides that were easy or difficult to pronounce. Then participants rated the risk level of those rides, with risk framed as either a positive attribute (exciting) or a negative attribute (dangerous). Amusement-park rides with difficult to pronounce names were rated as more likely to make one sick (an undesirable risk) as well as more exciting and adventurous (a desirable risk). Note that such effects involve a higher-order bridging theory that links a fluency-dependent sense of familiarity with an interpretation of what kinds of risks are good. As a final example, research in consumer behavior showed that products advertised in “easy to read” fonts are sometimes perceived as less valuable. This is the case when the product is a luxury product that derives some of its appeal from its rarity – when fluent processing makes such a product seem highly familiar, the product loses its special appeal (Pocheptsova, Labroo, & Dhar 2010).

How does it work? Computational Mechanisms

Verbal descriptions of fluency are often vague. What exactly does it mean to say that one stimulus is more fluent than another? What does it mean concretely that cognitions are consistent? The answer to this question has been provided by computational models. In this section, we first describe some basic principles underlying such models, and then describe some actual models of fluency phenomena.

Connectionism. Much fluency-modeling work has been done using the neural network approach, or connectionism. This approach models cognition in terms of the passage of activation among simple, neuron-like units organized in large, densely interconnected networks (McClelland & Rumelhart, 1981). The individual units function as simple processors that can influence each other through connections, which vary in strength and sign (facilitatory or

inhibitory). This massively interconnected and parallel architecture gives the neural network approach a certain neurophysiological realism and makes it suitable for a wide variety of applications. For more biological applications, one can conceptualize the network units as actual neurons, whereas for more psychological applications, one can treat the units as blocks of neurons or functional sub-systems (O'Reilly & Munakata, 2000). Many different neural network architectures have been proposed, but for the current purposes we will first focus on a simple attractor neural network (Hopfield, 1984) and then address just one type of more complex models (Huber & O'Reilly, 2003).

Fluency in a simple attractor network. In a typical Hopfield network, representations are encoded as attractors of the network, i.e. states into which the network dynamics converge. The processing of information with the network can be seen as a gradual, evolving process, during which each neuron adjusts to the signal coming from other neurons. Because neurons are reciprocally connected, and because there are a large number of paths connecting one neuron to another, activation can reverberate dynamically through the network over simulated time steps until the network settles on the identified representation. For example, when presented with a to-be-recognized pattern, the network goes through a series of adjustments and after some time approaches a stable state, an attractor, corresponding to the "recognition" of a particular pattern (in a strict sense, it is just a reproduction of the pattern).

A typical Hopfield model can be extended with a simple control mechanism, which allows the network to monitor fluency of its own processing (Lewenstein & Nowak, 1989). Specifically, one can look at the network's "volatility," or the proportion of neurons changing their state at a given point. Fewer neurons change their state when the incoming, "to-be-recognized" pattern approximates a known pattern (an attractor). Another fluency-related

property is the coherence of the signals received by the neurons. In the vicinity of an attractor the signals arriving from other neurons are consistent. A related criterion is the signal-to-noise ratio. In the vicinity of the attractor, signals from other neurons typically add up, resulting in a relatively large summary signal dictating the state of a given neuron.

Extension to graded representations. Traditional Hopfield networks use simulated neurons that are either “on” or “off”, with no graded signal between these states (but see Hopfield, 1984). More realistic simulations use a continuous range of intermediary neuron values. This allows more graded measures of the magnitude and speed of settling into attractor states (e.g., O’Reilly & Munakata, 2000). However, because many applications are focused on learning and representational change, large simulated time steps are used and settling occurs in less than 10 time steps. This makes it difficult to measure relatively subtle differences in settling time. For such applications, fluency is measured rather indirectly as differentiation -- the magnitude of the most active units (Norman, O’Reilly, & Huber, 2000). Providing a more direct measure of fluency based on speed of processing, we have used neural simulations with millisecond time steps. This allows measurement of the time needed to achieve peak activation (Huber, 2008) and can be used to estimate reaction times (Huber & Cousineau, 2004).

Modeling fluency-inducing variables. So far, we have discussed computational models of fluency in terms of general principles. But such models can be used to precisely specify the processing dynamics that underlie affective responses in several concrete empirical phenomena discussed earlier. To recall, experimental psychological research found that positive affect, as well as other fluency-related judgments, can be enhanced by repetition, priming, figure-ground contrast, presentation duration, symmetry, and prototypicality. How does this work computationally?

The influence of these variables can be conceptualized as reflecting a process in which fluent patterns are represented by more extreme values of activation. This leads to fewer changes of state in the network, stronger signals in the network, more differentiated states of the neurons, and faster settling. It is easy to understand how and why priming, multiple repetition, longer duration, higher contrast, and greater clarity would result in more active and better differentiated representations, stronger signals in the network, and faster settling (e.g., see Drogosz & Nowak, 2006 for a simulation of mere-exposure). But what about symmetry and prototypicality? Note that the representation of symmetrical patterns is stronger because of simplicity and redundancy. For example, the left and the right sides of the symmetrical faces are identical, essentially doubling activation of a particular feature. Mental representation of symmetrical patterns is also more robustly activated because of their position-independence in recognition. For example, a symmetrical face looks the same from different angles (Johnstone, 1994). Similarly, fluency of prototypicality (responsible for the “beauty-in-averages effect”) result from converging exemplars creating a strong attractor (memory) for a prototype, which then is recognized with a faster settling time (Winkielman, Hooda, & Munakata, 2004).

Priming and habituation. Let us devote a bit more attention to the recent modeling work on priming, as this is a central variable in all fluency research. This will also allow us illustrate how computational modeling work can inspire new insights into fluency. The study of priming phenomena typically involves observing the effect of a prime stimulus upon reaction time or accuracy to a closely related or identical target stimulus. Priming is a useful tool for studying fluency because the effect of a related prime can be viewed as “priming the pump”, thus making the target more fluent. For instance, in spreading activation theory (Collins & Loftus,

1975), the prime sends activation to related concepts, which result in pre-activation of the target. This pre-activation results in faster identification of the target (i.e., the target has a head start).

The original modeling work on priming mechanisms dates back to the classic interactive-activation model of word recognition by McClelland and Rumelhart (1981). They implemented the idea of preactivation in a neural network, and explained how the surrounding context provided by the other letters in a word enhance processing speed of a particular target letter (e.g., identifying the R in SKRD versus the R in WORK). Their model obviously applies to phenomena at different levels, including words, sentences, pictures, sounds, etc.

In recent work, we extended the McClelland and Rumelhart model by considering not only the effect of preactivation between prime and target, but also the effect of habituation that can occur when the prime is processed for an extended period of time. To explore how habituation impacts fluency, we modified the interactive-activation model by including habituation of synaptic resources between each sending neuron and receiving neuron (Huber & O'Reilly, 2003). This way, the associations between features are temporarily lost with excessive processing of the prime. Simulation studies demonstrated that this is an effective mechanism for optimally clearing the deleterious effects of lingering activation from recently viewed objects (e.g., the prime) so as to clear the way for perception of subsequent objects (e.g., the target). In other words, habituation serves to eliminate the effect of pre-activation that might otherwise induce undue target fluency. However, this method of reducing the effect of a prime comes with a cost, making it difficult to easily process an identical or closely related target stimulus. In other words, with habituation, a related target is sluggish to respond, which we term 'disfluency'.

Our recent studies tested behavioral and physiological predictions of this habituation model using a repetition word priming paradigm. In this paradigm, we measured identification

accuracy for target words that were briefly flashed at the threshold of awareness. We tested different prime durations ranging from subliminal to two seconds of viewing the primed word and, as predicted, there was a gradual change from positive to negative priming with increasing prime duration (Huber, 2008). Follow up experiments used the same paradigm while measuring Event Related Potentials (ERPs), revealing that neural dynamics follow the same time course as the habituation model (Huber, Tian, Curran, O'Reilly, & Worocho, 2008).

Note that our habituation model is quite broad in its scope and it predicted that similar effects should exist not just for reading, but more generally for perception of any stimulus. Demonstrating this generality, we found the same crossover pattern from positive to negative priming as a function of increasing prime duration with repetition priming of social stimuli -- faces (Rieth & Huber, 2010). Furthermore, the habituation model predicted that similar effects should exist at multiple levels of representation, including those that underlie memory retrieval. In a series of experiments we examined the manner in which short-term repetition priming can bias recognition of previously studied words. These experiments once again produced a gradual crossover pattern from positive to negative priming as a function of increasing prime duration even though the task was to indicate whether an easily seen target word was previously studied (Huber, Clark, Curran, & Winkielman, 2008).

All of the above fluency/disfluency experiments used repetition priming. However, the habituation model predicts that similar effects should occur for similarity priming. To test this claim, we recently performed an experiment involving a task of speeded evaluations of highly valenced positive or negative pictures (e.g., a picture of puppies versus a picture of a mutilated body). The primes were also highly valenced pictures and the manipulation was consistency between prime and target (both positive or both negative versus mixed trials). As with the above

experiments, prime presentation varied across a range of durations. Once again there was a gradual crossover pattern from positive to negative priming even though nothing repeated except the implied valence of the picture (Irwin, Huber, & Winkielman, 2010). Similarly, we have demonstrated habituation effects for ‘semantic satiation’ (Tian & Huber, 2010), revealing that the apparent loss of meaning for a repeated word is not due to a habituation in the semantic representation, but rather due to the loss of association (i.e., loss of synaptic resources) between the lexical form of a word and its meaning (i.e., the meaning is still there, but it can’t be reached). Based on this result, and the associated model, this suggests that conceptual disfluency (and perhaps conceptual fluency) is due to difficulty or ease of access rather than direct inhibition or activation of the concept.

Summary and implications. This section has shown that experimental work on fluency can be enriched by computational modeling. We have reported a variety of experiments, which were successfully simulated with relatively simple models of processing. These models allow us to link the seemingly different fluency variables in a coherent, mechanistically-based framework. One interesting aspect of connectionist modeling is that its principles relate to, and mechanistically explain old Gestalt notions, like the aforementioned Pragnanz, or the idea that perception and cognition “prefer” and are facilitated by “good”, concise, structures (Palmer, 1990).

In addition, these models revealed interesting new, counterintuitive properties of fluency, such as a gradual transition from positive to negative priming. One interesting implications of such mechanical models is that they allow for a reconceptualization of some effects that were previously conceptualized as reflecting ‘strategic’ mechanisms. For example, it is well known that it is harder to obtain the mere-exposure effect when stimuli are presented consciously, for a

long duration, or when they are presented in homogenous fashion (Bornstein, 1989). Similarly, priming effects get weaker or reverse when participants are aware of and attending to the priming stimulus (Jacoby et al., 1989). These effects are typically explained as reflecting a judgmental correction – drawing an analogy to situations when subjects adjust their judgments when they are aware of the stimulus’ undue influence (e.g., Strack et al, 1993). However, as described above, the satiation model views awareness, attention, or homogenous repetition as conditions that promote automatic habituation, thus eliminating or reversing the typically positive impact of primes.

Modeling Complex Cognition: Fluency and coherence of arguments and stories.

In our discussion so far, fluency and consistency have been mostly modeled with simple, isolated stimuli – a picture, a word, or a sentence. However, a few researchers bring a consistency-oriented modeling perspective to complex cognition (see Read & Simon, and also Topolinski, this book). The idea here is that consistency processes operate even when individuals are processing a series of complex, related elements, such as persuasive messages, logical arguments, stories or legal evidence. Though these messages might be so large that they, as a whole, cannot be fit into working memory at one time, the overall ease of integrating the whole set of these messages (e.g., the whole legal argument) differs in fluency. And, as a consequence, this fluency influences the evaluation of the plausibility, favorability, truthfulness of the entire argument. Below, we briefly outline how fluency can function in two of such models: the coherentist account of reasoning (Thagard, 2000) and the story model of jury decision-making (Pennington & Hastie, 1992).

Coherentist accounts of thought propose that people evaluate conflicting propositions not only based on logical inferences, but also on the extent to which they are coherent with a larger

network of facts and propositions (Thagard, 2000). One advantage of coherentist accounts is its ability to show how people handle information that would seem to support different, irreconcilable conclusions. For example, consider a claim by your coworker that he did not receive your text message telling him that you'd like your book returned. If your text messages do sometimes disappear then you cannot rule out the possibility that the text actually never reached him. But if, for example, you knew that your coworker had his own urgent use for the book, this information would be coherent with the belief that your coworker received and ignored the text. Of course the ideas that the text never arrived and that it was ignored are incoherent (mutually inhibiting of each other's activation/acceptance). Additional evidence in favor of one of these propositions increases that proposition's activation, and thus indirectly inhibits the other proposition. Factors decreasing the acceptability of one proposition will also make the other more acceptable. For example if a norm that people should be taken at their word were present and activated, then this would inhibit the belief that the text was ignored and bolster the belief that it was never seen. Coherence theories thus provide a framework for seeing how people might make judgments about plausibility or truthfulness.

Mechanistically, Thagard proposes that the choice between two conflicting propositions is arrived at by first summoning relevant cognitive elements to mind. In the OJ Simpson case (analyzed fully in Thagard 2000) elements might be evidence such as "Nicole Simpson was murdered", and "a bloody glove was found in OJ's home", and propositions such as "OJ killed Nicole", "OJ is innocent" and "the glove was planted". These cognitive elements can be thought of as nodes on a network. Constraints, or coherence relations between the nodes, can be either positive (for concepts coherent with one another) or negative (for concepts incoherent with one another). Coherence relations include explanation, deduction, facilitation, association, and a

positive emotional connection. Incoherence relations include inconsistency and incompatibility, and negative association. Positive coherence relations between two elements mean that the activation of one element increases the activation of another while negative coherence constraints mean that the activation of one decreases activation of the other. In computer models of coherence, the nodes in this network are then given an initial activation level and started on an updating cycle. The network eventually settles on an equilibrium activation state. Coherence with important nodes and membership in a group of nodes that are mutually coherent leads to a node being favored for acceptance. Those nodes with activation above a certain threshold are “accepted” and those below it are rejected resulting in an accepted network of concepts, consistent with the more ‘preferred’ solution.

The connection between fluency and coherence in such models is straightforward. Processing of one stimulus increases the activation of related concepts. This activated store of concepts allows one to quickly (fluently) understand the meaning of related sentences, and integrate them more easily with related beliefs. One implication of this is that, in the coherentist model, the underlying mechanism for judging the believability of a statement or for judging between two competing arguments or stories might be our subjectively experienced fluency, and the positive/negative valence resulting from it. If we review a few competing explanations of an event, then the more ‘coherent’ account will create a more positive feeling than will the less coherent account and will thus be accepted.

This idea fits nicely with data from the experiments on the story model of jury decision making (Pennington & Hastie, 1992). It has been shown that the order in which the evidence for jury trials is presented strongly influences whether or not the accused is found innocent or guilty. Presumably, jurors expect a story that smoothly connects motive opportunity and evidence as

part of a narrative. A successful prosecution team takes advantage of this, hoping perhaps that the resulting fluency of integration gets misattributed to judgments of plausibility and truth, or simple liking of “their side”. Though it is often recognized that the story model and coherence theories have a connection (Thagard 2000), a fluency approach suggests a particular synthesis and makes specific empirical predictions. Elements of the story should be arranged in such an order that the subjective ease of processing of the overall story is maximized, and that fluency, with its resulting affective consequences, gets properly attributed. In short, the fluency account provides the actual underlying mechanism for explaining why a set of coherent concepts is favored as an explanation.

Concluding Summary

Our chapter discussed the relation between fluency, consistency and coherence. We emphasized their connection to evaluation, though we also made clear that a host of other social cognitive judgments are influenced via similar principles. We covered behavioral and physiological experiments and showed how computer models can capture the underlying processes. By taking this multi-method approach, and discussing phenomena from different levels of complexity, from simple words to complex stories, we tried to emphasize similarities in how the mind processes information. One limitation of previous formal approaches to cognition was its silence on the role of specific stimulus features. Thus, our chapter also highlighted how the ‘what’ is connected to the ‘how’ of processing. Given all this, we see a bright future for fluency and consistency theories that are closely tied to mechanistic principles of the mind.

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