Associative processes in intuitive judgment

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Dual-system models of reasoning attribute errors of judgment to two failures: the automatic operations of a 'System 1' generate a faulty intuition, which the controlled operations of a 'System 2' fail to detect and correct. We identify System 1 with the automatic operations of associative memory and draw on research in the priming paradigm to describe how it operates. We explain how three features of associative memory – associative coherence, attribute substitution and processing fluency – give rise to major biases of intuitive judgment. Our article highlights both the ability of System 1 to create complex and skilled judgments and the role of the system as a source of judgment errors.

Intuitive judgment and associative memory

The study of intuitive judgment has identified a long list of systematic errors (biases) and specific models that explain subsets of these errors. Many of the models proposed to account for these judgment errors invoke a dual-process or dual-system view, in which automatic processes (System 1) generate impressions and tentative judgments, which might be accepted, blocked, or corrected by controlled processes (System 2; e.g. [1–7]). Even the originators of the two-system view, however, consider it as incompletely specified [4,5]. Here we identify System 1 with the automatic operations of associative memory [8]. We then show that three features of associative processes account for the major biases of judgment and choice that have been identified over the past four decades.

A breakthrough in our understanding of the structure of associative memory occurred when students of social judgment began to explore the determinants and consequences of accessibility in the priming paradigm [9,10]. Probes of the structure of memory were neither random, as in earlier studies of free association, nor tightly restricted to logical relations as in studies of propositional networks. Instead, the search for priming effects was guided by specific hypotheses about the rules that govern the spread of activation in associative memory, such as the idea that activation spreads between literal and metaphorical meanings. Holding a warm cup of coffee, for example, increases the likelihood of perceiving a stranger as warm [11]. More generally, priming research has documented the links that connect verbal representations, emotions, facial expressions, motor responses, visual perception and even conscious and unconscious goals [12]. We draw on this new knowledge to explain major phenomena of intuitive judgment.

It is often useful to think of judgments as a weighted combination of items of information [13]. In this scheme, judgment biases can always be described as an overweighting of some aspects of the information and underweighting or neglect of others, relative to a criterion of accuracy or logical consistency [7]. We offer an uncontroversial hypothesis – strongly activated information is likely to be given more weight than it deserves and relevant knowledge that is not activated by the associative context will be underweighted or neglected (e.g. [14,15]). In this fashion, the principles of associative activation help explain biases of judgment.

In the next sections we focus on three features of associative activation and trace their role in intuitive judgments. We discuss, in turn, associative coherence, attribute substitution and processing fluency.

Feature 1: associative coherence

A stimulus evokes a coherent and self-reinforcing pattern of reciprocal activation in associative memory. For example, exposure to an emotional word – VOMIT – brings about a facial expression of disgust and a motor response of recoil, as well as an autonomic response and a lowered threshold for detecting and responding to noxious stimuli [16,17]. The reciprocity of many of these connections has been a theme of recent research. The facial expression and the act of recoiling tend to reinforce an initial emotion of disgust. Similarly, activation of the elderly stereotype

Glossary

Associative memory: a network of long-term memory for semantic information, emotions and goals that is governed by the spread of activation, as determined by the strengths of interconnecting weights (associations).
Accessibility: the ease with which a particular unit of information is activated or can be retrieved from memory.
Anchoring effect: the assimilation of a second estimate to an anchor – a value considered during the prior estimate.
Confirmation bias: testing a hypothesis by considering more evidence that confirms rather than disconfirms it. Usually occurs automatically, without explicit intent to do so.
Egocentric bias: overestimating the degree to which one's perception of the world is accurate and the degree to which others perceive the world as one does.
Framing effect: different formulations of the same decision problem elicit different preferences.
Hindsight bias: 'Naïve' probability estimates of the probability of an outcome increase when it is known to have occurred.
Processing fluency: the subjective experience of the ease or difficulty with which a cognitive task is accomplished.

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leads to slower walking, and walking slowly activates the elderly stereotype [18,19].

Reciprocal activation favors a pattern of compatible ideas reinforcing each other, whereas initially activated ideas that are not reinforced soon drop out [20,21]. Depending on the context, the word BANK will be interpreted as referring to money or to a river but not simultaneously to both, and the ambiguity is likely to be resolved without being noticed. The power of context is manifest in the question: “How many animals of each kind did Moses take into the Ark?” The Biblical context makes the ‘Moses illusion’ almost undetectable [22]. By contrast, incongruities that cannot be reconciled or ignored are detected quickly. When spoken in a male voice, the phrase, “I believe I am pregnant” elicits a distinctive indication of surprise in brain activity within 200 ms [23]. Finally, a stimulus also evokes its own context and the norms to which it will be compared [24] – an eagle is coded as LARGE and a hut as SMALL, although the hut is objectively larger than the eagle.

The associations automatically evoked by a stimulus include elements that are often attributed to high-level inferences. In particular, the description of an event immediately retrieves possible causes [25], as well as counterfactual alternatives [26].

The blocking effect in Pavlovian conditioning of fear illustrates the ability of simple associative systems to duplicate achievements of complex reasoning. The first phase in a typical blocking experiment is a series of trials in which a tone reliably predicts an electric shock. The animal learns to fear the tone. In the next phase a light is introduced, which always appears at the same time as the tone. The blocking effect is observed when the light is then presented alone: although the light has been consistently paired with shock, the animal is not afraid of it.

In an informal discussion of this finding, Rescorla and Wagner [27] observe that the shock is not surprising in the presence of the tone, and therefore needs no further explanation or prediction. This sounds like an inference, but they derive the result from a formal model of associative learning that involves no reasoning at all. As observed in a recent review [28], the fact that blocking is observed in mollusks makes cognitive explanations unattractive (but see [28,29]).

Blocking is analogous to the discounting effect identified by social psychologists (e.g. [30]), in which a possible cause of an event is ignored when the event is already attributed to another cause. Unsurprising events do not prompt further explanation in discounting and do not induce conditioning in the blocking design. There is no conclusive evidence that explicit causal reasoning is necessary for either effect [31]. The success of connectionist models in explaining complex cognitive phenomena by activation in an associative machine lends further support to the computational power of associative processes [32].

In summary, the pattern of automatic activation in memory tends to produce a comprehensive and internally consistent interpretation of the present situation, which is causally embedded in the context of the recent past, and incorporates appropriate emotions and preparedness for likely future events and for future actions [33]. This list of features serves as our working definition of associative coherence.

The coherence of associative activation induces a confirmatory bias when people examine a hypothesis [20,34,35] by increasing the accessibility of hypothesis-consistent information. For example, the intention to test the proposition that “Sam is friendly” preferentially activates evidence of Sam’s friendliness, whereas testing the proposition that “Sam is not friendly” preferentially evokes instances of hostile behavior [15,21]. In a paradigm that has been used to study confirmation biases, anchoring, hindsight bias, egocentric biases, attribution biases, and overconfidence, participants are encouraged to retrieve information that either supports or undermines a focal hypothesis. Only the consideration of incompatible evidence affects their judgments. The instruction to retrieve supporting information has no effect at all – presumably because that evidence had been spontaneously retrieved earlier [8,36–39].

The activation of compatible associations is a primary mechanism of both anchoring and framing effects (Box 1). In a standard anchoring experiment, participants’ attention is first focused on an answer to a question about a quantity (e.g. “Is the proportion of African nations in the UN greater or smaller than (10%/65%)?”. Later, all participants estimate the quantity (“What is the exact percentage of African nations in the UN?”). Even obviously random anchors (e.g. determined by a wheel of chance or by the participant’s social security number) induce a confirmatory bias in the estimate [42,46].

Framing effects commonly occur when alternative statements of a decision problem evoke different emotions. For example, a price difference between cash and credit at the gas station can be framed either as a cash discount or a credit surcharge [47]. Because people hate a surcharge more than they like a discount, the surcharge formulation reduces the use of credit. Framing is an automatic System 1 response, which is not eliminated by expertise. For example ‘10% mortality’ is a more frightening description of surgery outcomes than ‘90% survival’ and the two formulations elicit different preferences for surgery versus radiation therapy even among experienced physicians [43]. It is effectively impossible for decision makers to resist framing effects, unless they are able to generate an alternative frame and observe their inconsistency.

Feature 2: attribute substitution

Judgment intentions resemble a shotgun more than a rifle. Because dimensions of judgment are associated with each other, an intention to evaluate a particular attribute of a stimulus automatically activates assessments of other dimensions as well as. For example, people who listened to words with the task of detecting whether the words rhyme were slowed by a mismatch of spelling: VOTE–GOAT was confirmed as rhyming more slowly than VOTE–NOTE [48]. The comparison of spelling was evoked automatically, although it was disruptive. Similarly, an intention to verify whether a statement was literally true activated an evaluation of metaphorical truth: participants were slow to detect that statements such as “some roads are snakes” or “some jobs are jails” are literally false [49].

Box 1. Associative coherence in anchoring and framing

Anchoring effects occur when a judge considers a possible value of a quantity before judging that quantity: the final estimates are assimilated to the anchor. There is direct evidence that associative processes are involved, and that the anchor selectively retrieves compatible information. Participants in one study first evaluated an anchor for the average price of a car. In a subsequent lexical decision task, those who had seen a low anchor (e.g. ''Is the average price of a German car more or less than 10 000 Deutchmarks?''), were faster to recognize as words the names of inexpensive brands (e.g. Volkswagen) and slower to recognize names of expensive brands (e.g. Mercedes). The mirror-image pattern was observed when the anchor was high [40].

In another paradigm, the influence of randomly-generated anchors is reduced when participants are asked to think of reasons for rejecting the anchor as an estimate. By contrast, participants who are asked to retrieve reasons for endorsing the anchor are no different from controls who simply considered the anchor. This suggests that the anchor automatically evokes compatible information; inconsistent information only comes to mind with deliberate intent [39].

Questions such as ''What is the freezing point of vodka?'' evoke a different type of anchoring, which appears to engage System 2. The anchor (32 °F) comes to mind, and is recognized as too high. Participants in such experiments engage in an effortful search for differences between the target and the anchor, which commonly ends too soon. Cognitive load disrupts the search and increases System 2 anchoring effects, but has little or no influence on associative anchoring [41].

Framing effects occur in choice when key words in alternative frames automatically evoke different response tendencies: 'keep' versus 'lose', 'mortality' versus 'survival', or 'award' versus 'deny' [42,43]. In transactions (e.g. bargaining over the sale of a mug), the different strategic positions of sellers and buyers predispose them to think of different aspects of the transaction [44]. Sellers focus on the benefits of keeping their good (e.g. ''I like the heft of this mug.''), whereas buyers focus on the advantages of keeping their money (e.g. ''I could buy coffee instead.''). The difference between the valuations of sellers and buyers disappears when they are asked to first consider the information that would be more accessible in the alternate frame [45]. For a related but different interpretation see Ref. [13].

Studies of person perception suggest that an intention to judge a specified trait produces a composite judgment of that trait and its associative neighbors (e.g. [50]). Because of this halo effect, evidence for one favorable trait (e.g. warmth) induces favorable judgments on a wide range of other dimensions. In extreme cases, a trait might be endorsed in the absence of any directly relevant evidence. For example, the instruction to evaluate whether a person is generous will automatically evoke judgment of that person on other favorable dimensions (e.g. whether she is warm, friendly, or virtuous). An impression that the person is generous could be formed even when no instances of generous behavior have actually been observed.

Sometimes the target attribute is much less accessible than one of those it evokes. Assessing the future productivity of a young job candidate can be difficult, but judging the quality of a job talk is much easier. In such cases, perfect substitution of the target attribute by the more accessible one might occur. In accord with the general principle that the associative system does not keep track of the source of impressions, substitution typically occurs without any awareness [7]. Automatic attribute substitution has been proposed as the mechanism that generates heuristic judgments, in which the answer to a simpler (and more accessible) question is substituted for a difficult one (Box 2).

A robust bias is observed when observers rely on a subjective impression to estimate an objective quantity in the presence of an obvious biasing factor, as when judging the slant of a hill while carrying a heavy backpack [55]. People fail to allow for two facts they know, that the effort of climbing enters in their judgment of slope, and that the backpack increases effort. Although they have the information necessary to correct for the bias, they substitute their impression of steepness for the required objective judgment. The biased judgment of slant, like the common tendency to overestimate distances on foggy days, represents a joint failure of System 1 and System 2: System 1 generates a biased impression and System 2 fails to correct it [7].

Feature 3: processing fluency

The influence of processing fluency on judgment has been the subject of intense research interest in recent years, (e.g. [56–58]). In a counter-intuitive demonstration, people who were asked to recall 12 instances in which they had behaved assertively subsequently judged themselves to be less assertive than did people asked to recall only 6 instances. Evidently, the difficulty of retrieving the last few instances was the heuristic by which assertiveness was judged [59]. The same counter-intuitive result has been observed for many other judgments made by the availability heuristic (e.g. [60]).

Recent research has identified several distinct factors that converge on a single dimension of fluency, which, in turn, has multiple consequences (Figure 1). The interchangeability of the determinants of fluency is the most intriguing aspect of these findings: the quality of the font in which a problem is presented, the complexity of the language, a good or bad mood, and the presence or absence of contextual support and priming – all appear to have similar effects on judgments of familiarity, truth and goodness (e.g. [57,61–63]). The deliberate exertion of effort induces a subjective experience of strain, and low fluency – regardless of its source – engages effortful processing. Performance on demanding cognitive tasks therefore improves when the problem is shown in a font that is difficult to read, or when a bad mood is induced (e.g. [22,58,64]). As Figure 1 illustrates, fluency is an input to many judgments. Irrelevant variations in the determinants of fluency shown

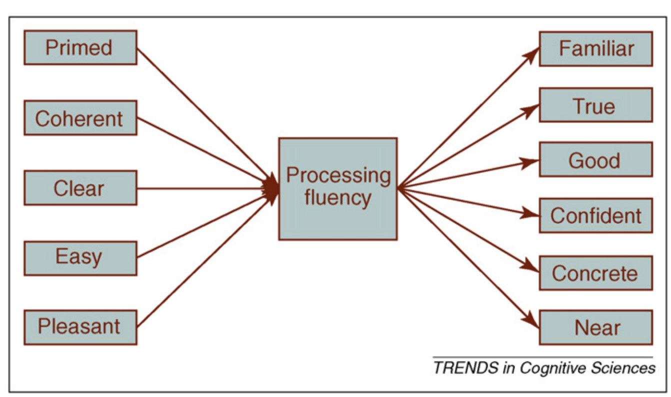

Figure 1. Causes and judgmental consequences of processing fluency.

Box 2. Attribute substitution

''What is the probability that Mary will graduate from college?'', ''What should be the amount of punitive damages in this case?'' ''How happy have you been lately?'' Reasoned answers to these questions require difficult intermediate steps. What is probability? How does one quantify punishment? What is happiness? The surprising observation is that people quickly come up with an intuitive answer to such questions, without dwelling on the conceptual difficulties. The associative system provides the answer by a process of attribute substitution: the judgment of a target attribute automatically evokes assessments of related attributes. If one of these attributes is immediately accessible, it could be mapped onto the target scale (probability, dollars of damages, or happiness), producing an immediate intuitive answer to the initial question [7]. The answer to an easy question is substituted for a difficult one.

In a survey of students, a question about their global happiness appeared just before the question ''how many dates did you have last month?'' [51]; the correlation between the two questions was negligible (r=–0.12). The correlation was much higher (r=0.66), however, when the dating question appeared first. We surmise that thoughts of romantic success or failure evoked an emotional response, which was still highly accessible when the happiness question appeared, and was consequently substituted for it. Similar effects have been found with questions about health and marriage (e.g. [52]).

Direct tests of attribute substitution require separate groups to assess a set of stimuli on the target attribute and the hypothesized heuristic attribute. Figure I shows two examples. Participants ranked nine possible outcomes for an intelligent woman named Linda who had been a student activist (including ''teacher in elementary school'', ''bank teller'', ''insurance salesperson'', ''bank teller and active in the feminist movement''). Some participants ranked the outcomes by their probability. Others ranked them by ''the degree to which Linda resembles a typical member...'' The rankings were effectively identical. As predicted by the representativeness heuristic but contrary to logic, the outcome ''feminist bank teller'' was considered more probable than ''bank teller'' [53].

Participants in another experiment assigned punitive damages to a set of cases, or judged the outrageousness of the defendant's action [54]. The harm suffered by the plaintiff was separately assessed [7]. A plot of the median assessment of damages against the product of outrageousness and harm again shows a close relation between the target attribute and the heuristic.

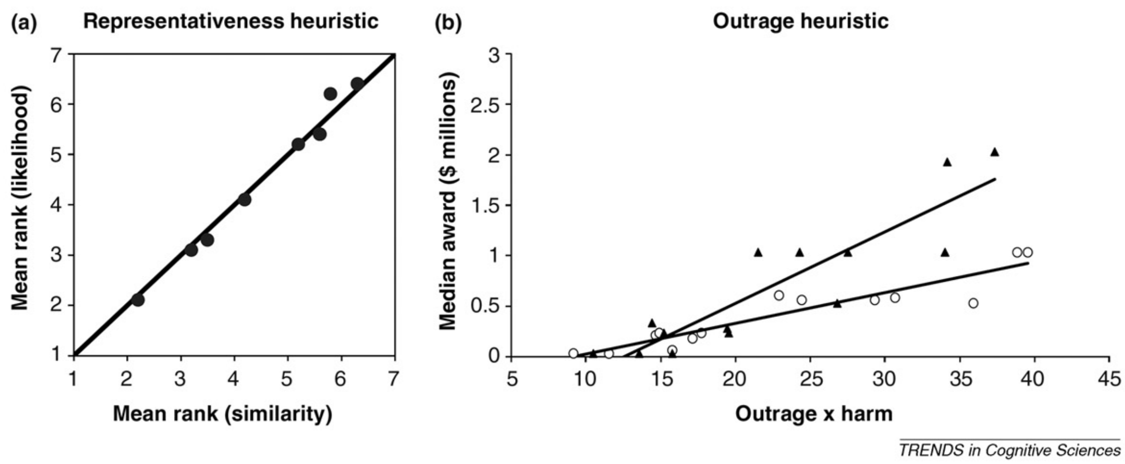

Figure I. Two tests of attribute substitution. **(a)** Plot of average ranks for eight outcomes for Linda, ranked by probability and similarity [53]. **(b)** Plot of median punitive awards (in dollars) for 14 cases, against the product of average ratings of outrageousness and of severity of harm for each case, for large firms (filled triangles) and for medium-size firms (circles), right [54]. Plots are from Kahneman and Frederick [7].

on the left of the figure will induce predictable errors in the judgments shown on the right.

The internal consistency of the information available for a judgment is an important determinant of cognitive fluency [56], which, in turn, determines subjective confidence in judgments [65]. The effect of consistency and fluency on confidence is a source of bias. Evidence that is both thin and redundant appears highly consistent and

Box 3. Associative coherence in subjective confidence

Many studies of confidence examine the accuracy or calibration of probability judgments. Unfortunately, calibration studies depend on the unlikely assumption that stated probabilities correspond precisely to subjective confidence. An alternative approach would focus on whether the determinants of confidence are appropriately weighted. Judgments that are based on highly consistent evidence are likely to be overconfident, particularly if the evidence is scarce, unreliable or redundant [63].

Subjective confidence is one of the manifestations of fluency, and it can be affected by irrelevant manipulations: Harvard students answering trivia questions were less confident in their judgments when instructed to furrow their brow (an expression of effort) than when they puffed their cheeks [58]. Irrelevant uncertainty also reduces confidence: respondents who were told that a basketball game might take place either at 13.30 h or at 16.30 h were much less confident in predictions of its outcome than when that uncertainty was not introduced [65].

Evidence matters, certainly, but coherence is overweighted at the expense of other factors that should influence confidence. When people assign probabilities to competing hypotheses, judgments are determined by relative rather than absolute support for one hypothesis over the other. Consider the question of whether a sample of colored balls was drawn from an urn that contains a majority of white balls or from one that contains mostly red balls. The sample (3 red, 0 white) is much more consistent than the sample (13 red; 9 white) and is accordingly associated with higher subjective confidence, contrary to Bayesian inference [66]. When individual predictions are based on psychological tests, highly correlated tests yield the most confidence, although validity is higher when the tests are independent [67]. The confidence of jurors in their judgments similarly depends on the coherence of the 'causal story' they construct from the evidence. Contrary to logic, the case of the defense is more persuasive if jurors hear a single story in which the defendant is innocent than if another scenario is added [68].

Box 4. Outstanding questions

- Should the distinction between System 1 and System 2 be viewed as a continuum? How does automatic memory activation differ from deliberate search of memory?
- What are the complexity limits of the computations that are performed automatically (e.g. generation of counterfactuals, but not negation)?
- What is the associative structure of the dimensions of judgment that are revealed in priming studies? Are there core or stable dimensions (e.g. valence, intensity and distance)?
- What are the limits of the perfect attribute substitution that is sometimes observed (see Figure I)? When are judgments of associated attributes combined?
- What cues determine whether controlled processing is mobilized, and when intuitive judgments are expressed, suppressed, or corrected?

is processed fluently [66]. The coherence of the associative pattern that underlies a judgment is likely to be misleading when the information is redundant or when the sample of data is small (Box 3). Fluency is therefore a poor indicator of accuracy.

Concluding remarks

As we understand them, System 1 and System 2 are best described as operating systems – software, not hardware. They share hardware and data, can operate in parallel, and tasks can migrate between them. We have identified System 1 with the automatic and mostly unconscious operations of associative memory. System 1 generates impressions, intuitions and response tendencies that are monitored, sometimes rejected and sometimes modified and made explicit by the slower and mostly conscious operations of System 2. System 1 can generate complex representations, but it does not have a capability for rule-governed computations, or even for the processing of explicit negation [69]. It mobilizes the effortful activities of System 2 when it runs into difficulties.

An important feature of System 1 is that it is rarely stumped. In many situations, it automatically, quickly and effortlessly generates a skilled response to current challenges [70]. When an appropriate response is not accessible, another response is usually produced, sometimes by answering a question that is only associatively related to the one that was asked.

Our theoretical view is a list of specifications, not an engineering blueprint, which is a task for the future (Box 4). The specifications are drawn largely from recent studies of priming, which have confirmed the existence of networks of reciprocal activation that link goals, ideas, emotions and response tendencies. The evidence of the priming paradigm suggests that activation spreading selectively within associative memory generates and continuously maintains a rich, coherent and mostly accurate representation of the current state of affairs, with links both to the past and to the likely future and supports a readiness to act and react appropriately. Many biases of intuitive judgment are predictable side effects of this highly adaptive mechanism.

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