Trends in Cognitive Sciences

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REVIEWS

Opinion

The Mythical Number Two

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It is often said that there are two types of psychological processes: one that is intentional, controllable, conscious, and inefficient, and another that is unintentional, uncontrollable, unconscious, and efficient. Yet, there have been persistent and increasing objections to this widely influential dual-process typology. Critics point out that the 'two types' framework lacks empirical support, contradicts well-established findings, and is internally incoherent. Moreover, the untested and untenable assumption that psychological phenomena can be partitioned into two types, we argue, has the consequence of systematically thwarting scientific progress. It is time that we as a field come to terms with these issues. In short, the dual-process typology is a convenient and seductive myth, and we think cognitive science can do better.

Highlights

While there is little controversy that the brain is topographically organized into distinct areas integrated into networks, the unique contribution of each area to behavior is yet to be elucidated.

Diverse lines of research using different approaches have contributed to numerous behavioral associations for any brain area.

Emerging databases of task-based activation data offer the possibility to characterize the engagement of brain regions across a broad range of experimental behavioral conditions.

New large samples of both imaging and phenotypical data provide an opportunity to complement the activation pattern by examining cross-subject associations between imaging-derived neurobiological markers and ecological behavioral characteristics.

'My problem is that I have been persecuted by an integer'. – George A. Miller.

A Tale of Two Types

We humans have a penchant for binaries. We think in terms of either-ors, this-and-thats, on-the-one-hands, and on-the-other-hands, compensating for our limited information processing capacity [1] by distilling nature's complexity down to simpler, more manageable structures. Scientists are no exception. Many years ago, Alan Newell [2] remarked upon psychologists' habit of constructing binary oppositions – nature versus nurture, serial versus parallel, peripheral versus central, and so forth. So it was not surprising when, at the dawn of the cognitive revolution, a distinction emerged between two types of psychological processes (Box 1). One type was said to be efficient, unintentional, uncontrollable, and unconscious (Type 1). The other was described in precisely the opposite terms: inefficient, intentional, controllable and conscious (Type 2).

This dual-process typology has grown more popular with each passing decade [3]. In just the past 5 years it has shaped empirical and theoretical work on emotion [4], morality [5,6], alcoholism [7], drug abuse [8], personality [9], religiosity [10], judgment and decision making [11–14], reasoning [15–17], lie detection [18], autism [19], advertising [20], close relationships [21], interview bias [22], criminal behavior [23], evolutionary modeling [24–26], and drift diffusion modeling [27]. Identifying the neural underpinnings of the two types of thought has been called a top priority for neuroscience [28], and Daniel Kahneman's best-selling book, '*Thinking, Fast and Slow*', canonized the distinction for experts and laypeople alike [29]. In 2015, the World Bank issued a report calling for decision makers around the globe to use more Type 2 thinking in order to avoid the errors associated with Type 1 thinking [30] (Box 2). In the same year, the Institute of Medicine released a report urging health care providers to use Type 2 thinking instead of Type 1 thinking to avoid deadly mistakes [31].

Popularity of this magnitude is typically reserved for ideas that have withstood decades of conceptual scrutiny and empirical vetting, so it is no surprise that the Type 1/Type 2 distinction

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Box 1. Origins of the Dual-Process Typology

The Type 1/Type 2 distinction, and dual-process theories in general, emerged during a very fertile theoretical period in the mid-1970s. LaBerge and Samuels [117] found that words automatically activate their internal semantic representations, as presaged by the Stroop [118] color–word effect. Posner and Snyder [53] then presented the first dual-process model, with (i) an automatic spreading-activation process that is efficient, can occur without intention and conscious awareness, and runs to completion without controlled guidance; and (ii) a conscious, limited-capacity attentional mechanism that is relatively inefficient, intentionally activated, and controlled, which can override the automatic process given enough time to do so. Neely experimentally tested this model [54,55] and showed how the two types of processing interact. Then came the classic work on automaticity by Shiffrin and Schneider [56], who presented extensive experimental evidence on the conditions under which fast, efficient and parallel processing capabilities develop.

From these studies emerged the canonical sets of qualities that ostensibly differentiate the two types of human information processing [32,33,43]. One (Type 1) is triggered by the stimulus itself so it does not require the intention that it occur; it cannot be controlled (stopped or altered) once it has started; it is efficient, using minimal working memory capacity; and it requires little conscious awareness. The other type (Type 2) requires an intention that it occurs and thus cannot be triggered directly by the stimulus; its operation can be controlled (stopped and/or altered) after starting; it is relatively inefficient, occupying limited processing resources and thus interfering with other ongoing mental tasks; and it occurs consciously, so one is phenomenally aware of the process and can verbally report on it.

The popularity of the Type 1/Type 2 distinction subsequently grew hand-in-hand with the rise of dual-process theories. Unlike the dual-process typology, which simply posits that processes can be partitioned into two particular categories, dual-process theories make additional predictions about the operations of the two categories, such as how they interact, the contents on which they operate, their neural correlates, the nature of their underlying computations (e.g., associative vs. rule-based [119]), and so forth. Today, the dual-process typology is the unifying factor of a wide range of dual-process theories [120].

Because our critique is of the dual-process typology, we do not address the unique claims that individuate the various dual-process theories. However, other researchers have examined the evidence for specific dual-process theories and revealed that it is equivocal at best, and frequently more consistent with single-process or multi-process alternatives [e.g., 35,37–39,44–51]. We highly encourage the reader to consider these critiques of specific dual-process theories alongside our arguments against the underlying typology.

has a reputation among many researchers of being uncontroversial, even axiomatic. But this reputation, it turns out, is undeserved. For over 30 years now, detractors have been offering compelling reasons to doubt whether the dual-process typology is a valid approximation of human cognitive architecture [32–52] (Box 3). Indeed, the immense popularity of the dual-process typology belies two inconvenient truths: there is no evidence that processing features cluster together into two groups; and there is substantial evidence that they do not.

Our goal is to bring these truths to light. First, we reveal that the dual-process typology, to the best of our knowledge, has never been tested, and may not be testable. Then, we offer an account of how the typology rose to prominence in the absence of direct empirical support. Finally, we review the many findings that oppose the dual-process typology, and conclude that we as a field should no longer assume that mental process can be partitioned into the categories Type 1 and Type 2.

The Alignment Problem

The central premise of the 'two types' framework has to do with alignment, or the degree to which the attributes within each category co-occur. With four sets of binary features there are $2^4 = 16$ possible combinations, or types of processes. The dual-process typology stipulates that the attributes within each category are aligned such that most processes occupy 2 cells of this 16-cell matrix [40]. On the face of it, it seems unlikely that 14 of the 16 possible types are rare or nonexistent. What, then, is the empirical support for this surprising claim?

Box 2. The Good/Bad Fallacy

Historically, there has been an additional distinction between the two types of processing: Type 2 processing is good in that it generates rational judgments and decisions, whereas Type 1 processing is bad and error-prone [121,122]. This distinction is central to numerous dual-process theories [123–126], and Morewedge and Kahneman [127] explicitly state that Type 1 processing makes the errors, whereas Type 2 processing corrects them.

This is perhaps the most persistent, and dangerous, oversimplification of all. Even proponents of the Type 1/Type 2 distinction have lamented the perpetuation of this myth: 'Perhaps the most persistent fallacy in the perception of dual-process theories is the idea that Type 1 processes (intuitive, heuristic) are responsible for all bad thinking and that Type 2 processes (reflective, analytic) necessarily lead to correct responses' [128]. Calling Type 2 thinking good is to champion motivated reasoning, the domain of self-serving rationalizations and of finding creative self-serving justifications for choices and policies that help oneself or one's group at the expense of others. Indeed, when pursuing any goal (e.g., to be fair, lose weight, pass an exam, or help someone in need) in the face of temptation (e.g., to cheat, eat dessert, go to a party, or to stay out of harm's way), we often fail because Type 2 thinking produces self-sabotaging rationalizations: 'Most people are selfish, so why should I be fair?'; 'I deserve a slice of cake'; 'It would be rude to miss the party'; 'Somebody else will help so I am not needed'. It is precisely because Type 2 thinking is so facile in finding such rationalizations that deliberate, effortful thought can be a hindrance to effective self-regulation. Indeed, a growing number of motivation and health researchers are concluding that effective self-regulators – those who make more money, have more friends, are healthier and live longer – are those who rely on Type 1 processing to regulate their behavior, not Type 2 [129–132].

Beyond the domain of motivated reasoning, classic research shows that consciously reflecting on one's decision-making can lead to poorer choices by focusing disproportionate attention on nonoptimal criteria [133], attenuating memory [134], reducing attitude–behavior consistency [135], and lowering postchoice satisfaction [136]. Numerous cognitive illusions and fallacies only occur when we make conscious, Type 2 judgments or decisions, and disappear when we make unconscious, Type 1 judgments or decisions. For instance, people will consciously believe that they wrote content that they did not in fact write (the illusion of authorship), yet at the same time are able to unconsciously discriminate their own written content from that of others [71,137]. People are also prone to consciously believe that if something happens less frequently for a period, it will happen more frequently in the future (and vice versa). This is the so-called gambler's fallacy, and it is specific to conscious, Type 2 processing. Unconsciously, people expect that if something happens less (more) frequently for a period, it will continue to happen less (more) frequently in the future [138].

In the general domain of skill execution, dedicating Type 2 attentional resources to the execution of well-practiced skills hinders performance and, in such situations, inducing cognitive load – that is, inducing Type 1 processing – improves performance [139,140]. Moreover, there are many simple, efficient decision-making heuristics that outperform highly complex, inefficient processing algorithms [42].

These well-established findings are applicable to a wide range of real-word scenarios, and so there is simply no justification for the claim that Type 1 processing is worse than Type 2 processing. Rather, the good–bad dimension is just an orthogonal processing feature.

There is none. In fact, the alignment requirement has never been tested. The reader will not find a single statistic pertaining to the degree of correspondence between processing features. No attempt has been made to estimate the probability of a process being intentional given that it is conscious versus unconscious, or the probability of a process being controllable given that it is efficient versus inefficient, and so forth. For all we know, Type 1 features (e.g., unconsciousness) are no likelier to occur with other Type 1 features (e.g., unintentional) than they are to occur with Type 2 features (e.g., intentional). Likewise, it could be the case that Type 2 features (e.g., consciousness) are no likelier to occur with other Type 2 features (e.g., intentional) than they are to occur with Type 1 features (e.g., unintentional). The basic tenet of the Type 1/Type 2 distinction – that the attributes within each category are aligned – simply has not been demonstrated.

What researchers have demonstrated is that processing features sometimes align as the dual-process typology would predict [53–56]. Yet, there are also many examples of where processing features do not align as the dual-process typology would predict. Considering only the

Box 3. Past Critiques

Although the dual-process typology is widely accepted, it has not gone unchallenged. The earliest critiques were put forth by Zbrodoff and Logan in 1986 [52], and by Bargh in 1989 [32]. These critiques cautioned the broader field against adopting the then-nascent typology, since a substantial amount of evidence had already accumulated showing that processing features do not come in two all-or-nothing packages. Note that these early critiques specifically argued against the strong claim that processing features are perfectly aligned, but were silent on the weaker claim that processing features are at least somewhat correlated. In 1994, Bargh expanded these early warnings into a full-fledged analysis of processing features, which concluded that cognitive science ought to proceed under the assumption that processing features are orthogonal unless proven otherwise [33].

These early warnings went largely unheeded. In the following decade, several influential theories emerged that endorsed the Type 1/Type 2 distinction and made claims about the way the two categories operate [113,119,141–144]. These dual-process theories proved wildly popular, but also attracted a handful of critics, most notably Osman [44–47], Gigerenzer [38,42], Kruglanski [41,42], and Keren and Schul [40]. These researchers have put forth many compelling critiques of a range of dual-process theories on empirical and conceptual grounds. One recurring theme in these critiques is the recapitulation of the alignment problem. Like Zbrodoff and Logan [52] and Bargh [32,33], these critics have attacked the strong claim that processing features are perfectly aligned. Keren and Shul [40], for instance, challenged the idea that the 'dichotomous characteristics used to define the two-system models are uniquely and perfectly correlated' (p. 537).

Evans and Stanovich – two long-time proponents of the Type 1/Type 2 distinction – addressed these critiques in 2013 [145]. Specifically, they acknowledged that the two categories of features are not perfectly aligned, but argued that they are nonetheless strongly correlated. This marked a turning point towards consensus in the ongoing debate. However, we believe that the shift from perfectly aligned to strongly correlated features does not go far enough. We stand with past critics, and with Evans and Stanovich [145], in encouraging the field to abandon the idea of perfect alignment – we depart, however, by encouraging the field to be agnostic about whether the features are correlated at all until there is actual evidence one way or the other.

times when they do is a clear case of the confirmation bias at work. A falsifiable test of the dual-process typology would estimate the direction and strength of the relationship between processing features across a representative sample of mental phenomena. Just as a taxonomist would not group the physical characteristics mammary glands, hair, and middle ear bones into the category mammal without first documenting their alignment across large samples of animals, cognitive scientists should not group processing characteristics into categories without first documenting their alignment across large samples of processes. Since no such test has been conducted, the dual-process typology is purely speculative, and will remain so until it has been vetted according to the same standards to which scientists hold all other correlational claims. In other words, the assumption needs to be tested by generating a representative sample of mental processes, reliably coding each one on the dimensions of interest, and then assessing the actual correlations between these dimensions.

Demonstrating featural alignment is easier said than done. One would have to determine what counts as a process in the first place – a notoriously slippery issue [43] – and even then, it may turn out that psychologists have identified the operating characteristics of so few processes that no meaningful analysis can be conducted. Moreover, one would have to specify how strongly correlated the features ought to be if the two-types hypothesis is correct – an issue that has yet to be broached. Some readers might consider these hurdles to be insurmountable and conclude, therefore, that no direct evidence for the Type 1/Type 2 distinction can be provided (see Outstanding Questions). These readers may well be correct. But an inability to support a claim is hardly a reason for perpetuating it.

The 'Two Types' Bias

It is not surprising that the dual-process typology has become widely accepted despite having no empirical support (Box 1). After all, people frequently see alignment where none exists.

Reducing an unmanageable number of categories, such as 16, into a dichotomy seems to satisfy our need for knowledge and predictive power while cutting costs in terms of mental effort [57]. In fact, the tendency to reduce many categories (e.g., white, black, good, and bad) into two (e.g., white–good and black–bad) is the basis of the widely used Implicit Associations Test for racism and other social biases [58,59]. Take, for instance, the pervasive stereotype that gender is aligned with math ability. Once this belief is acquired through socialization, it sticks without compelling evidence to support it. Indeed, many people believe that men are better at math than women are; when, in reality, gender is unrelated to math ability [60] and it is women who tend to earn the higher grades in math courses [61]. In our view, the belief that processing features are aligned reflects a similar phenomenon. The rise of the dual-process typology has been propelled not by scientific evidence but by the human tendency to be seduced by simplifying but baseless stereotypes.

There is another parallel between the dual-process typology and stereotypes: both are damaging. Indeed, because processing features are assumed to be aligned, discovering that a process has just one feature of a given type (e.g., unintentional) often leads to the conclusion, with no further testing, that the process has other features of that type (e.g., unconscious) as well [32–34,62,63]. Since the degree of alignment between processing features is unknown, such conclusions are not permissible and may frequently be wrong. For instance, the first research on implicit bias (i.e., the unintentional activation of racially biased attitudes) occurred in 1995 [64], and by 1999 researchers started referring to this phenomenon as unconscious bias [65]. Soon enough, people around the world learned that implicit biases are unavailable to introspection. Yet conscious awareness of implicit bias was not assessed until 2014, when it was found that people are aware of their implicit biases after all [66].

An equally important concern is that uncritical acceptance of the Type 1/Type 2 dichotomy biases the field against counterintuitive evidence that does not fit it. This is 'putting the cart before the horse'. Any process with a mixture of Type 1 and Type 2 features – that is, any process that cannot be classified using the dual-process typology – is considered implausible a priori. The result is that mixture phenomena are less likely to be discovered, and if they are discovered, they are likely to be met with skepticism, and less likely to be viewed as reliable findings [67–69].

Now for the 'million-dollar question': what would it take for people to stop assuming that processing features are correlated? For >30 years critics have been urging the field to abandon the dual-process typology for this reason: that the key processing features do not actually align (Box 3). In 1986, Zbrodoff and Logan argued that there were no theoretical reasons to believe that processing features co-occur, and that it would be more profitable to investigate each feature separately [52]; a position one of us echoed in 1989 and 1994 analyses [32,33]. Recently, several more theorists have joined the chorus by arguing against the validity of the Type 1/Type 2 distinction because there is no direct evidence for featural alignment [36,40,42–45]. Yet, despite these converging voices, the dual-process typology has never been more popular. This time we have decided to take a different tack.

If the uncritical acceptance of the dual-process typology is indeed akin to the human tendency towards simplification that also underlies stereotyping, then interventions known to reduce stereotyping may help to debias people's assumptions about processing features. The classic intervention is to provide strong counter-stereotypic exemplars. For instance, exposure to female math professors has been shown to make people appropriately skeptical of the idea that gender and math ability are aligned [70]. Thus, in an effort to make our field appropriately

skeptical of the idea that processing features are aligned, we will provide the largest list of counter-stereotypic exemplars ever compiled.

The list contains two sections. The first includes misalignments between processing features – these are processes that contain mixtures of Type 1 and Type 2 features; each one a data point against the dual-process typology. The second section reveals that the alignment problem applies not only to the categories Type 1 and Type 2, but also to the processing features that supposedly comprise these categories. Indeed, the qualities of consciousness, efficiency, intentionality, and controllability each contain their own set of lower-order dimensions that fail to cohere as the dual-process typology assumes. The picture that emerges is one of a typology that not only lacks empirical support, but also stands at odds with entire swaths of psychological phenomena.

Misalignments between Processing Features

Unconscious (T1) and Intentional (T2)

We start with phenomena that are intentional yet able to operate without conscious monitoring. Such misalignments are common because consciousness and intentionality are affected differently as information processing becomes more routinized [32–34,71]. Specifically, routinization can make processing less reliant on conscious attention without affecting whether it requires an intention to be executed. A skilled typist, for example, does not need to consciously monitor their typing, but will never start plucking away at their keys without intending to type something in the first place [71]. Driving, typing, playing piano, and many other skills can also be practiced to the point that they can operate unconsciously while remaining completely intentional activities.

Other intentional phenomena can operate unconsciously with no practice at all, the most important one being language production. Humans can communicate via language despite having practically zero awareness of the basic ingredients of language or of the rules for combining those ingredients to create meaningful utterances [72] – yet, we only use language if we intend to do so. From typing to driving to speaking, we can already see that the categories Type 1 and Type 2 fail to capture much of what we do in our everyday lives.

Unconscious (T1) and Inefficient (T2)

Many unconscious processes are inefficient. One example is the process of problem solving. Consider studies exploring how people learn to solve complex problems like the balls and boxes puzzle. This puzzle involves a single row of five boxes, each containing one ball. The goal is to remove all of the balls by figuring out how to open the boxes. Solving the puzzle requires learning a rule: the rightmost box is always open; other boxes open if the box immediately to the right contains a ball and all other boxes to the right are empty.

Performance on the balls and boxes puzzle improves after participants solve it a single time, revealing learning of the correct rule. However, this learning can be completely unconscious; verbal reports and recognition tests of puzzle-specific rules have revealed that participants can learn the solution while having no conscious awareness of having done so [73–76]. According to the dual-process typology, the process by which people learn to solve problems like the balls and boxes puzzle, given its unconscious character, has to be efficient. But this prediction turns out to be wrong: learning is in fact slowed down by working memory load despite being unconscious [73,77].

In a similar vein, research has shown that people are capable of solving effortful, multistep math problems unconsciously [78]. For instance, people can generate the correct solution to

'9 – 3 – 4 =' even when the equation is presented subliminally. This was shown in a series of experiments in which participants identified a number more quickly if that number was the solution to an equation that had been presented outside of conscious awareness. Yet it is well established that math performance critically depends on working memory capacity [79]. Again, such effortful yet unconscious problem solving is a violation of the dual-process typology.

Another type of unconscious yet inefficient process is goal pursuit [80–84]. Pursuing a goal requires expending effort over time, often in the face of challenging obstacles. Nonetheless, goals can be activated and then guide effortful behavior without the person's awareness, using the same brain regions and also consuming the same working memory capacity as when consciously pursued [83].

In one illustrative set of experiments, the activation of an achievement goal by an external stimulus caused participants to persist on a challenging word-finding task, even after being told to stop. Extensive debriefings revealed no signs of awareness of the setting or activation of an achievement goal. Moreover, a recent meta-analysis of >300 studies concluded that unconscious yet effortful goal pursuit is a robust and reliable effect in the research literature [84]. This phenomenon constitutes a major misalignment of Type 1 and Type 2 qualities – effortful information processing operating without the person's awareness.

Uncontrollable (T1) and Inefficient (T2)

Inefficient processes can be uncontrollable. One such process comes from the domain of moral judgment. When one intends to resolve a moral dilemma pitting a utilitarian option (e.g., killing one person to save many others) against a deontological option (e.g., saving one person at the expense of many others), it is difficult to control the initial output: an inclination to pick the deontological option [85,86]. Yet, despite its uncontrollable quality, deontological judgment can be dramatically reduced by inducing cognitive load [87]. Thus, moral judgment can be simultaneously uncontrollable yet inefficient: it is difficult to stop or alter the initial urge to choose the deontological option, yet this urge requires working memory capacity.

Unintentional (T1) and Inefficient (T2)

Effortful, inefficient processes can also be unintentional. Indeed, cognitive load has been shown to interfere with many processes that can be activated directly by external stimuli. These processes include stereotype activation [88] (the activation of category knowledge by social stimuli); implicit theory of mind (unintentionally representing the mental states of others) [89]; speech recognition (identifying phonemes in speech input) [90]; hedonic temptation (being tempted by desirable stimuli, such as palatable foods) [91]; word reading (whereby words activate their semantic meaning) [92]; negation (interpreting negative utterances, as when not bad is understood as good) [93]; and task switching (the execution a task immediately following the execution of a different task) [94]. Researchers have found that all of the above processes can be activated unintentionally yet are attenuated by cognitive load.

Unintentional (T1) and Controllable (T2)

Unintentional processes can be controllable. A meta-analysis of 25 years of research concluded that positive and negative evaluations are activated directly by external stimuli in the absence of any sort of evaluation intention or task instruction [95]. However, the evaluation itself, as positive or negative, is controlled by the person's goal state [82,96]. For instance, smokers who are trying to quit manifest negative automatic attitudes towards smoking paraphernalia, as long as their nicotine cravings are sated and they are not in the need state; but if they have not recently smoked they will unintentionally evaluate the same stimuli positively

[97] – their need state controls the unintended effect of the stimulus. Unintentional evaluations are controlled by other top-down goal states as well, such as those to quench one's thirst [96], win a game [96], be environmentally friendly [98], socialize [99], and more [100].

A completely different class of unintentional yet controllable processes are ideomotor effects, whereby stimulus exposure spontaneously elicits action tendencies. The classic example is the Simon effect: while categorizing stimuli on a nonspatial dimension (e.g., color) by initiating left- and right-hand key presses, participants respond faster when stimuli are presented at the same relative location as the appropriate key press. For instance, if one must categorize blue stimuli with right-hand key presses, one will respond faster when blue stimuli are presented on their right-hand side versus their left-hand side.

This effect is activated unintentionally by stimulus exposure, yet is highly controllable. This was demonstrated in a set of classic studies in which a Simon task was modified so that left-hand key presses illuminated a light bulb on the participants' right-hand side, and right-hand key presses illuminated a light bulb on the participants' left-hand side [101]. The stimuli were low- and high-pitched tones emitted on the participants' left- or right-hand side. Participants were told to respond to low-pitched tones by performing one of two equivalent acts: (i) press the left-hand key or (ii) illuminate the right-hand light bulb. To respond to high-pitched tones participants had to (i) press the right-hand key or (ii) illuminate the left-hand light bulb.

Participants with key-pressing intentions displayed the typical Simon effect: faster responding when the tone was emitted from the same relative location as the appropriate key press. Participants with light-bulb-illuminating intentions displayed the inverse effect: faster responding when the tone was emitted from the opposite relative location as the appropriate key press. This is because participants with light-bulb-illuminating intentions chose to think of their right-hand key presses in terms of left-oriented effects (and their left-hand key presses in terms of right-oriented effects). Thus, the unintentional Simon effect is controllable, capable of being completely inverted by higher-order processing. And this mixture of unintentionality and controllability is by no means specific to performance on the Simon task – rather, it is a feature of ideomotor phenomena in general [102]. For example, people unintentionally mimic the physical behaviors of others, yet they can completely stop or intensify (i.e., control) this process to satisfy their current affiliative goals [103,104].

Uncontrollable (T1) and Intentional (T2)

The unintentional yet controllable processes of evaluation and ideomotor phenomena serve as natural counterpoints to another set of misalignments: the uncontrollable yet intentional processes documented by the heuristics and biases literature. Unlike evaluation and ideomotor effects, which are activated directly by external stimuli yet have controllable outputs, these processes are entirely dependent on internal goals yet have uncontrollable outputs. A classic example comes from the bat-and-ball problem [105]. 'A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?" People almost invariably generate an initial answer of 10 cents, but the correct answer is 5 cents. Apparently, the erroneous output of 10 cents is uncontrollable; no goal manipulation has been shown to cause people to produce instead an initial answer of 9 cents, 11 cents, or anything else other than 10 cents. Nonetheless, all of the available evidence suggests that the process by which we generate the uncontrollable error is intentional [106] – it is not initiated directly by an external stimulus (the question itself), but by an internal goal (to answer the question, a goal activated by the experimental task instructions). In other words, reading or hearing the bat-and-ball problem does not elicit the 10 cents output unless one intends to solve the problem. So, unlike

evaluation, which has a controllable output (liking vs. disliking) and is unintentionally activated by external stimuli, the bat-and-ball error is an uncontrollable output (10 cents) that is intentionally produced. In other words, another misalignment.

Ironically, this mixture of intentionality and uncontrollability characterizes many of the biases documented in Tversky and Kahneman's classic research program, which is frequently used to justify the classic dual-process typology. Take, for example, the availability heuristic, which involves estimating frequency by the ease with which information comes to mind. In the classic demonstration, individuals estimate that more words begin with the letter K than have K in the third position (despite the fact that the reverse is true) because examples of the former more easily come to mind [107]. This bias is difficult to control – we can hardly resist concluding that more letters start with K than have K in the third position – but again, all of the available evidence suggests that it only occurs in the presence of an intention to make a judgment. The process of generating examples of the two kinds of words is not activated directly by an external stimulus, but by an internal intention to estimate the relative frequencies of the words. Likewise for many judgments and decisions. They exist somewhere in Type 1/Type 2 limbo, whether it is the unintentional yet controllable way in which we judge the valence of a cigarette, or the intentional yet uncontrollable way in which we estimate frequencies.

Misalignments Within Processing Features

In addition to the misalignments between features, there are many misalignments within features. As one of us first noted 23 years ago [33], and as Moors and De Houwer [43] later elaborated in fine detail, the qualities of consciousness, efficiency, intentionality, and controllability each contain their own set of lower-order dimensions. As we will see, these lower-order dimensions frequently fail to cohere as the dual-process typology assumes. This is a major issue for the Type 1/Type 2 distinction. The typology presupposes the existence of four coherent dimensions, and so it immediately collapses if each of these dimensions lack internal consistency.

Consciousness

Conscious awareness has at least three subdimensions: (i) awareness of the cause of a process; (ii) awareness of the effect of a process on judgment or behavior; and (iii) awareness of the cause–effect relationship [32–34]. These subdimensions are dissociable. For instance, a recent set of high-powered studies documents a process with an unconscious cause and a conscious effect [108]. Participants in these studies played a game of blackjack. During each hand, participants were subliminally exposed to a gambling-related word or a neutral word, then chose to bet or pass. The investigators found that participants were more likely to bet after exposure to a gambling-related prime versus a neutral prime – a conscious output (choosing to bet) with an unconscious cause (subliminally presented words). Conversely, a process can be unconscious in the sense that the individual is unaware of the output despite being aware of the evoking stimulus. Nonverbal expressions of racial bias, for instance, are cases of awareness of an interaction partner's race but not of its negative effect on one's own mannerisms and facial expressions during the interaction [109].

Yet another form of unconscious processing involves awareness of both the cause and effect, but not of the cause–effect relationship. It is in this way that decision-makers have been shown to unconsciously favor the resumes of male versus female applicants to prestigious jobs [110]. In such cases decision makers are completely aware of the evoking stimulus (the applicant's sex) as well as the effect (selecting the applicant to be interviewed), but are unaware that the former caused the latter.

Given that there are at least three dissociable ways in which a process can be unconscious, it makes little conceptual sense to talk about consciousness as a unitary processing feature that can co-occur with other features.

Efficiency

A similar issue applies to efficiency. Working memory contains separate stores for verbal information and visuospatial information [111,112]. Thus, cognitive processes can be more or less efficient with respect to different types of working memory, which means that cognitive load can have opposite effects depending on the type of working memory that is occupied. This is highly problematic for the dual-process typology; it has been argued that the best way to determine whether a process is Type 1 or Type 2 is to determine whether it is inhibited by cognitive load [113], but this approach will lead to completely different classifications depending on which cognitive load manipulation one uses.

On the Stroop task, for instance, loading spatial working memory (SWM) increases the extent to which word reading interferes with color naming, whereas loading verbal working memory (VWM) completely eliminates such interference [92]. Thus, a researcher who loads SWM would conclude that word reading is an efficient Type 1 process that is likely to be unconscious, unintentional, and uncontrollable, whereas a researcher who loads VWM would conclude that word reading is an inefficient Type 2 process that is likely to be conscious, intentional, and controllable. In a completely different domain, VWM load decreases the tendency to make utilitarian moral judgments but not deontological moral judgments, whereas SWM decreases the tendency to make deontological moral judgments but not utilitarian moral judgments [87]. So, researchers who load SWM would conclude that deontological moral judgment is a Type 2 process, whereas researchers who load VWM would conclude that deontological moral judgment is a Type 1 process. Clearly, we cannot describe these or any other processes as having more or less of some unitary efficiency feature – rather, we must describe them as being more or less efficient with respect to different types of working memory – but again, the oversimplified dual-process typology does not admit of such nuance.

Intentionality

There are at least two flavors of intentionality [32,33,43,114]. One, which we simply call intentional, describes any process that is activated by a goal to perform that particular process. Examples include hugging, singing, eating, and so forth. Alternatively, a process can be goal dependent. Such processes are activated directly by external stimuli (so they are not purely intentional) but only in the presence of a relevant processing goal (so they are not purely unintentional). For instance, when a driver slams their foot on the break, they do something that was initiated directly by an external stimulus, like a stop sign or brake lights. However, this process is dependent on having a goal to drive safely in the first place. If that same person were exposed to the same stimulus while walking down the street or attempting to cause a massive car wreck, the seemingly unintentional process would not occur. This is unlike purely unintentional processes such as evaluation, stereotyping, and word reading, which do not require a processing goal, as well as purely intentional processes such as hugging, singing, and eating, which cannot be activated directly by external stimuli. This in-between form of intentionality is simply a square peg that does not fit into the round hole of the 'two types framework.

Controllability

Controllability as a feature lacks internal coherence as well. Processes can be controllable in very different ways: in the sense that they can be stopped after being triggered [115], and in the sense that their output can be modulated or altered [43]. For example, evaluations can be

altered but not stopped – that is, we cannot stop a stimulus from producing an evaluative response, but we can control whether the evaluation it produces is positive or negative [96,116]. Other processes can be stopped but not altered. Mimicry, for instance, can be attenuated by one's current goals [103,104], but the output of the mimicry process – for instance, whether the mimicker taps her foot or touches her face – is controlled exclusively by the stimulus. Thus, the broader concept of controllability is not a meaningful dimension on which to categorize mental processes; we must instead ask, as with awareness, intentionality, and efficiency, what precise type or form of the quality is at issue.

Concluding Remarks

We suspect that the response of many researchers when they hear 'there are not two types of processes' will be to dismiss the claim out of hand. 'Of course there are two types of processes. There are unconscious automatic ones, and there are conscious deliberate ones.' However, we are asking the reader to check their work before accepting the intuitive answer.

Consider this analogy: we say that there are two types of cars, convertibles and hard-tops. No debate there. But now we say: there are two types of cars, automatic and manual transmission. Yes, those are certainly two different types of cars. And still further: there are two types of cars, gasoline and electric motors. Or: foreign and domestic. The point is that all of these are different types of cars. But we all know that there are not just two types of cars overall: convertibles that all have manual transmission, gasoline engines, and are manufactured overseas; and hard-tops that all have automatic transmission, electric engines, and are made in our own country. All around us we see counterexamples, automobiles that are some other combination of these basic features.

So, the issue is not whether mental processes differ on various dimensions – they certainly do. The issue, we argue, is that the degree of alignment between the various dimensions has not been tested. Furthermore, as outlined above, entire swaths of psychological phenomena are characterized by misalignments of these dimensions. Perhaps more troubling, the underlying dimensions themselves lack internal consistency – a problem that, if irremediable, is absolutely fatal to the dual-process typology.

It is time that we as a field come to terms with these issues. With institutions like the World Bank and Institute of Medicine now endorsing our highly speculative and frequently misleading typology, we cannot afford to wait. Luckily, the solution is straightforward: researchers should rigorously explore each feature of a given process one by one, without making assumptions or drawing conclusions about other features that are not being studied. For too long the dual-process typology has obscured the rich diversity of the human mind. Let us embrace that diversity instead.

Outstanding Questions

Are there any systematic relationships between processing features?

Can the dual-process typology be tested?

What should replace the dual-process typology as a model of the human mind?

How can we as a field convey to policy makers that there are many types of mental processes, and that one is not always better than the other?

References

1. Miller, G.A. (1956) The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychol. Rev.* 63, 81–97
2. Newell, A. (1973) You can't play 20 questions with nature and win: projective comments on the papers of this symposium
3. Pennycook, G. (2017) A perspective on the theoretical foundation of dual-process models. *Dual Process Theory* 2, 34
4. Evers, C. *et al.* (2014) Emotion response coherence: a dual-process perspective. *Biol. Psychol.* 98, 43–49
5. Amit, E. *et al.* (2014) Visual versus verbal thinking and dual-process moral cognition. In *Dual-Process Theories of the Social Mind*, pp. 340–354, Guilford Press
6. Hayakawa, S. *et al.* (2017) Thinking more or feeling less? Explaining the foreign-language effect on moral judgment. *Psychol. Sci.* 28, 1387–1397
7. Lannoy, S. *et al.* (2014) Beyond inhibition: a dual-process perspective to renew the exploration of binge drinking. *Front. Hum. Neurosci.* 8, 1–6
8. Ames, S.L. *et al.* (2017) Adolescents at risk for drug abuse: a 3-year dual-process analysis. *Addiction* 112, 852–863
9. Back, M.D. and Nestler, S. *et al.* (2016) Dual process approaches to personality. In *Reflective and Impulsive Determinants of Human Behavior* (Deutsch, R., ed.), pp. 137–154, Psychology Press

10. Baumard, N. and Boyer, P. (2013) Religious beliefs as reflective elaborations on intuitions: A modified dual-process model. *Curr. Dir. Psychol. Sci.* 22, 295–300
11. Bago, B. and De Neys, W. (2017) Fast logic?: Examining the time course assumption of dual process theory. *Cognition* 158, 90–109
12. Pennycook, G. *et al.* (2015) What makes us think? A three-stage dual-process model of analytic engagement. *Cogn. Psychol.* 80, 34–72
13. Scherer, L.D. *et al.* (2017) The influence of effortful thought and cognitive proficiencies on the conjunction fallacy: implications for dual-process theories of reasoning and judgment. *Pers. Soc. Psychol. Bull.* 43, 874–887
14. Oaksford, M. and Hall, S. (2016) On the source of human irrationality. *Trends Cogn. Sci.* 20, 336–344
15. Taber, C.S. and Lodge, M. (2016) The illusion of choice in democratic politics: the unconscious impact of motivated political reasoning. *Polit. Psychol.* 37 (Suppl. 1), 61–85
16. Toplak, M.E. *et al.* (2014) Assessing miserly information processing: an expansion of the Cognitive Reflection Test. *Think. Reason.* 20, 147–168
17. Stupple, E.J.N. *et al.* (2013) Matching bias in syllogistic reasoning: evidence for a dual-process account from response times and confidence ratings. *Think. Reason.* 19, 54–77
18. ten Brinke, L. *et al.* (2014) Some evidence for unconscious lie detection. *Psychol. Sci.* 25, 1098–1105
19. Brosnan, M. *et al.* (2016) Reasoning on the autism spectrum: a dual process theory account. *J. Autism Dev. Disord.* 46, 2115–2125
20. Büttner, O.B. *et al.* (2014) A dual-step and dual-process model of advertising effects: implications for reducing the negative impact of advertising on children's consumption behaviour. *J. Consum. Policy* 37, 161–182
21. Sturge-Apple, M.L. *et al.* (2015) A dual-process approach to the role of mother's implicit and explicit attitudes toward their child in parenting models. *Dev. Psychol.* 51, 289–300
22. Derous, E. *et al.* (2016) Why your stigma isn't hired: a dual-process framework of interview bias. *Hum. Res. Manage. Rev.* 26, 90–111
23. Van Gelder, J.L. and de Vries, R.E. (2014) Rational misbehavior? Evaluating an integrated dual-process model of criminal decision making. *J. Quant. Criminol.* 30, 1–27
24. Bear, A. and Rand, D.G. (2016) Intuition, deliberation, and the evolution of cooperation. *Proc. Natl. Acad. Sci. U. S. A.* 113, 936–941
25. Bear, A. *et al.* (2017) Co-evolution of cooperation and cognition: the impact of imperfect deliberation and context-sensitive intuition. *Proc. R. Soc. B* 284, 1–9
26. Rand, D.G. *et al.* (2017) Cyclical population dynamics of automatic versus controlled processing: an evolutionary pendulum. *Psychol. Rev.* 124, 626–642
27. Caplin, A. and Martin, D. (2016) The dual-process drift diffusion model: evidence from response times. *Econ. Inq.* 54, 1274–1282
28. Huettel, S.A. (2010) Ten challenges for decision neuroscience. *Front. Neurosci.* 4, http://dx.doi.org/10.3389/fnins.2010.00171
29. Kahneman, D. (2011) *Thinking, Fast and Slow,* Farrar, Straus and Giroux
30. World Bank Group (2015) *World Development Report 2015: Mind, Society, and Behavior,* World Bank
31. Balogh, E.P. *et al.* (2015) *Improving Diagnosis in Health Care,* Institute of Medicine
32. Bargh, J.A. (1989) Conditional automaticity: varieties of automatic influence in social perception and cognition. *Unintended Thought* 3, 51–69
33. Bargh, J.A. (1994) The four horsemen of automaticity: intention, awareness, efficiency, and control as separate issues. In *Handbook of Social Cognition: Vol. 1, Basic Processes* (2nd edn) (Wyer, R.S. and Srull, T.K., eds), pp. 1–40, Erlbaum
34. Bargh, J.A. and Morsella, E. (2008) The unconscious mind. *Perspect. Psychol. Sci.* 3, 73–79
35. Conrey, F.R. *et al.* (2005) Separating multiple processes in implicit social cognition: the quad model of implicit task performance. *J. Pers. Soc. Psychol.* 89, 469–487
36. Ferguson, M. *et al.* (2014) Rethinking duality. In *Dual-process theories of the social mind*, 578–594
37. Ferguson, M.J. and Wojnowicz, M.T. (2011) The when and how of evaluative readiness: a social cognitive neuroscience perspective. *Soc. Pers. Psychol. Compass* 5, 1018–1038
38. Gigerenzer, G. and Regier, T. (1996) How do we tell an association from a rule? Comment on Sloman (1996). *Psychol. Bull.* 119, 23–26
39. Houwer, J.D. (2014) A propositional model of implicit evaluation. *Soc. Pers. Psychol. Compass* 8, 342–353
40. Keren, G. and Schul, Y. (2009) Two is not always better than one: a critical evaluation of two-system theories. *Perspect. Psychol. Sci.* 4, 533–550
41. Kruglanski, A.W. *et al.* (2006) On parametric continuities in the world of binary either ors. *Psychol. Inq.* 17, 153–165
42. Kruglanski, A.W. and Gigerenzer, G. (2011) Intuitive and deliberate judgments are based on common principles. *Psychol. Rev.* 118, 97–109
43. Moors, A. and De Houwer, J. (2006) Automaticity: a theoretical and conceptual analysis. *Psychol. Bull.* 132, 297–326
44. Osman, M. (2004) An evaluation of dual-process theories of reasoning. *Psychon. Bull. Rev.* 11, 988–1010
45. Osman, M. (2013) A case study: dual-process theories of higher cognition – Commentary on Evans & Stanovich (2013). *Perspect. Psychol. Sci.* 8, 248–252
46. Osman, M. and Stavy, R. (2006) Development of intuitive rules: evaluating the application of the dual-system framework to understanding children's intuitive reasoning. *Psychon. Bull. Rev.* 13, 935–953
47. Osman, M. and Wiegmann, A. (2016) Explaining moral behavior: a minimal moral model. *Exp. Psychol.* 64, 68–81
48. Shanks, D.R. and Berry, C.J. (2012) Are there multiple memory systems? Tests of models of implicit and explicit memory. *Q. J. Exp. Psychol.* 65, 1449–1474
49. Stephens, R. *et al.* (2017) Are there two processes in reasoning? the dimensionality of inductive and deductive inferences. *Psychol. Rev.* Published online 21 December 2017. http://dx.doi.org/10.1037/rev0000088
50. Stillman, P.E. *et al.* (2017) Resisting temptation: tracking how self–control conflicts are successfully resolved in real time. *Psychol. Sci.* 28, 1240–1258
51. Wojnowicz, M.T. *et al.* (2009) The self-organization of explicit attitudes. *Psychol. Sci.* 20, 1428–1435
52. Zbrodoff, N.J. and Logan, G.D. (1986) On the autonomy of mental processes: a case study of arithmetic. *J. Exp. Psychol. Gen.* 115, 118–130
53. Posner, M.I. and Snyder, C.R.R. (1975) Attention and cognitive control. In *Information Processing and Cognition: The Loyola Symposium* (Solso, R.L., ed.), pp. 55–85, Erlbaum
54. Neely, J.H. (1976) Semantic priming and retrieval from lexical memory: evidence for facilitatory and inhibitory processes. *Mem. Cogn.* 4, 648–654
55. Neely, J.H. (1977) Semantic priming and retrieval from lexical memory: roles of inhibitionless spreading activation and limited-capacity attention. *J. Exp. Psychol. Gen.* 106, 226–254
56. Shiffrin, R.M. and Schneider, W. (1977) Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychol. Rev.* 84, 127–190
57. Simon, H.A. (1990) Invariants of human behavior. *Annu. Rev. Psychol.* 41, 1–19
58. Banaji, M.R. and Greenwald, A.G. (2016) *Blindspot: Hidden Biases of Good People,* Random House

59. Greenwald, A.G. *et al.* (1998) Measuring individual differences in implicit cognition: the implicit association test. *J. Pers. Soc. Psychol.* 74, 1464–1480
60. Hyde, J.S. *et al.* (2008) Gender similarities characterize math performance. *Science* 321, 494–495
61. Voyer, D. and Voyer, S.D. (2014) Gender differences in scholastic achievement: a meta-analysis. *Psychol. Bull.* 140, 1174–1204
62. Bargh, J. (1984) *Automatic and Conscious Processing of Social Information. Handbook of Social Cognition.* 1–43
63. Fiske, S.T. (1989) Examining the role of intent: toward understanding its role in stereotyping and prejudice. In *Unintended Thought* (Uleman, J.S. and Bargh, J.A., eds), pp. 253–283, Guilford Press
64. Fazio, R.H. *et al.* (1995) Variability in automatic activation as an unobtrusive measure of racial attitudes: a bona fide pipeline? *J. Pers. Soc. Psychol.* 69, 1013–1027
65. Rudman, L.A. *et al.* (1999) Measuring the automatic components of prejudice: flexibility and generality of the Implicit Association Test. *Soc. Cogn.* 17, 437–465
66. Hahn, A. *et al.* (2014) Awareness of implicit attitudes. *J. Exp. Psychol. Gen.* 143, 1369–1392
67. Bargh, J.A. *et al.* (2005) Bypassing the will: demystifying the nonconscious control of social behavior. In *The New Unconscious* (Hassin, R.R., ed.), pp. 37–58, Oxford University Press
68. Hassin, R.R. (2013) Yes it can: on the functional abilities of the human unconscious. *Perspect. Psychol. Sci.* 8, 195–207
69. Mandelbaum, E. (2016) Attitude, inference, association: on the propositional structure of implicit bias. *Noûs* 50, 629–658
70. Dasgupta, N. and Asgari, S. (2004) Seeing is believing: exposure to counterstereotypic women leaders and its effect on the malleability of automatic gender stereotyping. *J. Exp. Soc. Psychol.* 40, 642–658
71. Logan, G.D. and Crump, M.J. (2010) Cognitive illusions of authorship reveal hierarchical error detection in skilled typists. *Science* 330, 683–686
72. Chomsky, N. (1959) A review of BF Skinner's verbal behavior. *Language* 35, 26–58
73. Reber, P.J. and Kotovsky, K. (1997) Implicit learning in problem solving: the role of working memory capacity. *J. Exp. Psychol. Gen.* 126, 178–203
74. Maier, N.R. (1931) Reasoning and learning. *Psychol. Rev.* 38, 332–346
75. Metcalfe, J. (1986) Premonitions of insight predict impending error. *J. Exp. Psychol. Learn. Mem. Cogn.* 12, 623–634
76. Metcalfe, J. (1986) Feeling of knowing in memory and problem solving. *J. Exp. Psychol. Learn. Mem. Cogn.* 12, 288–294
77. Hassin, R.R. *et al.* (2005) Non-conscious control and implicit working memory. In *The New Unconscious* (Hassin, R.R., ed.), pp. 196–225, Oxford University Press
78. Sklar, A.Y. *et al.* (2012) Reading and doing arithmetic nonconsciously. *Proc. Natl. Acad. Sci. U. S. A.* 109, 19614–19619
79. Ashcraft, M.H. and Krause, J.A. (2007) Working memory, math performance, and math anxiety. *Psychon. Bull. Rev.* 14, 243–248
80. Bargh, J.A. *et al.* (2001) The automated will: nonconscious activation and pursuit of behavioral goals. *J. Pers. Soc. Psychol.* 81, 1014–1027
81. Bargh, J.A. *et al.* (2010) Motivation. In *Handbook of Social Psychology* (5th edn) (Fiske, S.T., ed.), Wiley
82. Huang, J.Y. and Bargh, J.A. (2014) The selfish goal: autonomously operating motivational structures as the proximate cause of human judgment and behavior. *Behav. Brain Sci.* 37, 121–135
83. Marien, H. *et al.* (2012) Unconscious goal activation and the hijacking of the executive function. *J. Pers. Soc. Psychol.* 103, 399–415
84. Weingarten, E. *et al.* (2016) From primed concepts to action: a meta-analysis of the behavioral effects of incidentally presented words. *Psychol. Bull.* 142, 472–497
85. Conway, P. and Gawronski, B. (2013) Deontological and utilitarian inclinations in moral decision making: a process dissociation approach. *J. Pers. Soc. Psychol.* 104, 216–235
86. Greene, J.D. (2007) Why are VMPFC patients more utilitarian? A dual-process theory of moral judgment explains. *Trends Cogn. Sci.* 11, 322–323
87. Amit, E. and Greene, J.D. (2012) You see, the ends don't justify the means: visual imagery and moral judgment. *Psychol. Sci.* 23, 861–868
88. Gilbert, D.T. and Hixon, J.G. (1991) The trouble of thinking: activation and application of stereotypic beliefs. *J. Pers. Soc. Psychol.* 60, 509–517
89. Schneider, D. *et al.* (2012) Cognitive load disrupts implicit theory-of-mind processing. *Psychol. Sci.* 23, 842–847
90. Mattys, S.L. and Wiget, L. (2011) Effects of cognitive load on speech recognition. *J. Mem. Lang.* 65, 145–160
91. Van Dillen, L.F. *et al.* (2013) Turning a blind eye to temptation: how cognitive load can facilitate self-regulation. *J. Pers. Soc. Psychol.* 104, 427–443
92. Kim, S.Y. *et al.* (2005) Concurrent working memory load can reduce distraction. *Proc. Natl. Acad. Sci. U. S. A.* 102, 16524–16529
93. Deutsch, R. *et al.* (2009) Fast and fragile: a new look at the automaticity of negation processing. *Exp. Psychol.* 56, 434–446
94. Dudarev, V. and Hassin, R.R. (2016) Social task switching: on the automatic social engagement of executive functions. *Cognition* 146, 223–228
95. Herring, D.R. *et al.* (2013) On the automatic activation of attitudes: a quarter century of evaluative priming research. *Psychol. Bull.* 139, 1062–1089
96. Ferguson, M.J. and Bargh, J.A. (2004) Liking is for doing: the effects of goal pursuit on automatic evaluation. *J. Pers. Soc. Psychol.* 87, 557–572
97. Sherman, S.J. *et al.* (2003) Implicit and explicit attitudes toward cigarette smoking: the effects of context and motivation. *J. Soc. Clin. Psychol.* 22, 13–39
98. Tate, K. *et al.* (2014) Influencing green behaviour through environmental goal priming: the mediating role of automatic evaluation. *J. Environ. Psychol.* 38, 225–232
99. Fitzsimons, G.M. and Shah, J.Y. (2008) How goal instrumentality shapes relationship evaluations. *J. Pers. Soc. Psychol.* 95, 319–337
100. Ferguson, M.J. and Wojnowicz, M.T. (2011) The when and how of evaluative readiness: a social cognitive neuroscience perspective. *Soc. Pers. Psychol. Compass* 5, 1018–1038
101. Hommel, B. (1993) Inverting the Simon effect by intention. *Psychol. Res.* 55, 270–279
102. Hommel, B. *et al.* (2001) Codes and their vicissitudes. *Behav. Brain Sci.* 24, 910–926
103. Chartrand, T.L. and Lakin, J.L. (2013) The antecedents and consequences of human behavioral mimicry. *Annu. Rev. Psychol.* 64, 285–308
104. Aragón, O.R. *et al.* (2014) Modulations of mirroring activity by desire for social connection and relevance of movement. *Soc. Cogn. Affect. Neurosci.* 9, 1762–1769
105. Frederick, S. (2005) Cognitive reflection and decision making. *J. Econ. Perspect.* 19, 25–42
106. Mackay, D.G. (1973) Aspects of the theory of comprehension, memory and attention. *Q. J. Exp. Psychol.* 25, 22–40
107. Tversky, A. and Kahneman, D. (1973) Availability: a heuristic for judging frequency and probability. *Cogn. Psychol.* 5, 207–232
108. Payne, B.K. *et al.* (2016) Replicable effects of primes on human behavior. *J. Exp. Psychol. Gen.* 145, 1269–1279
109. Dovidio, J.F. *et al.* (2002) Implicit and explicit prejudice and interracial interaction. *J. Pers. Soc. Psychol.* 82, 62–68
110. Moss-Racusin, C.A. *et al.* (2012) Science faculty's subtle gender biases favor male students. *Proc. Natl. Acad. Sci. U. S. A.* 109, 16474–16479

111. Baddeley, A. (1996) The fractionation of working memory. *Proc. Natl. Acad. Sci. U. S. A.* 93, 13468–13472
112. Smith, E.E. *et al.* (1996) Dissociating verbal and spatial working memory using PET. *Cereb. Cortex* 6, 11–20
113. Kahneman, D. (2003) Maps of bounded rationality: psychology for behavioral economics. *Am. Econ. Rev.* 93, 1449–1475
114. Bargh, J.A. *et al.* (1996) The automatic evaluation effect: unconditional automatic attitude activation with a pronunciation task. *J. Exp. Soc. Psychol.* 32, 104–128
115. Logan, G.D. and Cowan, W.B. (1984) On the ability to inhibit thought and action: a theory of an act of control. *Psychol. Rev.* 91, 295–327
116. Payne, B.K. *et al.* (2005) An inkblot for attitudes: affect misattribution as implicit measurement. *J. Pers. Soc. Psychol.* 89, 277–293
117. LaBerge, D. and Samuels, S.J. (1974) Toward a theory of automatic information processing in reading. *Cogn. Psychol.* 6, 293–323
118. Stroop, J.R. (1935) Studies of interference in serial verbal reactions. *J. Exp. Psychol.* 18, 643–662
119. Sloman, S.A. (1996) The empirical case for two systems of reasoning. *Psychol. Bull.* 119, 3–22
120. Evans, J.S.B. (2008) Dual-processing accounts of reasoning, judgment, and social cognition. *Annu. Rev. Psychol.* 59, 255–278
121. Bargh, J.A. (2016) The devil made me do it. In *The Psychology of Good and Evil* (2nd edn) (Miller, A.G., ed.), Guilford
122. Bargh, J.A. and Barndollar, K. (1996) Automaticity in action: the unconscious as repository of chronic goals and motives. In *The Psychology of Action: Linking Cognition and Motivation to Behavior* (Gollwitzer, P.M. and Bargh, J.A., eds), pp. 457–481, Guilford Press
123. Epstein, S. (1994) Integration of the cognitive and the psychodynamic unconscious. *Am. Psychol.* 49, 709–724
124. Gibbard, A. (1990) *Wise Choices, Apt Feelings: A Theory of Normative Judgment,* Harvard University Press
125. Klein, G. (1998) *Sources of Power,* MIT Press
126. Mischel, W. *et al.* (1996) Principles of self-regulation: the nature of willpower and self-control. In *Social psychology: Handbook of basic principles* (Higgins, E.T. and Kruglanski, A.W., eds), pp. 329–360, Guilford Press
127. Morewedge, C.K. and Kahneman, D. (2010) Associative processes in intuitive judgment. *Trends Cogn. Sci.* 14, 435–440
128. Evans, J.S.B. and Stanovich, K.E. (2013) Dual-process theories of higher cognition: advancing the debate. *Perspect. Psychol. Sci.* 8, 223–241
129. Galla, B.M. and Duckworth, A.L. (2015) More than resisting temptation: beneficial habits mediate the relationship between self-control and positive life outcomes. *J. Pers. Soc. Psychol.* 109, 508–525
130. Wood, W. and Ruenger, D. (2016) Psychology of habits. *Annu. Rev. Psychol.* 37, 289–314
131. Fishbach, A. and Shen, L. *et al.* (2014) The explicit and implicit ways of overcoming temptation. In *Dual Process Theories of the Social Mind* (Sherman, J.W., ed.), pp. 454–467, Guilford Press
132. Milyavskaya, M. *et al.* (2015) Saying "no" to temptation: want-to motivation improves self-regulation by reducing temptation rather than by increasing self-control. *J. Pers. Soc. Psychol.* 109, 677–693
133. Wilson, T.D. and Schooler, J.W. (1991) Thinking too much: introspection can reduce the quality of preferences and decisions. *J. Pers. Soc. Psychol.* 60, 181–192
134. Schooler, J.W. and Engstler-Schooler, T.Y. (1990) Verbal overshadowing of visual memories: some things are better left unsaid. *Cogn. Psychol.* 22, 36–71
135. Wilson, T.D. *et al.* (1989) Introspection, attitude change, and attitude-behavior consistency: the disruptive effects of explaining why we feel the way we do. *Adv. Exp. Soc. Psychol.* 22, 287–343
136. Wilson, T.D. *et al.* (1993) Introspecting about reasons can reduce post-choice satisfaction. *Pers. Soc. Psychol. Bull.* 19, 331–339
137. Wegner, D.M. and Wheatley, T. (1999) Apparent mental causation: sources of the experience of will. *Am. Psychol.* 54, 480–492
138. Perruchet, P. (1985) A pitfall for the expectancy theory of human eyelid conditioning. *Integr. Physiol. Behav. Sci.* 20, 163–170
139. Beilock, S.L. and Carr, T.H. (2001) On the fragility of skilled performance: what governs choking under pressure? *J. Exp. Psychol. Gen.* 130, 701–725
140. Lewis, B.P. and Linder, D.E. (1997) Thinking about choking? Attentional processes and paradoxical performance. *Pers. Soc. Psychol. Bull.* 23, 937–944
141. Evans, J.S.B.T. and Over, D.E. (1996) *Rationality and Reasoning,* Psychology Press
142. Smith, E.R. and DeCoster, J. (2000) Dual-process models in social and cognitive psychology: conceptual integration and links to underlying memory systems. *Pers. Soc. Psychol. Rev.* 4, 108–131
143. Stanovich, K.E. and West, R.F. (2000) Individual differences in reasoning: Implications for the rationality debate? *Behav. Brain Sci.* 23, 645–665
144. Strack, F. and Deutsch, R. (2004) Reflective and impulsive determinants of social behavior. *Pers. Soc. Psychol. Rev.* 8, 220–247
145. Evans, J.S.B. and Stanovich, K.E. (2013) Dual-process theories of higher cognition: advancing the debate. *Perspect. Psychol. Sci.* 8, 223–241