non-autonomous Type 2 processing) and that theoretical claims should be tested empirically, this issue is nonetheless irrelevant to the central thesis that Melnikoff and Bargh set up and knock down: that some set of Type 1 and Type 2 features are aligned and that this is a central premise of the two-types framework. This is not a necessary requirement of DPT (which could be based on a single dichotomy); the authors do not substantiate their typology claim with regard to any specific examples, and they ignore recent research that has directly refuted this list-of-features view. They thus present their arguments as addressing the foundation of DPT when in fact is it largely irrelevant to current investigations of the theory (see [3]).

In 2013, Evans and Stanovich argued that 'in general, these critiques (of DPT) are problematic because they attack not any particular theory but rather a class of theories, effectively treating all dual-process and dual-system theories alike' (p. 224). This is true of Melnikoff and Bargh, who not only attack a class of theories instead of any specific DPT, but aim their critique at a set of assumptions that contemporary theorists have explicitly refuted.

[1]Department of Psychology, Yale University, New Haven, CT, USA
[2]LaPsyDe (CNRS Unit 8240), Paris Descartes University, Paris, France
[3]School of Psychology, University of Plymouth, Plymouth, UK
[4]Department of Applied Psychology and Human Development, University of Toronto, Toronto, ON, Canada
[5]Department of Psychology, University of Saskatchewan, Saskatoon, SK, Canada

*Correspondence:
gordon.pennycook@yale.edu (G. Pennycook).

https://doi.org/10.1016/j.tics.2018.04.008

References
1. Melnikoff, D.E. and Bargh, J.A. (2018) The mythical number two. *Trends Cogn. Sci.* 22, 280–293
2. Bago, B. and De Neys, W. (2017) Fast logic? Examining the time course assumption of dual process theory. *Cognition* 158, 90–109
3. *Dual Process Theory 2.0.* De Neys, W., ed.), 2017. Routledge
4. Evans, J.S.B.T. and Stanovich, K.E. (2013) Dual-process theories of higher cognition: advancing the debate. *Perspect. Psychol. Sci.* 8, 223–241
5. Newman, I.R. *et al.* (2017) Rule-based reasoning is fast and belief-based reasoning can be slow: challenging current explanations of belief-bias and base-rate neglect. *J. Exp. Psychol. Learn. Mem. Cogn.* 43, 1154–1170
6. Pennycook, G. *et al.* (2015) What makes us think? A three-stage dual-process model of analytic engagement. *Cogn. Psychol.* 80, 34–72
7. Stanovich, K.E. and Toplak, M.E. (2012) Defining features versus incidental correlates of Type 1 and Type 2 processing. *Mind Soc.* 11, 3–13
8. Stanovich, K.E. *et al.* (2011) The complexity of developmental predictions from dual process models. *Dev. Rev.* 31, 103–118
9. Evans, J. (2012) Dual process theories of deductive reasoning: facts and fallacies. In *The Oxford Handbook of Thinking and Reasoning* (Holyoak, K.J. and Morrison, R.G., eds), pp. 115–133, Oxford University Press
10. Morewedge, C.K. and Kahneman, D. (2010) Associative processes in intuitive judgment. *Trends Cogn. Sci.* 14, 435–440
11. Pennycook, G. (2017) A perspective on the theoretical foundation of dual-process models. In *Dual Process Theory 2.0* (De Neys, W., ed.), pp. 5–39, Routledge
12. Thompson, V.A. (2013) Why it matters: the implications of autonomous processes for dual process theories – commentary on Evans & Stanovich. *Perspect. Psychol. Sci.* 8, 253–256

Letter

The Insidious Number Two

David E. Melnikoff[1],* and John A. Bargh[1]

We recently joined other researchers [1–5] in challenging the popular assumption that 'consciousness', 'efficiency', 'intentionality', and 'controllability' are correlated such that they form two clusters – those typically called 'Type 1' and 'Type 2', which we refer to collectively as the dual-process typology. More specifically, we argued that (i) these processing features have never been shown to correlate with one another, (ii) there are good reasons to assume that the features are, in fact, completely uncorrelated, and (iii) the features are incoherent, therefore (iv) the dual-process typology should be abandoned [6].

In their commentary, Pennycook, De Neys, Evans, Stanovich, and Thompson (hereafter, PDES&T) seem to agree that cognitive scientists should not assume that processing features are correlated [13]. They say we went awry, however, because the dual-process typology is 'outdated'. For instance, PDES&T state that Evans and Stanovich (the third and fourth authors of PDES&T) 'explicitly argued against assuming an alignment of the numerous characteristics that have been assigned to so-called "Type 1" and "Type 2" processes . . . '. PDES&T also state that, in their opinion, featural alignment 'is not a necessary requirement of dual-process theory'. The sole requirement for dual-process theory, they believe, is the existence of one dichotomous feature – this 'defining feature', as they call it, need not correlate with anything for dual-process theory to be valid.

We wish to make two points. First, to our knowledge, hardly any dual-process advocates agree with PDES&T that the alignment assumption is outdated and unnecessary for dual-process theory (and for good reason; see Box 1). In fact, PDES&T provide no evidence that these

---

Box 1. A Dual-Process Theory without Correlated Features Is Not a Theory

PDES&T never explain how a theory could possibly consist of a single 'defining feature' if the 'defining feature' is not correlated with any other features. Theories must generate predictions [12], and it is unclear how any predictions can be derived from a 'defining feature' that is not correlated with anything. Indeed, PDES&T insist that the 'defining feature' of a dual-process theory need not correlate with effort, speed, controllability, intentionality, awareness, erroneous responding, or any other feature that has been associated with Type 1 and Type 2 processing – as far as we can see, such a dual-process 'theory' would be incapable of making a single prediction. Thus, it seems to us that when PDES&T say that zero degree of featural alignment is required for dual-process theory, they are saying something deeply incoherent – that is, they are saying that dual-process theory need not make predictions.

views are held by anyone but them, and they acknowledge that researchers, public policy experts, and some dual-process theorists ' . . . assume an alignment or correlation between various features.' At worst, then, we critiqued a set of assumptions that are held by most, but not all.

Second, it is interesting to note that the correlation assumption tends to seep into PDES&T's writing, despite the fact that PDES&T reject it and consider it irrelevant to the central premise of dual-process theory. For example, the following statement appears in the 2013 article by Evans and Stanovich [7] – the article in which they are said to have ' . . . argued against assuming an alignment of the numerous characteristics that have been assigned to so-called "Type 1" and "Type 2" processes . . . ':

> . . . the defining characteristic of Type 1 processes is their autonomy. They . . . make minimal demands on working memory resources . . . the execution of Type 1 processes is mandatory when their triggering stimuli are encountered and they are not dependent on input from high-level control systems. Autonomous processes have other correlated features—their execution tends to be rapid, they do not put a heavy load on central processing capacity, they tend to be associative . . . (p. 236).

Later, Evans and Stanovich [8] state that 'there are good theoretical reasons for some features to be correlated' (p. 265) – this quote appears under the subheading: 'Why some features are imperfectly correlated: The example of normative responding'. The next year, Stanovich et al. [9] wrote this:

> Type 2 processing enables us to solve a wide range of novel problems, and solve them with great accuracy. However, this power comes with a cost. Type 2 processing takes up a great deal of attention, tends to be slow, tends to interfere with other thoughts and actions that we are carrying out, and requires great concentration that is often experienced as aversive. In

contrast, Type 1 processes are low in computational power but have the advantage that they are low in cost. These mechanisms cannot solve a wide range of problems and do not permit fine-grained accuracy, but they are fast acting, do not interfere with other ongoing cognition, require little concentration, and are not experienced as aversive. (p. 148).

Pennycook [10], the lead author of PDES&T, wrote the following in 2015:

> Human reasoning and decision-making is thought to involve two distinct types of processes . . . : Type 1 processes that are intuitive, fast, autonomous, and high capacity; and Type 2 processes that are reflective, slow, and resource demanding. Type 1 processes are thought to provide default outputs that may be acted upon as explicit representations manipulated in working memory via Type 2 processing.

De Neys [11], the second author of PDES&T, wrote the following in 2017:

> Type 1 processing is fast, autonomous, does not require working memory, operates unconsciously and immediately triggers an answer. Type 2 processing puts a heavy load on working memory, operates consciously, controlled and relatively slow.

Apparently, the dual-process typology is quite insidious! PDES&T continue in practice to perpetuate the typology's assumption of correlated processing features – while at the same time explicitly rejecting it here as 'largely irrelevant to current investigations of [dual-process] theory'. Moreover, PDES&T did not take issue with the central content of our critique, instead making only the irrelevant (and tenuous) claim that our critique does not apply to their personal views. This leaves our original conclusion still standing: the dual-process typology should be abandoned.

[1]Department of Psychology, Yale University, 2 Hillhouse Avenue, New Haven, CT 06511, USA

*Correspondence:
david.melnikoff@yale.edu (D.E. Melnikoff).

References

1. 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
2. Moors, A. (2014) Examining the mapping problem in dual process models. In *Dual-Process Theories of the Social Mind* (Sherman, J.W. *et al.*, eds), pp. 20–34, Guilford Press
3. Moors, A. (2016) Automaticity: componential, causal, and mechanistic explanations. *Annu. Rev. Psychol.* 67, 263–287
4. Moors, A. and De Houwer, J. (2006) Automaticity: a theoretical and conceptual analysis. *Psychol. Bull.* 132, 297–326
5. Moors, A. and De Houwer, J. (2006) Problems with dividing the realm of processes. *Psychol. Inq.* 17, 199–204
6. Melnikoff, D.E. and Bargh, J.A. (2018) The mythical number two. *Trends Cogn. Sci.* 22, 280–293
7. Evans, J.S.B.T. and Stanovich, K.E. (2013) Dual-process theories of higher cognition: advancing the debate. *Perspect. Psychol. Sci.* 8, 223–241
8. Evans, J.S.B. and Stanovich, K.E. (2013) Theory and metatheory in the study of dual processing: reply to comments. *Perspect. Psychol. Sci.* 8, 263–271
9. Toplak, M.E. *et al.* (2014) Assessing miserly information processing: an expansion of the Cognitive Reflection Test. *Think. Reason.* 20, 147–168
10. Pennycook, G. *et al.* (2015) What makes us think? A three-stage dual-process model of analytic engagement. *Cogn. Psychol.* 80, 34–72
11. Bago, B. and De Neys, W. (2017) Fast logic?: Examining the time course assumption of dual process theory. *Cognition* 158, 90–109
12. Wacker, J.G. (1998) A definition of theory: research guidelines for different theory-building research methods in operations management. *J. Oper. Manage.* 16, 361–385
13. Pennycook, G. *et al.* (in press) The mythical dual-process typology. *Trends Cogn. Sci.*

Spotlight

With Great Data Comes Great (Theoretical) Opportunity

Michael C. Frank[1],*,@

Is there a 'critical period' for language? Using a viral online grammar test, Hartshorne, Tenenbaum, and Pinker (2018) collected a new massive dataset on the relationship between age and language learning. Their data highlight both the importance – and the challenges – of creating quantitative