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What happened to the "new paradigm"? A commentary on Knauff and Gazzo Castañeda (2022)

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ABSTRACT

Knauff and Gazzo Castañeda (this issue) critique the "new paradigm" – a framework that replaces logic with probabilities – on the grounds that there existed no "old" paradigm for it to supplant. Their position is supported by the large numbers of theories that theorists developed to explain the Wason selection task, syllogisms, and other tasks. We propose some measures to inhibit such facile theorizing, which threatens the viability of cognitive science. We show that robust results exist contrary to the new paradigm, and that it is unable to account for other results.

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Long ago, one of us (J-L) had an office on the opposite side of the corridor to Tom Kuhn's. He was already famous for *The Structure of Scientific Revolutions*, but very approachable. He had also published a profound essay on thought experiments, most appropriate for a book of readings on cognitive science (Kuhn, 1977). As this essay showed, he was interested in cognition, and we had many discussions, in particular about whether people could judge two entities as similar in a holistic way without decomposing them into their attributes. His basic ideas about science were convincing. As he argued, there were periods of normal science punctuated with revolutions in which the dominant paradigm was overturned by a new one. It did so when the new paradigm accounted for replicable observations that the old paradigm did not. Quite what constituted a "paradigm" he never did quite say. He followed the wise

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philosophical maxim: never try to define the necessary and sufficient conditions for anything. A tribute to this maneuver hung on the living-room wall in his house: "God bless our paradigm."

These thoughts were prompted by Knauff and Gazzo Castañeda's (this issue) stimulating critique of the new paradigm in studies of reasoning. In a brilliant coup, its proponents named it themselves as, "the new paradigm". No-one had ever done that before. Their proposal to replace standard logic with the probability calculus was also new. And because it blossomed into various distinct points of view, it might well count as a paradigm rather than as a particular theory. Knauff and Gazzo Castañeda, however, make a convincing case that it isn't clear what counts as an instance of this new paradigm: its proponents' views are perhaps too divergent (see Table 2 in their paper). Knauff and Castañeda also show that there was no single old paradigm for reasoning before the new one arrived. They end with a generous exhortation for future collaboration.

Collaborations among theoretical adversaries are seldom fruitful. Neither side likes to give up ideas. Indeed, in cognitive science, it is harder to get rid of an old theory than to devise a new one. As a consequence, various well-known inferential tasks have surprising numbers of distinct theories: 16 for Wason's (1968) selection task (see Ragni et al., 2018); 12 for syllogistic reasoning (see Khemlani & Johnson-Laird, 2021), and an even larger number, yet to be counted, for the paradoxes of disjunctive reasoning (see Johnson-Laird et al., 2021). Knauff and Gazzo Castañeda are right: no dominant paradigm existed for the new one to supplant. That a single experimental task can inspire a multiplicity of theories is the scandal of cognitive science. They threaten its viability. They were one of the motivations for the development of architectural accounts of the human mind (e.g., Anderson, 2014; Newell, 1990), but these accounts run into the difficulty that it is too easy for them to have the power of Universal Turing machines, which in principle can compute the values of any computable function. So, what can cognitive scientists do to make theorizing about reasoning harder, and eliminating theories about it easier?

One way to impede facile theorizing is to require that new theories account for both the function that the brain computes and the algorithm that it relies on. The new paradigm lacks algorithms, e.g., it says nothing about the processes of sentential or syllogistic reasoning (see Oaksford & Chater, 2007). Yet, if a theory proposes only a function that the brain is supposed to compute, the function may not be computable — there is no simple test for computability — or it may have only an intractable algorithm. Consider Ramsey's test for fixing a person's belief in a conditional, which as Knauff and Castañeda note, some new paradigmers advocate. Its description begins: "If two people are arguing 'If *p*, then *q*?' and are both in doubt

Table 1. Six empirical results contrary to the new paradigm: their domains, the results, and relevant references.

Domains	Results contrary to the new paradigm	Relevant references
1. Probabilities of conjunctions and disjunctions are subadditive	Estimates of p(A), p(B), p(A&B), and of p(A), p(B), p(AorB), yield joint distributions summing to over 100%.	Khemlani et al. (2012) Khemlani et al. (2015)
2. Probabilities of joint distributions are subadditive	Estimates of joint distributions for disjunctions and conditionals sum to over 100%.	Hinterecker et al. (2016) Byrne and Johnson-Laird (2019)
3. Effect of "probably" on inferences	People make different inferences from conditionals with & without "probably".	Goodwin (2014)
4. Inferences of free choice permission and other *or*-deletions	People accept certain predictable inferences of the sort: *A or B*; ∴ *A*.	Johnson-Laird et al. (2021)
5. Meta-analysis of Wason's selection task.	People select potential counterexamples in certain cases.	Ragni et al. (2018)
6. Meta-analysis of syllogistic inferences.	Reasoners' conclusions fail to fit the new paradigm theory.	Khemlani and Johnson-Laird (2022)

as to *p*, they are adding *p* hypothetically to their stock of knowledge and arguing on that basis about *q* …" (Ramsey 1929/1990, p. 155). So, they each need to determine whether *p* is consistent with their knowledge. And this problem is computationally intractable (Cook, 1971)—a state that new paradigmers once inveighed against (e.g., Oaksford & Chater, 1995). Our ecumenical appeal is therefore for at least one theory in the new paradigm to explain mental processes, and to be implemented in a working computational model.

One way to eliminate superfluous theories is to keep track of whether they account for results in their domains. Table 1 shows six robust results contrary to the new paradigm. Table 2 shows 15 robust results for which it makes no predictions. And, at least one domain has no possibility of explanation in the new paradigm. It cannot predict the "paradoxes" of free choice permissions. Suppose, for instance, a museum attendant tells you:

You can enter now or you can enter later.

This speech act creates a permission, and you are entitled to infer:

So, I can enter now.

Your inference is invalid in any normal logic based on a truth-functional semantics for "or" (see Kamp, 1974). The attendant's speech act is rooted in deontic possibilities, and they cannot be expressed as probabilities

Table 2. Fifteen empirical results for which the new paradigm offers no explanations: their domains, the results, and relevant references.

Domains	Results the new paradigm needs to explain	Relevant references
1. Spatial & temporal relations	Inferences from premises referring to more than one layout or order are difficult.	Ragni and Knauff (2013) Schaeken and Johnson-Laird (2000) Kelly et al. (2020)
2. Causal relations	People distinguish *causes* from *enables*. One or two counterexamples refute *causes*.	Frosch and Johnson-Laird (2011) Khemlani et al. (2014)
3. Pseudo-transitivity	Relational premises can yield illusory transitivity.	Goodwin and Johnson-Laird (2008)
4. Strategies	Individuals create strategies based on possibilities.	Van der Henst et al. (2002)
5. Counterfactuals	Some inferences are easier from counterfactuals.	Byrne (2005)
6. Factual and counterfactual assertions	Their meanings run in parallel for *if* and *or*.	Espino et al. (2020)
7. Negation	Denials of *or* are easier to understand than those of *and*.	Khemlani et al. (2014)
8. Reasoning about possibilities	Conditionals and disjunctions imply possibilities.	Barrouillet et al. (2000) Hinterecker et al. (2016)
9. Consistency of sets of compound assertions	Predictable intuitive but illusory assessments.	Khemlani and Johnson-Laird (2021)
10. Judgments of analytic truth	Certain assertions judged true a priori.	Quelhas et al. (2017, 2019)
11. Probabilities of conditionals	Erroneous estimates occur, equivalent to p(A&B).	Lopéz-Astorga et al. (2021)
12. Inferences from premises about possibilities	Acceptable inferences differ from those in normal modal logics.	Johnson-Laird & Ragni (2019) Ragni & Johnson-Laird (2020a)
13. Inferences from individual quantifiers	Fit data from individual reasoners.	Khemlani and Johnson-Laird (2021)
14. Inferences from multiple quantifiers	Difficulty of iterative use of premises.	Cherubini and Johnson-Laird (2004)
15. Inferences from algorithms	Complexity of an algorithm predicts difficulty.	Khemlani et al. (2013) Bucciarelli et al. (2016)

(Johnson-Laird & Ragni, 2019). To try to interpret the attendant's speech act as:

P(entering now or entering later) $>$ 0%

is to miss the point of permissions. To smuggle into an interpretation "can" or "may" is to acknowledge the indispensability of deontic possibilities. They assert nothing about the probabilities of permitted actions. You may never enter the museum, but that abnegation is to refuse to act on the permission, not to deny it. For Kuhn, a new paradigm predicts all the real phenomena that the old paradigm predicts, and also something new that replicable observations corroborate. As far as we can tell, no robust results exist that all and only theories in the new paradigm explain; and plenty of

phenomena refute its predictions or go beyond its explanatory scope (see Tables 1 and 2). It may be able to accommodate the latter phenomena, but it does not predict them. And, as Bayesians acknowledge, predictions count for more than accommodations (see Howson & Urbach, 1993, p. 411).

A major inspiration for the new paradigm was Oaksford and Chater (1994) probabilistic proposal about Wason's (1968) selection task. They proposed that participants' failure to select potential counterexamples to a hypothesis has a rational explanation based on probabilistic considerations. The idea was thrilling, brilliant, and revolutionary. After much work, and testing the equivalent of a small town's population (over 14,000 participants) in experiments, cognitive scientists now know that the idea was wrong. In the original selection task, people had just one chance to select evidence to test an abstract hypothesis, and so their choices tended to match their intuitive representation of an example of the hypothesis. However, changes to the contents of the hypothesis, or to the framing of the task, elicited correct selections from the participants. And they soon realized the relevance of potential counterexamples even to abstract hypotheses when they had to make repeated selections either of them or of potential examples. This history can be found elsewhere (Ragni et al., 2018; Ragni & Johnson-Laird, 2020b). It is a microcosm of the new paradigm: an exciting idea launches many experiments that end in its demise. Some evidence refutes the new paradigm's predictions, some evidence is outside its explanatory scope, and the evidence that supports it has alternative explanations. People do reason from uncertain premises, but no good grounds exist for the probability calculus to be the underlying paradigm for everyday reasoning.

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