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Editorial: **Exploratory Reports: a new article type for *Cortex*.**

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Exploratory Reports: a new article type for *Cortex*.

There are many ways to find things out; but, in science, the process of discovery can be divided conceptually into exploratory and confirmatory phases. In the exploratory phase, we observe and explore, generating theories to explain the patterns that we find. Useful theories will support predictions about what we should and should not find in the future if that theory is true. We are then in a position to collect new data, by targeted observation or controlled experiment, confirming or challenging our predictions through critical tests, and revising our theories in light of the outcomes. We may also explore these new data for unanticipated patterns, updating our ideas in an iterative cycle of (inductive) exploration and (deductive) confirmation.

Exploratory and confirmatory approaches are complementary, but when we seek to share our work through publication, they are rarely weighed as equal. At most empirical journals (not just those with ‘Experimental’ in their name), the confirmatory approach has special status as the proper mode of science. This preference is pervasive: funding agencies and ethics committees demand that we show clear hypotheses, as an assurance that something might come from the money and the effort; and we learn and we teach that an empirical report has an ordered *Introduction*, building up to a statement of the hypotheses that the study is designed to test. Exploratory work, which does not fit this template, may be dismissed as ‘*insufficiently hypothesis-driven*’ - the death sentence for many a hopeful submission.

This idealisation of the confirmatory mode creates pressure for published research to conform neatly to the template, even though the reality may be more messy or complex. A preference for positive findings, combined with the expectation that the main results should be predicted *a priori*, incentivise some ‘questionable’ practices that, whether engaged in consciously or not, seriously distort the scientific record (John, Loewenstein, & Prelec, 2012). High on this list are: p-hacking, whereby analytic flexibility is exploited to probe the data for p-values below the threshold for significance, the fruits of this exploration being reported as if from a planned analysis (Simmons, Nelson, & Simonsohn, 2011; Ware & Munafò, 2015); and HARKing (Hypothesising After Results are Known; Kerr, 1998), whereby hypotheses suggested by the data are presented as if formulated in advance. The pressure to conform is not only implicit. Some of us may have had well-intentioned advice from editors or reviewers, that we should rethink our introductory rationale to make our paper stronger; and some of us must, at other times, have been that editor or reviewer.

Questionable research practices, their causes and consequences, are now widely recognised, and many competent discussions exist (e.g. Ioannidis, 2005). Constructive solutions have also been proposed, and efforts to reform the conduct and publishing of science are gaining traction, especially in Psychology and Neuroscience where the problems have been most acutely apparent (Chambers, 2017; Nosek, Alter, Banks, & Borsboom, 2015; OpenScienceCollaboration, 2012). *Cortex* was at the forefront of this movement, as one of the first journals to offer *Registered Reports*, an empirical format that focuses reviewer scrutiny on the importance of the scientific question, and the rigour and power of the methods, before the first data point is collected (Chambers, 2013; Chambers, Dienes, McIntosh, Rotshtein, & Willmes, 2015). Publication is guaranteed, regardless of outcome, provided that the agreed plan is followed. Beyond the benefits that accrue from the discipline of detailed forethought, this locking-in of the study plan makes it impossible to present later analysis choices or theoretical insights as having happened in advance, eliminating any scope for p-hacking or HARKing.

Pre-registration does not preclude additional exploration, or discussion of serendipitous findings, it just requires these to be clearly distinct from the pre-registered parts. This assurance of clarity about which elements of the work were planned in advance is the reason that pre-registration is a key recommendation for transparency and openness in science (Nosek et al., 2015; <https://cos.io/top>). Along with many other journals (> 2900 at the last count), *Cortex* is a signatory to the Transparency and Openness Promotion (TOP) Guidelines, and will in due course be awarding up to three Open Practices badges per paper to certify compliance with modular standards in the areas of data sharing, materials sharing, and pre-registration (<https://osf.io/tvyxz/>). By enhancing the perceived value of the published work, these badges are designed to incentivise the wider adoption of open practices, and the early indications are that these badges are effective (Kidwell et al., 2016).

So far, so good, but these measures may also have pitfalls. If pre-registered studies are the preferred sort of science, with a special badge of honour, then studies that do not fit this mould may be relatively devalued. *Registered Reports* (and, to a lesser extent, online self-registrations) are tightly constrained and resource intensive. Our experience at *Cortex* suggests that the format is best matched to mature research questions, or direct replications, where theories and methods are well-developed, where prior studies or pilot data can inform the effect sizes of interest, and where predictions can be correspondingly precise. It is, in effect, a purified and certified format for mature confirmatory research; it would be possible

in principle to pre-register an exploratory study, but it could be self-defeatingly complex and restrictive in practice. If the misaligned incentives in contemporary science stem, even partially, from an idealisation of the confirmatory mode, then we should be wary of intensifying this idealisation by holding up pre-registered studies as the most worthy kind of empirical paper.

A good deal of exploratory groundwork precedes any research programme mature enough to frame a well-powered confirmatory test. The truth value sought by the latter is built on the generative value of the former, and the critical testing of ideas is not inherently more valuable than the generation of candidate ideas to test. Nor would it be productive to publish only targeted tests of hypotheses, leaving the generative work unshared, behind the scenes. Naturally, different rules apply for interpreting findings from different modes of study, and different strengths of conclusion may be warranted. But major problems arise only when we fail to distinguish these modes, and exploratory work is forced into a confirmatory framework to create an artificially-neat empirical story, with the impactful conclusions that our journals seem to require: ‘*shoehorning Thomas Kuhn into Karl Popper*’, as Chambers (2017) has so vividly put it.

Transparency about the processes by which data have been gathered and analysed is therefore essential; and formal pre-registration provides one form of transparency. A complementary strategy could be for journals to combat the perceived pre-eminence of confirmatory research, by better-serving more exploratory studies, in which the research question may be relatively open-ended, and data exploration and hypothesis generation take precedence over hypothesis-testing. An explicit valuing of such work would have the benefit of reducing the incentive for anyone to repackage it as more tightly targeted. A paper that is *openly* exploratory, which shows its working and shares its data, is as transparent in its own way as a confirmatory study that has been pre-registered. One could even envisage an Open Practices badge for openly exploratory studies; this would remind us that there is more than one way to do open science, and that these badges are descriptors of particular processes, not a points-tally of worth.

A new article type

In this spirit, *Cortex* is launching a new empirical article type, *Exploratory Reports*. The aim is to support and promote more open-ended, open science, providing a high-status specialised

format for its publication, with an editorial process attuned to exploratory approaches. We therefore invite authors to submit their exploratory work to this section of the journal. There is no obligation to do so: many studies have confirmatory and exploratory components, and would be more appropriately considered as a standard Research Report, and even wholly exploratory studies may still be submitted as standard research reports if the authors prefer. However, we hope that authors will instead prefer to submit such work to this new format, more specifically tailored to the research approach. We have produced a corresponding set of guidelines, to help authors decide whether their work fits the category, and how best to prepare it for submission.

What is the essence of these guidelines? The importance and interest of the research question, the rigour of methods and analysis, the value of the data, and the novelty and quality of theory, are paramount. The overall bar for publication will be as high as ever, but different aspects of the work may be weighted more heavily than others, depending on the nature of the work. If the research question is open-ended, and the results provisional, then the discussion should be outstanding in its theoretical analysis and generation of novel testable predictions. Or, where an empirically-grounded conclusion is advanced, then the evidence should be *more* compelling than usual, given the likelihood of finding shallow patterns in any substantial dataset. Compelling evidence is not satisfied merely by small p-values. Indeed, conventional significance testing is arguably meaningless in the exploratory mode, and we would welcome submissions with no p values at all. Instead, we urge authors to show their data as fully as possible, using visualisation to allow the reader into the detail of the dataset (Tukey, 1970), and parameter estimation to aid confirmatory follow-ups (Cumming, 2014). Because this article type aims for high transparency, we require authors to upload their data at the point of submission, and to share it freely on publication (those who are unable or unwilling to share their data are politely directed to a different article type).

The candidate studies for this publishing pipeline could be diverse. Data-mining approaches would be one obvious match, perhaps exploring patterns of association and dissociation of neuropsychological symptoms, or correlates of cognition in imaging data from normal or damaged brains. Neuro-computational modelling studies might also yield large and complex datasets, well-suited to an exploratory approach (e.g. Pulvermüller & Garagnani, 2014). Some submissions might be of high value primarily because the data are of special rarity or potential use to others; for instance, a substantive database of clinical records from an uncommon neuropsychological condition. Experimental studies with very open

hypotheses would also be suited to this format, allowing researchers to declare their exploratory intentions clearly at the outset. There might even be a class of paper that tells the ‘true story’ of an experiment in which the major finding was unanticipated by the hypotheses. Hypothesising after the results are known is central to the progress of science; it only becomes HARKing when the timeline is fudged to give a false history (Kerr, 1998). But exploration is a positive approach to discovery, not a strategy to salvage weak experiments, to offload random data, or to publish pilot work where follow-up studies would be a better option. The rationale must be convincing, the rigour evident, and the generative value high.

The article category is new, but this is not a wholly novel departure. *Cortex* has always published papers that take exploratory approaches to the study of brain and behaviour. For recent examples, one need only look at the first five research reports published in 2017 (Doidge, Evans, Herron, & Wilding, 2017; Dzieciol et al., 2017; Grossi et al., 2017; Leyton, Hodges, Piguet, & Ballard, 2017; Wehrle, Latal, O’Gorman, Hagmann, & Huber, 2017), or any of the ‘ultra-brief’ Clinical Postcards (Beschlin, de Bruin, & Della Sala, 2016; Jacquin-Courtois, Christophe, Chabanat, Reilly, & Rossetti, 2017; Nascimento Alves et al., 2016; Warren et al., 2016; White & Aimola Davies, 2017). So, one may very well ask, if *Cortex* publishes so much exploratory work already, why do we need a new article type?

The major driver is transparency, for researchers, reviewers and for readers. Specific author guidelines make it clear that exploratory work does not have to mimic the conventions of hypothesis-testing in order to get published, but can focus more broadly on pattern-finding, parameter estimation, and hypothesis generation. Specific reviewer guidelines make it clear that the criteria for evaluating such work are not identical with those for confirmatory studies, and that a perfect empirical story is not expected, provided that the methodological rigour, quality of data presentation, and theoretical interest are high. A specific article type also makes it clear to readers that the evidence and ideas were generated in an exploratory mode, and should be interpreted in this context. Finally, this new article type makes a public statement that exploratory research is not only published at *Cortex*, but is highly esteemed as being central to scientific discovery. Of course, this new article type is itself something of an open-ended experiment. Its success will depend upon the willingness of researchers to engage with the format, and ultimately upon the value that it offers to the field. There are many ways to find things out, especially in territory as uncharted as brain and behaviour. At *Cortex*, we look forward to publishing your *Exploratory Reports*.

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