Pre-registration in the undergraduate dissertation: A critical discussion

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Over recent years, psychology has become increasingly concerned with reproducibility and replicability of research findings (Munafò et al., 2017). One method of ensuring that research is hypothesis driven, as opposed to data driven, is the process of publicly pre-registering a study's hypotheses, data analysis plan, and procedure prior to data collection (Nosek et al., 2018). This paper discusses the potential benefits of introducing pre-registration to the undergraduate dissertation. The utility of pre-registration as a pedagogic practice within dissertation supervision is also critically appraised, with reference to open science literature. Here, it is proposed that encouraging pre-registration of undergraduate dissertation work may alleviate some pedagogic challenges, such as statistics anxiety, questionable research practices, and research clarity and structure. Perceived barriers, such as time and resource constraints, are also discussed.
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IN 2015, a taskforce of psychological scientists from labs across the world set out to replicate 100 of psychology's most influential experiments. Of the 100 experimental and correlational studies replicated, only 36 per cent obtained statistically significant results, compared with 97 per cent in the original reports (Open Science Collaboration, 2015). This has since sparked a discipline-wide discussion of the reproducibility and replicability of psychological findings (Munafò et al., 2017), which has called into question the trustworthiness of reported findings in psychological science. Since this landmark work, researchers have identified threats to open and trustworthy science, including questionable research practices such as the manipulation of data to obtain a significant result (i.e. 'p-hacking'; Simmons et al., 2011), changing hypotheses in response to data results (i.e. Hypothesising After Results are Known or 'HARK'ing), and selective reporting of results to fit a predefined research narrative (Chan & Altman, 2005). Some have indicated that the prevalence of these questionable research practices is surprisingly high in psychological research (e.g. John et al., 2012).

In response to this, innovative methods to combat poor reproducibility and questionable research practice within psychological research have been proposed. These have included the endorsement of open access data and research protocols (e.g. through Open Science 'badges'; Eich, 2014), sharing of data analysis scripts (e.g. through the Open Science Framework; OSF), and explicitly stating hypotheses prior to data collection via a publicly available pre-registration (Nosek et al., 2018).

Pre-registration (on online servers such as the OSF or AsPredicted) allows researchers to outline their theory-driven hypotheses, aims, and data analysis plan before data collection has begun, which reduces the pervasive effects of confirmation bias and selective reporting (e.g. Nuzzo, 2015). Pre-registration can be beneficial to researchers in a number of ways (Wagenmakers & Dutilh, 2016). Clearly outlining hypotheses makes the relationship between literature, hypotheses, and results more linear (Moore, 2016), reducing publication bias (or the 'file drawer problem'; van't Veer & Giner-Sorolla, 2016), which can improve research transparency (LeBel & Peters, 2011). Pre-registration encourages research which is explicitly grounded in theory and driven by well defined, well powered, operationalised hypotheses (Chambers, 2014). The

benefits of pre-registration to researchers may be clear, however, the utility of pre-registration as an undergraduate academic exercise during the final-year dissertation is yet to be fully explored.

Pre-registration as pedagogic practice

Currently, whilst 'Conceptual and Historical Issues in Psychology' and Research Skills both form a core part of the British Psychological Society standards for degree programme accreditation, the teaching of Open Science practices in undergraduate psychology curricula is not explicitly mandated by the BPS (British Psychological Society, 2019). Therefore, many undergraduates will likely not have had practical engagement with the issues of reproducibility, replication, and Open Science principles before they commence their first major independent empirical work, in the final year of their degree programme. There are notable exceptions to this, including psychology departments that actively and enthusiastically embed practical engagement with reproducible research practices into the curriculum (e.g. PsyTeachR, 2020; Ball et al., 2020; Lynott, 2019), this is by no means the current status quo. Final-year undergraduate dissertations thus pose a unique site of opportunity for psychology educators.

Dissertations are typically substantial, independent bodies of work, which are designed and conducted in relation to previous peer-reviewed literature. In light of recent concerns about questionable research practice and data distortion in the literature, supervision of undergraduate empirical work should reflect gold-standard research integrity and openness. The standards and practices communicated to undergraduates during this research experience, through both direct supervision and research skills teaching, should reflect the state of scientific integrity more broadly in the field. As Krishna and Peter (2018) explain, undergraduate dissertations are the 'ultimate expression of the standards of scientific rigor that students learn and internalize over the period of their courses' (p.3). Therefore, this process is a useful opportunity for learning.

However, despite an emerging body of literature discussing how supervisors can best scaffold the independent learning of dissertation students (e.g. Wisker, 2012), some pervasive pedagogic challenges remain. Most notably, for example, undergraduate students often struggle to make the transition from traditional large-group teaching, which features heavily throughout a typical degree programme, to the more autonomous self-directed requirements of closely supervised dissertation work (Day & Bobeva, 2007). In light of this, students may find that researching, designing, and conducting a piece of research is a daunting task for many reasons. Factors affecting engagement with independent research work include power imbalances between student and supervisor (Roberts & Seaman, 2018), omnipresent pressures from supervisors to create publishable work (Brewer et al., 2012), and, by extension, find significant results (Wagge et al., 2019), and under-confidence with writing (Greenbank & Penketh, 2008). Moreover, ambivalence surrounding the statistical data analysis element of independent research may also compound dissertation-related anxiety (Onwuegbuzie & Wilson, 2003).

For example, research shows that student's worries surrounding the mathematical and statistical aspect of their psychology degree, termed 'statistics anxiety', affects overall academic performance (Macher et al., 2011) and positively predicts procrastination and disengagement (Onwuegbuzie, 2004). To explore the different predictors and factors associated with graduate students' statistics anxiety when faced with writing a research proposal, Onwuegbuzie (1994) conducted a mixed-methods study. The qualitative results indicated that students' 'perception that statistics is not relevant' (p.27) increased statistics anxiety; 'Perceived Usefulness of Statistics' was considered a key dimension. Therefore, clarifying the purpose of statistics and highlighting to students the relationship between research questions and methods

of statistical analysis may diminish statistics anxiety, improving student engagement and academic attainment.

Therefore, pre-registration of undergraduate dissertations well in advance of data collection may provide a pedagogic solution to this challenge. Pre-registration prompts students to create a clearly articulated data analysis plan, with the close guidance of supervisors, including details of relevant statistical approaches and step-by-step analysis procedure. This may alleviate some concerns for the statistical content of the dissertation, by aligning statistical processes more clearly with original research questions, thus increasing perceived usefulness of statistics in this context.

Moreover, the Framework for Open and Reproducible Research Training (FORRT) include pre-registration as one of the six key pillars of reproducibility training. The framework proposes that pre-registration 'facilitates transparency and removes several QRPs [Questionable Research Practices]' (p.31). Pre-registration of research questions, study design, and analysis plan may indeed reduce QRPs (Nosek et al., 2018); however, the introduction of pre-registration in the undergraduate dissertation may be less concerned with reduction of QRPs and publication bias, and more about pedagogic benefit to the student, in terms of both engagement and opportunity to learn.

Importantly, van't Veer and Giner-Sorolla (2016) note that pre-registration is a useful tool in the research process, because it requires a more considered, thoughtful approach to the development of an initial research question, which is then refined and collaboratively discussed with collaborators prior to the collection of data. Due to this process of collaborative refinement in the early stages of the work, the authors suggest that 'pre-registration might especially benefit students and early career researchers' (p.5). This is also reflected in Jekel et al.'s (2019) notion that undergraduate students' research literacy can be improved through authentic application of research skills, by embedding open science principles into the undergraduate dissertation.

Crucially, pre-registration extends the current practices common in dissertation supervision, such as informal data considerations in conversations with the supervisor or ethical approval processes, because preregistration requires a tangible, written plan. This commits students to their pre-registered plan and thus enforces well-governed standards of open and reproducible science. (as set out by the Open Science Framework; https://cos.io/prereg/). Indeed, some elements of this process do feature in current dissertation practices. For example, some institutional research ethical applications ask students to report their proposed data analysis plan in this early stage of the research process. However, the purpose of providing these details in this context is purely to assess the ethical content of the research. In this sense, data analysis plans in ethical applications do not necessarily *challenge* students to consider an exhaustive account of their data analysis plan, grounded heavily in the assumptions, contradictions, or uncertainties within their chosen theory or research question.

For example, as Nosek et al. (2019) explain, all research begins with a general idea about methodology and design, with abroad analysis plan. This initial level of detail will likely suffice for most ethical application or research proposal procedures. Pre-registration, as an extension of these current practices, requires researchers to compile concrete, specific plans including 'what has not yet occurred and decisions about what will be done' (Nosek et al., 2019, p.816). This is likely to include data stopping rules, specific parameters for data inclusion, and description of steps involved in each proposed analysis. Hence, pre-registration, encourages a deeper, more thoughtful appreciation of the proposed study, prior to data collection, which can prompt more critical and practical engagement with the topic.

The role of supervision

Successfully embedding open science principles, such as pre-registration, into the undergraduate curriculum requires investment from both student and supervisor. Supervisor buy-in, in the first instance, is particularly important, because this drives the inclusion of open science ideology into the work. Krishna and Peter (2018) provide useful commentary to this. In a study of students' attitudes towards 'questionable research practices' (which the authors define broadly as falsification or distortion of research findings), the authors note that students in their sample did *not* endorse the view that obtaining significant results alone would improve their dissertation grade. Instead, supervisors' attitudes towards questionable research practices, including p-hacking or 'fishing' for significant results, played an important role in students' attitudes to research integrity and researcher conduct. This is echoed by Wright, Titus and Cornelison (2008), who indicated that teaching of best practice research standards is often lacking from the mentor-mentee relationship.

Good dissertation supervision, as previous researchers have noted, should instil confidence in the student through clear and directed advice (Roberts & Seaman, 2018). In a qualitative study exploring students' experiences of dissertation supervision, Roberts and Seaman (2018) note that lack of clarity and inconsistencies negatively impact students' supervision satisfaction. Students also report that perceived skill acquisition is a key factor in supervisory satisfaction (Del Río et al., 2018). Pre-registration of research question(s) and concrete analysis plan may alleviate some of these tensions in the student-supervisor relationship, by outlining clearly the purpose, aims, and procedure of a study well in advance.

Practical barriers

There are, of course, some practical barriers to consider. Undergraduate students are typically required to complete their dissertation in a short timeframe and supervision can be a demanding time-intensive task for academic staff (Rowley & Slack, 2004). Indeed, a common criticism of the pre-registration framework is the perception of added workload to researchers (van't Veer & Giner-Sorolla, 2016). However, the questions involved in a formal pre-registration are already typically discussed at the onset of any dissertation supervision process. For example, in Stage 3 of a 'process map' for undergraduate students to identify a dissertation topic (titled 'literature review and idea refinement'), Holliman and Jones (2018) urge students at this point to consider the ethical, analytical, procedural and theoretical details of their proposed empirical study. Therefore, one may argue that formal pre-registration can serve as a pedagogic tool to facilitate thorough and rigorous formulation of a suitable research question and designing of a robust study, whilst merely complementing a process that intrinsically already holds these features.

Other criticisers of the pre-registration movement have argued that pre-determining data analysis plans in advance may restrict researchers' flexibility and thus hinder scientific advancement (e.g. Kornell, 2013; Mathôt, 2013) Rather, open scientists note that it is feasible for researchers to conduct analyses beyond the scope of the pre-registration, but this section of analysis should be labelled clearly as exploratory rather than confirmatory in the study write-up. This same principle can be applied to dissertation work. In the context of undergraduate dissertations, pre-registration does require students to engage with the statistical content of their project at the onset of the process, which may be a daunting task for statistically anxious students. However, as a rebuttal to this, the process also 'front loads' the work and takes the onus off students at the end of the dissertation process to start thinking through a data analysis plan.

Conclusion

To conclude, Nosek and colleagues (2018) note explicitly that the structured, thoughtful nature of undergraduate dissertations means that they lend themselves well to the pre-registration model. Encouraging students to think through the hypotheses, procedure, and data analysis plans prior to data collection is a useful pedagogic tool for many reasons. Firstly, it ultimately encourages best practice in psychological science and endorses robustness and transparency in the scientific process. Secondly, it relieves some of the pedagogic challenges involved in undergraduate supervision, such as improvement of clarity and communication of student-supervisor expectations. Finally, pre-registration prompts students to consider aspects of their empirical project that otherwise may have been saved for the latter stages of the project. This improves research thoughtfulness and analytical thinking. While this discussion has mainly considered the feasibility of pre-registration in quantitative student projects, there remains scope to apply these principles more widely, to include original qualitative work, meta-analyses, and analysis of secondary datasets.

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