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# Developing reproducible and reusable methods through research software engineering

Discussions around open science and digital scholarship often focus on the important topics of creating and applying data standards, and achieving a robust infrastructure to support research. That scientists will follow standard, or at least well-defined, methods and operating procedures is a given - a crucial first step in ensuring research is reproducible.

In reality, research methods in psychology are often far from standard; they continually and necessarily evolve to meet the challenges of understanding new forms of behaviour and interaction. In the domain of human-computer interaction (HCI), this is particularly true, as traditional paradigms for investigating behaviour often cannot be directly applied to technology use.

In many psychological studies, software is firmly embedded in both the data collection and analysis processes: packages such as E-Prime and Tobii Studio are popular tools for ensuring that reaction time and gaze data measurements are taken reliably, and are straightforward to interpret. Both these software tools are proprietary, however, and whilst this results in stability that is helpful from the perspective of reproducibility, it is less useful from the perspective of open science.

Truly achieving reproducibility is hard. The authors have been striving to ensure their science is open for several years, but issues such as incomplete raw data, data that cannot be published for ethical reasons, the use of proprietary software, hard-to-decipher analysis scripts and unavailable experimental materials have all proved barriers to reaching this goal.

At the University of Manchester, and in particular as part of the EPSRC-funded IDInteraction project (EP/M017133/1), we are trying to address these challenges, by developing open-source software methods that not only make it easy to reproduce experimental results, but are also suitable for reuse and extension. Underlying our new approach is one crucial factor: the recognition of software engineering as a first class citizen in the research process. By paying attention to the usability and sustainability of software during the experimental design process, rather than treating it as an afterthought (or ignoring it completely), we hope to develop tools and methods that can be used to demonstrate the reproducibility of our own work, and support further experiments in the future.

Convincing others of the utility of 'research software engineering', and embedding it in the mainstream of scientific activity, is likely to require a significant cultural shift. Both scientists and research funders must recognise that the additional resources necessary to support this activity are vital to the future of science. Excellence in software engineering practice is essential to developing reproducible and reusable methods; scientists (for now, at least), are unlikely to be able to achieve this alone. As such, people with a focus on software development are as vital to producing genuinely reproducible computational research as people with a focus on the science itself.