

Impact case study (REF3)

Institution: University of Nottingham		
Unit of Assessment: UoA4		
Title of case study: PsychoPy: Increased Efficiency and Capacity for Behavioural Studies through the Development of High-Precision, Open-Source, Software		
Period when the underpinning research was undertaken: 2003 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Jonathan Peirce	Associate Professor	2003-present
Period when the claimed impact occurred: 1 August 2013 – ongoing		
Is this case study continued from a case study submitted in 2014? N		
<p>1. Summary of the impact</p> <p>The open-source software package – PsychoPy – developed by Dr Jonathan Peirce at the University of Nottingham, has been adopted worldwide and has improved the efficiency and capacity for behavioural studies conducted by industrial, governmental and educational institutions. PsychoPy has a range of functions that enable specialist and non-specialist users to conduct behavioural studies with high precision. These features have led to the wide-scale adoption of PsychoPy globally, attracting in excess of 26,000 users per month. Different interfaces allow PsychoPy to be used either i) freely in lab-based experiments or ii) remotely through a web-based platform – Pavlovia – following the purchase of a low-cost site license. Due to the worldwide success of PsychoPy, a new start-up company – Open Science Tools Ltd – was established in February 2019 and has sold 116 site licences to date and generated revenue of GBP285,409. The adoption of PsychoPy by institutions purchasing a site license over commercial alternatives represents a potential combined cost-saving of GBP986,000 annually.</p>		
<p>2. Underpinning research</p> <p>The development of methods, techniques and instrumentation is acknowledged as a critical area of research by the Psychonomic Society, in particular the use of computer technology for psychological studies. Dr Jonathan Peirce from the University of Nottingham is part of a new wave of scientists spearheading the development of computerised psychological tools to facilitate flexible and open research in industry, government, and education.</p> <p>From 2003 Dr Peirce has developed a new open-source software tool, PsychoPy, for use in behavioural studies. The development of this instrument has involved: (i) the demonstration that high-performance measures are possible with scripting languages [1, 2]; (ii) the launch of a graphical interface to extend capabilities to users without programming skills [3]; (iii) an equivalent web-based option that has high precision and offers new avenues for behavioural research [4].</p> <p>The initial research (2003-2009) demonstrated that high-precision behavioural measurements can be made using powerful and easy-to-learn scripting languages, such as Python, and can be performed with a low-cost open-source model that benefits end users in multiple ways, including the functionality to include additional features as needed. This work was reported in the <i>Journal of Neuroscience Methods</i> [1] and <i>Frontiers in Neuroinformatics</i> [2] and to date has received a combined citation count of 4575 (correct December 2020), demonstrating broad uptake of this new tool within the field of behavioural research.</p> <p>Further development of PsychoPy (2008-2016) saw the launch of a graphical user interface that enabled users who could not programme in Python to access and apply the high-quality features and precision measurement embedded within the software package to their own work. This new graphical interface offered access to an unprecedented range of flexible features for studies, such as the ability to change stimuli on every screen refresh according to participant responses. The graphical interface was first described in <i>Behavioural Research Methods</i> [3].</p> <p>Finally, a web-based interface was developed between 2018 and 2020, supported by funding from the Wellcome Trust [6] and the Chan Zuckerberg Initiative [7]. The web-based interface enabled behavioural research to be conducted remotely. This is beneficial as it enabled people</p>		

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to participate in studies who would otherwise struggle to attend a formal research setting, for example patients in hospitals or children at home or at school. As reported in the *PeerJ* article [4] the web-based version of PsychoPy provided the same functionality as the lab-based version, including the option to change stimuli on every screen refresh with best-in-class timing.

PsychoPy was initially developed solely by Dr Peirce at the University of Nottingham and has since prospered further by increased participation from a global community of researchers (including New Zealand, USA, Germany and Japan) offering open-source contributions [5].

3. References to the research

1. Peirce JW (2007) PsychoPy—psychophysics software in Python. *Journal of Neuroscience Methods*, 162 (1-2), 8-13. DOI: 10.1016/j.jneumeth.2006.11.017
2. Peirce JW (2009) Generating stimuli for neuroscience using PsychoPy. *Frontiers in Neuroinformatics* 2 (10). DOI: 10.3389/neuro.11.010.2008
3. Peirce JW, Gray JR, Simpson S, MacAskill M, Höchenberger R, Sogo H, Kastman E, Lindeløv JK (2019) PsychoPy2: experiments in behavior made easy. *Behaviour Research Methods*, 51: 195-203. DOI: 10.3758/s13428-018-01193-y
4. Bridges D, Pitiot A, MacAskill MR, Peirce JW (2020) The timing mega-study: comparing a range of experiment generators, both lab-based and online. *PeerJ* 8: e9414. DOI:10.7717/peerj.9414
5. Dr Peirce's contributions to the software are detailed here on the GitHub repository where the code of the project is stored: <https://github.com/psychopy/psychopy/graphs/contributors>

Underpinning grants:

6. 'Enabling flexible online and portable experiments in behavioural health sciences', 2018-2020, Sponsor: Wellcome Trust, GBP207,000, PI: Jonathan Peirce.
7. "PsychoPy3: essential open-source software for neuroscience and psychology", 2020-2021, Sponsor: Chan Zuckerberg Initiative, USD150,000, PI: Jonathan Peirce.

4. Details of the impact

The development of [PsychoPy](#) has transformed research and teaching in the behavioural sciences. Its high-quality features and precision timing, alongside ease of use by non-specialists has resulted in a wide range of user groups adopting this innovative platform, spanning industrial, governmental and educational settings. Most recently in excess of 26,000 users globally have accessed PsychoPy each month. The successful adoption of PsychoPy by users worldwide led to the incorporation of a new start-up company in February 2019, Open Science Tools Ltd, which enables remote access to the software through a web-based platform Pavlovia following the purchase of a low-cost site license [6]. To date the company has sold 116 Pavlovia site licences, generating sales revenue of GBP285,409 and enabling 3.2FTE new positions to be established in 2020.

Reach of PsychoPy and economic success of Open Science Tools Ltd.

Since 2010 [active user numbers](#) have been monitored by tracking the number of unique IP addresses launching PsychoPy each month [a]. Between 2013 and 2020 peak user figures captured annually in November had risen from 6,156 to 26,863 per month [a, Fig 1]. This includes users from a broad geographical reach, demonstrating global uptake from over 100 countries [b]. User [testimonials](#) described their experience of PsychoPy and the studies it has enabled them to carry out [c]. For example:

"Using PsychoPy [...] really helped me a lot with my experiments and made me start learning Python. [...] I can now use PsychoPy and other Python modules to control the stimulation parameters and multiple hardware parts we have in the lab with great precision. Some experiments I am doing at the moment would not have been possible at

all if I could not do that,” Postdoc - Max Planck Institute of Neurobiology, Germany [c].

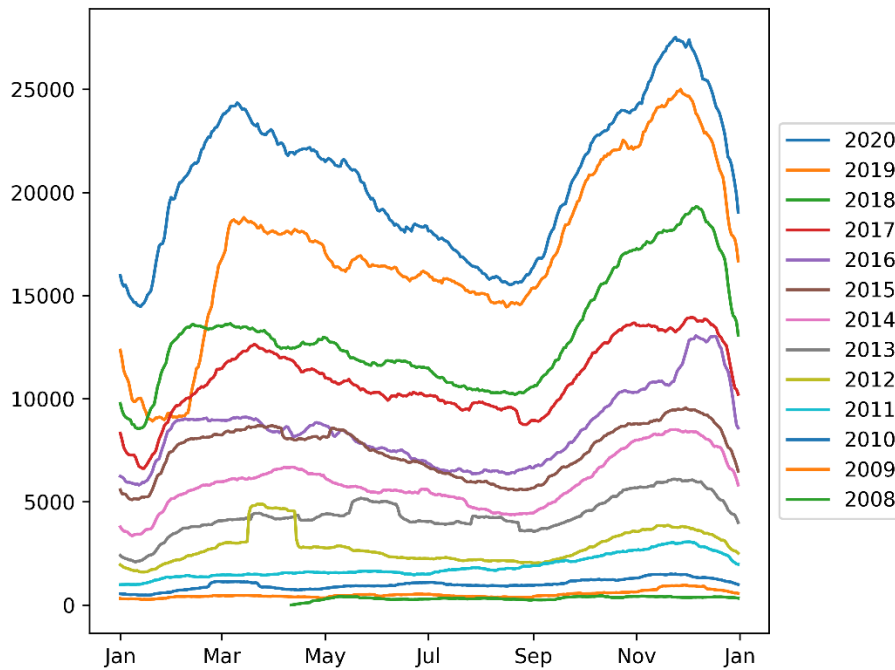


Figure 1: Monthly usage figures. Unique users determined by unique IP addresses launching the application each month [a].

Due to sustained high user counts, a new start-up company, Open Science Tools Ltd, was incorporated in February 2019 [b]. The company introduced a premium service that enables users to conduct studies online through the [Pavlovía site](#). Revenue is generated through the purchase of site licenses and the hire of services provided through a team of scientific consultants [b]. Dr Peirce, who founded the company, is the CEO and co-director. He is supported by a co-director in New Zealand. The company has 10 shareholders from all over the world [b]. Open Science Tools Ltd began trading in June 2019 and to date has sold 116 site licences to organisations worldwide, including, for example, The Institut de Recherche Biomedicale des Armees – France, and the NTT Communication Science Laboratories – Japan [d]. Between February 2019 and February 2020, the company generated a revenue of GBP22,805 [b]. Sales increased substantially between March 2020 and November 2020 when the company experienced revenue growth of GBP262,604 [b]. As a result of this economic growth, as of 1st December 2020, the company was able to create 3.2FTE new positions, employing a Python Programmer, JavaScript Programmer and Science Officer [b].

Improved efficiency for producers of commercial hardware

Commercial hardware companies have adopted PsychoPy to attract new users to their neuroscience research products. For example, PsychoPy has been adopted by Emotiv Ltd (San Francisco), an award winning, pioneering bioinformatics company and market leader for advancing understanding of the human brain using electroencephalography. The Director of Data Science explains, “*Emotiv has been using PsychoPy since 2017. Initially we used PsychoPy because it had the easy to use builder, so that non-technical people could build experiments... PsychoPy’s ability to accurately identify the time at which the various stimuli are presented to the subject is now very important. PsychoPy supports Emotiv EEG brainwear enabling anyone to perform accurate ERP experiments with PsychoPy with little to no coding*” [e]. PsychoPy has also been adopted by the Canadian company LabHackers Research Equipment as “*the main software we use for both internal testing and for official user demos*” [f]. The company owner explains how adopting PsychoPy in 2018 has led to a series of benefits to LabHackers. Promoting their own products as compatible with PsychoPy “*opens up the large PsychoPy user base as potential customers*” and the open-source aspect allowed for “*fast and easy integration*” of their own hardware with PsychoPy. The company has also saved money as without PsychoPy they would “*have to explicitly support several other, mainly commercial,*

alternatives” [f]. The adoption of PsychoPy by these commercial hardware producers has enabled improvements in efficiency as they are able to focus time and energy on hardware development rather than also needing to develop stimulus-presentation packages [e, f].

Improved health and wellbeing of service members in the US military

Since June 2015 PsychoPy has been used to monitor the health and wellbeing of members of the US military and has had a *“transformative impact on [their] ability to conduct research on the cognitive and sensory abilities of service members”* [g]. A Research Audiologist at Walter Reed National Military Medical Center reports, *“PsychoPy has become an indispensable tool in our mission of ensuring the health and well-being of the over 2,000,000 service members in the US military. PsychoPy not only allows our researchers to develop state of the art programs for collecting data on the cognitive and sensory health of US service members, but these programs can be easily understood, used, and modified by the clinicians and technicians collecting the data with little to no hands on instruction. There is no comparable tool that allows such high end experiments to be programmed with so little effort [...] Without PsychoPy, our ability to ensure the health and well-being of the US military would be compromised”* [g]. PsychoPy has also enabled the US military to update their service member’s ‘medical readiness’ policy. The Research Audiologist from Walter Reed National Military Medical Center reported *“the analysis tools and programming environment provided by PsychoPy were critical for conducting our large scale retrospective study on predicting speech-in-noise deficits from the audiogram that lead to the revised hearing profiles included in Army Regulation 40-502 Medical Readiness”* [g].

Building capacity in behavioural science methods worldwide

PsychoPy’s simple user interface makes it an accessible teaching tool. This high-precision, open–source, behavioural platform has been used by a range of education institutions around the world [h, i, j], including institutions based in low- and middle-income countries, for example Indonesia, Vietnam, the Philippines, and Ukraine [b]. Using PsychoPy, students can develop their own precise experiments, enhancing their practical knowledge, and building their capacity to carry out behavioural studies. The seasonal fluctuation in users accessing PsychoPy [Fig 1] suggests a large majority are students conducting their own research projects and lecturers teaching practical methods in behavioural sciences [a]. Head of Psychology at Aston University (a site license purchaser in March 2020) explains, *“PsychoPy has allowed our students to recruit study participants... remotely... developing more ambitious research projects”* [h].

In 2020 Arizona State University used PsychoPy to support students enrolled on a general science course. A Professor at Arizona State University, who won the 2001 Nobel Prize for Physiology or Medicine, commented, *“We created the ‘HON 294: Research at Pathfinder’ course based on PsychoPy... PsychoPy has been instrumental as a teaching tool in the design and delivery of the course, and has enabled students to design their own experiments, test hypotheses, and analyse research data... The software permits very efficient experimental implementation and subject testing, allowing students to spend their time focused on the creative aspects of formulating questions and designing experiments”* [j]. PsychoPy has also been used by the same team for professional development of in-service K-12 science teachers in the USA and India. *“It would not be possible to offer this course for teachers without the PsychoPy software and the Pavlovia website”* [j].

A series of YouTube tutorial videos also has increased the reach of PsychoPy within education. A Google search in November 2020 [“psychopy site:youtube.com”](https://www.youtube.com) retrieved 1,010 videos [k], and other training resources have been uploaded to the [PsychoPy website](https://www.psychopy.org/) by independent users for teaching purposes. Undergraduate teaching with PsychoPy has been further facilitated by a textbook – ‘Building Experiments in PsychoPy’ – published by Dr Peirce in May 2018. Up until 10th December 2020, 2,380 copies had been sold [l] and the text has now been translated and published in Japanese and Chinese. 38 higher education institutions, including 1 sixth form college (Gateshead College) have reported to the publisher (Sage) that they use the textbook in at least one of their modules, with an average module size of 118 students [l].

Capacity building for academic and non-academic users engaged in behavioural science has

also been achieved through the delivery of annual [PsychoPy workshops](#) by Dr Peirce. Since 2013 these workshops have attracted over 250 attendees, from all over the world. For example, in 2018 the attendees came from the UK, Netherlands, Spain, Germany, Lithuania, USA, Canada, Hong Kong and Chile [m]. Anonymous feedback from the 2019 cohort rated the workshop as highly useful, giving an average rating of 6.6 (from 45% of the attendees; where 1=not very useful, 7=very useful) [m].

Cost-savings for UK and international institutions

For web-based experiments, the leading alternative to PsychoPy is Gorilla, who charge a minimum of GBP10,000 annually for a site license [n]. In contrast PsychoPy's web platform [Pavlovia costs GBP1,500 per institution](#) [b]. To date 116 institutional site licenses have been purchased for the PsychoPy web platform [d] suggesting a potential combined cost saving of approximately GBP986,000 per annum across these institutions. In addition, for lab-based experiments the leading alternative to PsychoPy is E-Prime which costs an institution approximately GBP12,000 per year for a license enabling 100 concurrent users [n]. In contrast PsychoPy is freely available as an open-source tool. Hence using the lab-based version of PsychoPy, instead of E-Prime or other commercial solutions, represents a significant cost-saving for institutions worldwide.

Continued education in behavioural sciences during the Covid-19 pandemic

In response to the Covid-19 pandemic, when many universities moved to online teaching, PsychoPy facilitated the enhancement of teaching quality and engagement of students with impactful and participatory learning in international and national institutions [o]. For example, a Professor at Western University, Ontario, explained, "*PsychoPy and Pavlovia have been invaluable during the COVID-19 pandemic. This is one of the biggest benefits*" [i]. From March 2020 onwards 106 site licenses were sold through Open Science Tools Ltd [b]. Within the UK, to support the continuation of undergraduate and postgraduate teaching during the national lockdown University College London (UCL) purchased a site license [o]. A Research Technician at UCL commented "*due to the [lockdown] we had to move all of our face-to-face teaching online in a short period of time. PsychoPy was an instrumental resource in us being able to offer continued lessons in Research Methods and Statistics as well as for research project across Undergraduate and Postgraduate levels*" [o].

5. Sources to corroborate the impact

- a) PsychoPy usage figures and user geographical location from [website](#), accessed 14 January 2021 [PDF]
- b) Letter from Founding Director of Open Science Tools Ltd (December 2020) [PDF]
- c) PsychoPy user testimonials submitted to PsychoPy [website](#), accessed 26th November 2020 [PDF]
- d) Site licenses purchased for PsychoPy's web-based platform (Pavlovia) through Open Science Tools Ltd on Pavlovia [website](#), accessed 26th November 2020 [PDF]
- e) Letter from the Director of Data Science of Emotiv Inc. (December 2020) [PDF]
- f) Letter from LabHackers (January 2020) [PDF]
- g) Letter from Research Audiologist at Walter Reed National Military Medical Center, US Department of Defense (October 2020) [PDF]
- h) Letter from Aston University (January 2021) [PDF]
- i) Letter from a Professor at Western University, Ontario (January 2021) [PDF]
- j) Letter from a Professor at Arizona State University (November 2020) [PDF]
- k) Google search "[psychopy site:youtube.com](#)" YouTube teaching videos on PsychoPy by independent 3rd parties, accessed 26th November 2020 [PDF]
- l) Letter from the Senior Commissioning Editor – Psychology at SAGE Publications Ltd (December 2020) [PDF]
- m) Information, attendee figures and feedback for University of Nottingham workshops on PsychoPy [PDF]
- n) Pricing for Gorilla and E-Prime [PDF]
- o) Letter from a Research Technician in Psychology & Human Development at UCL (November 2020) [PDF]