Research computing specialist, Game/Experiment Design

Project & Job Description:	*Overview* My research group conducts experiments focused on human memory and its neural underpinnings, as investigated using neuroimaging. In order to obtain behavioural data from large number of participants - many more than could be recruited locally or invited to our laboratory on Queen's campus - we wish to develop experiments in the form of "video games" to be distributed to large numbers of web users in exchange for their data. In addition, we wish to capitalize on recent technical innovations in the domain of virtual reality (VR) to explore the effects of immersion on spatial memory representations. For instance, to what extent does navigating a virtual space contribute to learning of a spatial layout (allowing VR to be used as a stand-in for, e.g., expensive ship time for navy members in training)? This problem area, too, is most efficiently addressed through the development of experiments supported by "video game" development. To help develop experiments in these domains and gather new data, assistance from a student in the 2017 SWEP program with expertise in game development is requested. This project is led by the Poppenk Computational Cognitive Neuroscience (POPMEM) lab, a new, NSERC-funded research group focused on understanding the nature of memory and the contributions of neural structures to its function. The student will work directly with the leader of this group, Dr. Jordan Poppenk, a Tier 2 Canada Research Chair in Cognitive Neuroimaging. The student will be stationed in the main POPMEM lab suite in Craine Hall, rooms 202-205. For more information about our group, please visit http://popmem.com. *Project history* I have overseen development of tools to gather data from such video games as part of several undergraduate courses (CISC498 and PSYC570). Using these tools and a popular game engine (*Unity 3D*), I created one video game-based experiment (a "Virtual Water Maze"; see e.g., Wooley et al., 2015) to investigate the scale at which spatial information is recorded into memory. This experiment is undergoing in-lab validation in preparation for its distribution over the internet and use in brain imaging studies. Experimental data generated by the player using the game are securely transmitted over the internet to a server at Queen's for analysis. We will use this game as a template for future experimental development. Having completed most of its development, I am also prepared to supervise implementation of VR adaptations of the experiment. This fall, my lab completed installation of an VR computing station for game development and testing in the Craine Building, featuring a high-end computer system with cutting-edge NVIDIA 1080 GTX graphics capabilities, and an HTC Vive room-scale VR installation. It is fully configured and ready for development use.

My laboratory has planned a number of experiments based on these approaches with other researchers in the Psychology, Computing Science, Geology, and Geography departments that now require help with implementation.

Significance of the project to science, society, and Queen's

My laboratory conducts research aimed at distinguishing among similar, but different memory capabilities. For example, we are very interested in differences in the nature of memory representations that humans use to remember the organization of small vs. large portions of space; and the details vs. gist of an experience. Normally, we run such experiments in the laboratory, where we can control computer and environmental conditions, answer questions, ensure participants are paying attention, and gather other, brain-based measures. However, these experiments are limited to a few dozen people. It is often possible to abstract patterns from navigation data only by viewing the paths of hundreds of people. Accordingly, a complementary approach is to build experiments for large numbers of web volunteers in the form of "video games". In exchange for player data that is transmitted to our server, the participant receives free entertainment and a sense of contributing to science. By virtue of constituting data from thousands rather than dozens of people, this approach has tremendous promise for helping us to detect patterns in the way that people navigate and remember the space and landmarks around them. In this way, it will contribute to the Queen's thematic cluster of *Society, Culture, and Human Behaviour (Theme 1)*. As this work will contribute to basic science benefitting patients with memory disorders, as well as be used in neuroscience work to understand the human brain, it also falls within the clusters of *Human Health and Wellness (Theme 1)* and *Natural and Physical Sciences (Theme 3)*.

In addition, memory research stands to benefit from the introduction, in 2016, of consumer VR systems. Currently, it is not clear to what extent measurements of spatial memory representations, which are typically tested on a computer screen, are distorted by a lack of immersion in the space. We wish to test the extent to which navigating a virtual space can enhance learning of a real spatial layout (allowing, e.g., VR to be used as a substitute for expensive ship time for military or NASA traning) relative to screen-based approaches. Construction of virtual worlds that support navigation and memory testing would allow us to answer the question of whether VR-based training may be an effective learning tool. In this way, it will contribute to the Queen's thematic cluster of *Advanced Technologies (Theme 3)*.

This project is unique in that it combines elements of technical development (programming), scientific development (experiment design in Psychology and Neuroscience with collaborators in Geology and Geography) and artistic expression (implementation of technical elements into an artful game that is desirable to play). This combination

of creativity, innovation in multiple fields, and technical skill in the service will introduce an unusually high level of cross-disciplinarity, benefitting all of those associated with the project. In this way, the strategic driver of *student engagement and skill development* is advanced by virtue of allowing the Psychology graduate students who will working with the student to learn about approaches and requirements of game design as they pertain to development of experiments.

The project goals are also consistent with Queen's other strategic drivers: of research *prominence and internationalization* (drawing upon worldwide audiences for participation will create more generalizable samples, but simultaneously contribute to international awareness of Queen's University as a place where innovative approaches to research are deployed). Also, by allowing Queen's researchers to gather research data from thousands of participants without lab resources and compensation for participation, *Financial sustainability* will be enhanced.

Job Description

The successful student candidate will work closely with Dr. Poppenk to develop web-deployable and VR experiments in the form of entertaining video games. However, the student will be expected to work independently on a day-to-day basis. The work would involve several elements:

1. Participating in brainstorming sessions Meeting with Dr. Poppenk, collaborating faculty, and members of the POPMEM lab to create the detailed design for several game-based experiments. The student would be expected to contribute knowledge about elements of game design and ideas for helping experiments designed to satisfy scientific objectives be more entertaining to users.
2. Using the Unity 3D editor and our library of data-logging tools and art assets to create experiments.
3. Writing scripts in C# as required (with in-line commenting).
4. Preparing rough documentation concerning the gross construction of the experiment and modifiable assets, to facilitate code / project maintenance and alteration for future projects.

The product of this project will be used extensively by my research lab at Queen's, and will gather experimental data from users around the world.

Required qualifications

Technical ability and knowledge about game design will be crucial for success in this position, but adherence to best practices as well as communication skills are also important. The successful candidate will be a third or fourth-year student registered at Queen's, and will have:

	• Familiarity with C#, C++, or C programming and common libraries in this language. • Prior experience with the Unity 3D editor. • Evidence of creativity. • Course experience in the School of Computing, including courses from the School's game design stream, would be an asset, but are not strictly required. • Basic knowledge of, and evidence of adherence to, best practices in computing; • The ability to brainstorm effectively with a group about game design issues. • The ability to communicate effectively with a project manager about technical issues.
Learning Plan::	Relevance of training to positions in academia and industry According to a 2015 report, VR devices are set to explode to nearly 20 million units by 2018. Canadian startup companies, largely located in Ontario, are working to capture a large share of this market (see http://betakit.com/virtual-reality-north-a-look-at-the-major-vr-players-in-canada/). This rapid emergence of affordable consumer VR hardware is driving surging demand for content creators in VR. Accordingly, expertise in game development in general, and VR capabilities in particular, is in high demand, and a student gaining experience with this work in my lab will gain competitiveness in this area. In addition, game development experience in my laboratory will incldue the unique opportunity for a computing student to work alongside researchers in Psychology and Neuroscience in my lab towards behavioural science goals. In this way, the student will gain experience in cognitive computing, an area of intense interest and rapid growth. For example, a single company, Thomson Reuters, recently announced that it would add 400 jobs in Toronto focused on this area. Skill acquisition Specific skills to be acquired include the following: • Gain of practical experience with game development in Unity 3D and C#. • Learning to record diverse features of behaviour, and gaining awareness about forms of behaviour offer that may offer insight into cognition. • Knowledge about psychology and neuroscience: gaining experience and awareness of current topics in Psychology and Neuroscience by

learning the requirements of researchers and attending lab meetings.

- Quality assurance skills: gaining experience with best practices in writing code, error-checking, and code management. Also, inculcation of a sense of careful attention to detail.
- Collaborative skills: working with a supervisor and team of users to advance the quality control process.

Skill-development activities

To scaffold student learning in the context of this project, the student's work will progress through a number of phases:

1. The program will begin with directed reading about the theoretical objectives of the project and discussion about these goals with members of the POPMEM lab. Dr. Poppenk, collaborators and several graduate students will participate in ongoing discussions with the student on this topic.
2. The student will be asked to examine our existing experiment/game project, the Virtual Water Maze, and discuss with Dr. Poppenk the data-logging, experimental design and secure transmission features that make the project scientifically useful, and how to use these in future projects.
3. In a brain-storming phase, the student and research team members will work together to develop planned research initiatives into viable mini-game designs. Through participation, the student will gain experience adapting game design knowledge to theoretical applications as well as to the requirements of an employer.
4. The student will refine the proposed plans and present a detailed plan for each mini-game to Dr. Poppenk, contributing to experience with technical communication.
5. The student will develop and test each mini-game, contributing to experience with Unity 3D and C#.
6. The student will implement each game for various devices (e.g., VR headset; mobile devices), contributing to expertise working with modern game platforms.

Other opportunities

Throughout this process, students will receive regular and ongoing direction by Dr. Poppenk that provides opportunities throughout the project to grow in relation to the learning goals. Weekly project meetings will be held, and the PI will be available for impromptu meetings as

	needed to review progress, provide feedback, and suggest new directions. In addition, the student will be invited to attend ongoing lab meetings to learn about applications of the software, and current issues in Psychology and Neuroscience. At the conclusion of the project, a final meeting will be held to reflect together about the experience, and for the project lead to provide suggestions for further growth and possible next steps.