TITLE PAGE

The Central Place of Psychology in the Knowledge-Based Economy

NSERC GSC12. Psychology: Brain, Behaviour and Cognitive Science

Membership.

Lorraine Allan, McMaster University
Richard Brown, Dalhousie University (Chair)
Mel Goodale, University of Western Ontario
Colin MacLeod, University of Toronto
Isabelle Peretz, Universite de Montreal
Janet Werker, University of British Columbia
Ian Whishaw, University of Lethbridge
Linda Parker, Wilfrid Laurier University (Chair, GSC12)

allan@mcmaster.ca, rebrown@is.dal.ca, mgoodale@julian.uwo.ca,
macleod@scar.utoronto.ca, isabelle.peretz@umontreal.ca,
jwerker@neuron3.psych.ubc.ca, whishaw@uleth.ca, lparker@wlu.ca,
DANIELLE.MENARD@NSERC.CA, NORMAN.MARCOTTE@NSERC.CA,
bbcsadm@claret.psychology.mcmaster.ca,
cherdman@alfred.ccs.carleton.ca, latham@mgmt.utoronto.ca,
abraham@play.psych.mun.ca, vince.dilollo@ubc.ca

NOTE. This report is available on the BBCS website. In addition, the BBCS website has the joint proposal in neuroscience with GSC30/31 and two data appendices:
Appendix 1. Data cited in Tables 1 - 4 in the text.
Appendix 2. A reanalysis of the NSERC HQP and DD data, plus information on AUCC job advertisements in Psychology.

BBCS website: http://psych.mcmaster.ca/bbcs/index.html

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EXECUTIVE SUMMARY
Psychology was ranked first in quality in the initial reallocation exercise and was highly ranked again in the second reallocation exercise, but did not gain significantly in funding. Within the world rankings of highly cited papers in Psychology and in Neuroscience (1981-1998), Canada ranks third, behind the USA and the U.K. The demand for psychology HQP, the number of trainees and the number of applicants to GSC12 are all increasing and we can no longer conduct high quality research on a shoestring. For Canada to maintain its high world ranking in psychology, GSC12 must have increased funds to support highly qualified personnel, burgeoning animal research costs, training of students, international collaborations, and access to expensive new techniques. Our aim in the reallocation exercise is to increase the mean GSC12 grant to $35,000 while maintaining a 75% success rate. This will require a return of the $1.188M from the reallocation pool plus an increase of $1.212M for a total of $2.4M. We are thus requesting $600K/year for GSC12 and an additional $400K/year to support multidisciplinary research in neuroscience through a joint proposal with GSC30/31.

1. INTRODUCTION

1.1. Psychology: Brain, Behaviour, and Cognitive Science (BBCS) in Canada.

Our abilities to perceive the world, to learn from experience, to remember, to reason, and to communicate—and the brain mechanisms underlying these abilities—are the focus of research in GSC12. The scientific study of BBCS is central to understanding the mental abilities that enable us to function in society and to succeed in a knowledge-based economy. Psychology is currently undergoing a revolution driven by the development of extraordinary new techniques. Brain imaging techniques such as functional magnetic resonance imaging (fMRI) allow us to view the thinking and acting brain. Advances in genetics hold the promise of clarifying how genes are expressed in complex behaviour. Innovations in molecular biology provide insights into how the moment-to-moment changes in the chemical milieu of the brain result in behaviour. New approaches in mathematics and computer science provide us with the tools to model how the brain controls perception, thought, and action and, concomitantly, to produce intelligent machines that reflect and employ these principles.

Experimental psychology involves three distinct yet complementary approaches to the study of behaviour. One approach, which involves studies of brain processes and behaviour, is supported by NSERC. The second, which emphasizes the study of behavioural, neurological and psychiatric disorders and the treatments of such disorders, is largely supported by CIHR. The third, which focuses on the social nature of human behaviour, is supported by SSHRC. In most Psychology departments, research is funded by all three granting councils. For this reason, statistical analyses regarding NSERC-related scientists in departments of Psychology must take into account—but unfortunately often do not—that only a subset of psychologists are engaged in NSERC-related research. Moreover, GSC12 supports researchers in many departments other than Psychology, including Anatomy, Biology, Kinesiology, Audiology and Speech Pathology, Neurology and Neurosurgery, Nutrition, Optometry, Ophthalmology, Physiology, and Psychiatry. This diversity is a feature of psychology today, a sign of the attractiveness, health, and centrality of the discipline.

1.2. Past achievements of Psychology in Canada. Canadian psychology has a distinguished history [1: see references in Section 7]. One of the earliest Psychology laboratories in the world was established at the University of Toronto in 1892. The landmark 1949 book *The Organization of Behaviour* by McGill University psychologist Donald O. Hebb introduced the concepts of the "hebbian synapse" and the "cell assembly," pivotal concepts in modern computational neuroscience [2]. Brenda Milner (McGill), whose study of patient HM (begun in 1954) introduced the concept of multiple memory systems in the brain, now central to our current thinking about the neurobiology of memory, was one of the founders of the neuropsychological study of memory [3]. Ronald Melzack's (McGill) "gate theory" changed forever our concepts of pain perception [4]. In the 1970's and 1980's, Endel Tulving and Fergus Craik (U of T) and Alan Paivio (UWO) revolutionized our thinking about memory processes [5]. Roy Wise and Jane Stewart (Concordia) changed the study of psychopharmacology by relating addictions to learning processes and reward pathways in the brain [6].

1.3. BBCS in Canada today. Canadian experimental psychologists play leading roles in discoveries that are transforming the way we understand the brain and behaviour. GSC12 researchers constitute about 3% of the world's experimental psychologists, but publish over 9% of the papers in highly ranked journals in experimental and cognitive psychology **[Data in Appendix 1, Table 1]**. Many editors and associate editors of the top journals are in Canada [7]. Within the last 3 years GSC12 researchers have been awarded 32 CFI grants, 11 CRC awards, 6 Killam fellowships, 2 Killam prizes, 14 Royal society memberships, and 2 winners of Royal Society medals. What is especially distinctive about Canadian NSERC-supported psychology research is the integration of elegant behavioural experiments with careful studies of the neural mechanisms underlying this behaviour. Some highlights of this research are given below. Names of researchers are primarily based on NSERC GSC12 grants above $50K **[Appendix 1, Table 2]**.

1.3.1. Cognitive science. Canada is a world leader in the study of perception, attention, memory, problem solving, decision making, language, and consciousness [8]. New theories of basic cognitive processes, often presented as computational models, provide important insights to industry. For example, understanding visual-motor coordination and decision making, is crucial for the design of advanced communication systems and robotics. Canadian Aircraft Electronics has applied psychological knowledge about the neural processing of the human visual system to calculate such complex events as the "time-to-collision" with an object [9]. This has allowed Canada to become a world leader in the production of flight simulators for training aircraft pilots. The same techniques can be used for training drivers of other vehicles [10].

1.3.2. Cognitive neuroscience. The most complex 'intelligent system' known is the human brain, but how does neural activity produce thought and conscious awareness [11]? Answering such questions requires understanding how the brain experiences sensations and perceptions, controls movements, retains information, and solves problems. The study of these fundamental processes in the healthy, intact brain helps to elucidate the changes in behaviour caused by damage to the brain [12].

The study of the brain mechanisms underlying cognition is growing at an astonishing rate, with more than a dozen new journals in the last decade. Even 'molecular neuroscience' journals such as *Neuron* are now publishing articles in cognitive neuroscience. This is occurring because of new brain neuroimaging tools such as fMRI, positron emission tomography (PET) and magnetoencephalography (MEG) that did not exist a decade ago, and because of new developments in established methods such as single-cell recording, EEG, and event related potentials (ERPs). All of these enable rapid progress in mapping the mind onto the brain [13].

Although the brain is modified by experience throughout life, early experience plays a dominant role, setting up the initial organization of the central nervous system. It is estimated that over half of the genetic material in the human genome codes for brain development and functioning [14]. The expression of this genetic material depends on a developmental program in which neurochemical and environmental stimuli interact to modulate gene expression. GSC12 scientists study the intricate ways in which experience effects brain development [15].

1.3.3. Behavioural neuroscience. The study of perception, motivation, emotion, learning and memory in animals allows experimental manipulation and control that would not be possible in human studies. Canadian researchers have been leaders in both laboratory-based and field studies of animal behaviour [16]. The study of the behavioural, neural and hormonal basis of motivation, mother-infant interactions, circadian rhythms, stress and pain, the basis of epileptic activity in the brain, and the neurochemical and neuroanatomical basis of recovery of function following brain damage are fields in which Canadian researchers have had enormous impact [17]. In addition to contributing to fundamental knowledge, basic research in animals has important clinical applications. Concepts and findings from animal research are central to current models of anxiety, depression, phobias and panic disorder, the immune response, substance abuse and pain management [18]. GSC12 researchers have also used animal models, particularly lesion studies, single-neuron recording, and neuropharmacological studies, to reveal the intricate relations between brain mechanisms and behaviour [19] and to show how genetics and experience work together to determine the neural organization of cells in the visual and auditory cortices [20], how early experience with amblyopia or other visual deficits alters the way in which visual space is represented in the visual cortex [21], and why brain lesions at particular times in development can have devastating effects [22].

1.3.4. Genes, Brain and Behaviour. The completion of the Human Genome Project will have a great influence on Psychology. Psychology will be more important, not less important, in a post-genomics world [23]. The genome of the fruit fly (*Drosophila melanogaster*), the round worm (*C. elegans*), and the mouse (*Mus musculu*s) have also been sequenced [24]. Even more important for psychology, is the new science of Proteomics; the study of the proteins coded by each gene and the functions of these proteins in neural and behavioural actions [25].

GSC12 researchers explore the roles of genetics in normal human cognition and in conditions such as dyslexia, autism, and synaesthesia [26]. In animal research, the use of transgenic, knock-out, and mutant animals is one of the most exciting new tools for the study of behaviour and for investigating the contribution of specific gene sequences to normal and abnormal brain functioning [27]. With the completion of the human genome sequence, our window on brain-behaviour relations will be expanded enormously. To realize the potential of the genomics revolution requires multidisciplinary collaborations to study the links between genes, brain and behaviour [see Joint Neuroscience Proposal].

1.3.5. Multi-disciplinary interactions. GSC12 is inherently multi-disciplinary. Its researchers are trained as psychologists, speech scientists, neuroscientists, biologists, computer scientists, linguists, mathematicians, and statisticians, and they collaborate with computer scientists, engineers, neuroscientists, health care professionals, geneticists, physicists, educators, philosophers, and linguists. We bring to these collaborations not only an organizing theoretical framework, but also a strong experimental tradition. The multi-disciplinary nature of our research is also illustrated by the wide range of disciplines that use and benefit from psychological theories, methods and knowledge. These include the arts (eg., music theory), industry (eg., ergonomics), business and economics (eg., experimental economics) and law (eg., decision theory), as well as other scientific disciplines such as biology, medicine, and the health sciences.

1.4. The importance of GSC12 to Canada. From its basis in GSC12-funded research to its broader applications, the new knowledge created by our community is fundamental to numerous aspects of Canadian society [28] . In this report, we mention five ways in which research and training in BBCS is important to Canada.

1.4.1. The knowledge economy. Psychologists study the fundamental processes – the abilities to attend, learn, remember, and problem solve – that are essential to acquiring the complex skills needed to make the knowledge economy work [29]. Our research provides the basis for pedagogy from kindergarten to workplace retraining. The foundations for innovations in reading and mathematics instruction, the acquisition of highly skilled motor behaviour, and the multi-tasking required for operating complex machinery are all provided by GSC12 researchers. The staggering costs to society of not understanding cognitive abilities need to be underscored: Our welfare rosters and prisons are largely occupied by individuals who had difficulty succeeding in school. The emergence of the internet and 'distance education' is another domain to which GSC12 researchers are making critical contributions [30].

1.4.2. Health and productivity. Before health researchers can explore Alzheimer's disease, schizophrenia, or autism, they need to understand the nature and mechanisms of the normal brain and behaviour. GSC12 psychologists study these processes [31]. Through detailed studies of brain-behaviour relations, our community has a heavy commitment to unravelling the mystery of how mental disease occurs. Through interdisciplinary collaborations, GSC12 researchers help elucidate the cascade of events that leads to or prevents cognitive dysfunction [see 22].

1.4.3. Early childhood. Our children are our future. It is early experience that sets the stage for later functioning. GSC12 research has shown how experiences early in life organize and structure the mind and brain for optimal (or sub-optimal) learning at a later time [32]. Our research has begun to reveal the conditions under which increased plasticity and recovery might be possible later in life. This knowledge has changed — and will continue to change — social policy, governmental expenditures, and cultural attitudes and practices.

1.4.4. The aging population. Societies around the world are aging. By 2020, the number of persons aged 60 years and older will constitute 25% of the population [33]. From problems in hearing and vision to mental and emotional breakdown, too many elderly Canadians are wasting away, confused and depressed in homes or institutions around the country. The economic impact of this loss of well being and productivity – not just for the elderly, but for their caregivers as well – is substantial, and the cost in quality of life to the aging individuals as well as to their families is enormous. GSC12 researchers study the aging sensory and memory systems in both humans and animals, identifying how adjustments in the environment can allow for return of functioning [34]. Most importantly, GSC12 researchers have generated the theoretical frameworks that make this work useful [35].

1.4.5. Industry and innovation. It is not fully appreciated how closely GSC12 researchers work with industry and government. Many of our trainees currently work in industry, whether in transportation, communication, or pharmaceutical industries. Many of our researchers also collaborate with industrial sponsors on topics as diverse as the effects of early nutrition on language development [36], the design of safer instrument consoles for planes and automobiles, and human-computer interactions. Commercial products from our research include tests of visual and auditory functioning [37], and tests of reading readiness [38]. Many research projects in GSC12 have resulted in the production of high tech companies which employ HQP [39]. Services provided by GSC12 researchers include assessment of the environmental impact of noise, expert witness testimony in the courts, advising the aerospace industry, and driver safety [40].

1.5 The supply and demand of brain, behaviour, and cognitive scientists. The statistics supplied by NSERC for Discipline Dynamics (DD) and Highly-Qualified Personnel (HQP) encompass all areas of Psychology, including non-NSERC-related areas. Moreover, the statistics do not include individuals funded by GSC12 but working in non-Psychology Departments (e.g., Neuroscience, Cognitive Science, Audiology and Speech Science). This resulted in a non-representative and misleading portrayal of the state of NSERC-funded psychology. Thus, we re-examined the data, recalculating mean values over the most recent four-year period available. To study trends in the mean values, we calculated the slope of the linear component over the most recent six-year period. The results of our analysis for DD and HQP and for faculty jobs in psychology are presented in Appendix 2 [http://psych.mcmaster.ca/bbcs/index.html]. What emerged from our analysis is the portrait of a vigorous, dynamic, and growing discipline; a portrait that differs radically from the dismal negative 1% growth that emerged from NSERC's initial indications. The number of faculty and the number of applicants are increasing rapidly and substantially, as are the number of graduates at every level. The only negative growth is the relative level of funding of GSC12, both in terms of success rate and size of grant. Our population of researchers is growing, and growing fast, such that the funds allocated to GSC12 are becoming increasingly inadequate.

1.5.1 Discipline Dynamics. The number of applicants in GSC12 is increasing at a rate that is steeper than in most other GSCs. In a field of 21 GSCs, the rate of growth of GSC12 ranked 6th in total applicants [Appendix 2, DD Table 6], 6th in new applicants [DD Table 11], and 3rd in renewal applicants [DD Table 16]. In contrast to this healthy growth in number of applicants, the level of support presents a discouraging picture. We rank near the bottom in the proportion of applicants that we can support [17th in a field of 21, DD Table 8] and also in support for new applicants [15th, DD Table 13]. The size of the average grant is also very low: we rank 15th overall [DD Table 3], and our rank is low for both new [19th, DD Table 15] and renewal [15th, DD Table 20] grantees. It is true that GSC12 ranks at about the middle in overall funds allocated [9th, DD Table 2], but this is simply because there are so many applicants.

The quality of the research done by researchers in GSC12 is extremely high: we ranked 1st among all NSERC-supported disciplines in the first reallocation exercise, and near the top in the second reallocation exercise. Despite the excellence of our research, the funds allocated to GSC12 have been in a steady decline relative to other GSCs. In 1990-91, GSC12 funding ranked 9th in a field of 21. Our rank fell to a low of 17th in 1994-95, and has remained between 15th and 16th for the past several years [DD Tables 21-29]. It is of special concern that this decline has coincided with a major increment in the cost of our research. Such a discrepancy between the excellence of our research and the level of support that it receives must be corrected if we are to stem the brain drain that has plagued us in recent years. This is especially evident if we examine the number of faculty across age groups. Our standing is relatively high except for the 45-54 age group, where we have lost some of our most productive mid-career scientists to more lucrative funding situations elsewhere. It is the loss of this age group, as much as replacing people who are retiring (where we rank near the top), that is creating the demand for faculty positions.

1.5.2 Highly-Qualified Personnel. Data gathered by the Council of Canadian Departments of Psychology for the period 1993-2000 show that about 170 PhDs are awarded each year in Psychology of which about 70 are in NSERC-related areas. In the 12 months beginning October, 2000, a total of 44 full-time tenure-track faculty positions were advertised in the CAUT Bulletin in NSERC-related areas of Psychology [CAUT job data, Appendix 2]. In addition, there were numerous post-doctoral positions. Academic positions, however, represent but a small part of employment opportunities. NSERC-trained PhDs are sought after by industry, hospitals, and research institutions for their excellent methodological and analytical skills. In addition, our graduates are highly marketable in faculty positions outside Canada, reflecting the brain drain that we hope to stem.

Of the 13 clusters identified in the NSERC statistics, Psychology ranked 1st in enrolment of Bachelor's, 4th in Master's, and 1st in PhD's [Appendix 2, HQP Tables 1, 2, and 3, respectively]. With respect to degrees granted (as distinct from student enrolment): we ranked 1st , 6th, and 2nd for Bachelors, Masters, and PhDs, respectively [HQP Tables 4, 5, and 6]. The rankings are equally high (2nd) for PhDs awarded in the U.S. to Canadian citizens [HQP Tables 9 and 17]. In light of these data, we are at a loss to understand NSERC's prediction of low growth in the number of PhD students and low demand for new faculty in Psychology. Even B.A. students and Clinical Psychology students receive training in cognitive psychology and neuroscience classes taught by NSERC-related faculty. Missing from these statistics are students trained in such interdisciplinary programmes as Cognitive Systems and the Neurosciences. Many students enrolled in such interdisciplinary programs are trained by faculty members who are GSC12 researchers. Science journals are replete with ads for behavioural and cognitive neuroscientists. Because demand is so high, it is difficult for Canadian universities to fill these positions.

Finally, a discrepancy regarding student support must be noted. We rank near the top in numbers of PhD students, but our expenditures on graduate students and PDFs are among the lowest. While we rank 1st in number of PhDs enrolled [HQP Table 3], we rank 19th in a field of 23 in the amount of money spent on graduate students [HQP Table 15] and 14th on PDFs [HQP Table 16]. This discrepancy is explained easily, if unhappily: our grants are too small to provide the required support. With an average grant size of $28,377 (from 1998 to 2001) it is impossible for members of our community to support students and PDFs while hiring technical support required and paying for supplies, maintenance, imaging, and animal costs. Although psychology students and PDFs win numerous NSERC and other scholarships and fellowships, not all of our students can be supported.

2. VISION: WHAT ARE THE FUTURE DIRECTIONS OF PSYCHOLOGY?

Our vision for GSC12 is to continue to produce world-leading research in BBCS. To fulfill this vision, we must shift psychological research facilities from innovative but inexpensive to state-of-the art computational, neuroimaging, neurogenetic, and bioinformatic technologies. Such new technologies are expensive, require high levels of technical expertise, and necessitate interdisciplinary collaboration. The next decade of research in BBCS will require investment in three inter-related initiatives.

2.1. Cognitive science/cognitive neuroscience. It is imperative that we continue to promote research on the basic mechanisms of human perceptual, cognitive, linguistic, developmental, and affective processes using non-invasive techniques such as fMRI, PET, MEG, ERP, and EEG. At the same time, it will be essential to develop and implement research on computational models of these neural processes. This research will lead to fundamental breakthroughs in our understanding of the neural substrates of cognitive dysfunction in stroke, neurological and psychiatric disorders, and the new models of cognitive dysfunction will provide unique opportunities for evaluating the efficacy of treatments of these disorders. The study of the neural substrates of sensorimotor control has important implications for the design of 'bioprosthetic devices' which make use of neural signals to drive machines. Once the neural code is specified, neural implants could be built for patients with spinal damage to control robotic arms or to operate other machinery by simply 'willing' an action. This marriage of cognitive neuroscience, biology, and engineering has profound implications for the rehabilitation of neurological patients and for the development of hi-tech industry in this country. Similarly, understanding the way in which cognitive functions are realized in brain circuits can inform engineers who are trying to devise more efficient human-machine interfaces, tele-operation and tele-assistance systems. Techniques such as tele-surgery will benefit from information about the computational constraints of human cognitive and sensorimotor systems, which are what the surgeon depends upon to control movements in performing surgery. Hi-tech companies interested in artificial intelligence, robotic control, and tele-operations are already looking to cognitive neuroscience for directions and design.

2.2. Developmental cognitive neuroscience. Cognitive development is an area in which Canadian researchers are exceptionally strong, from behavioural studies of the cognitive processes underlying reasoning, literacy, and attention to neuroscientific studies of the biological underpinnings of development. For example, GSC12 researchers have shown how experience alters sensitivity to one's language by changing the sensitivity of the brain to the basic units of that language, and that similar processes are at work in listening to music [32]. It is also important to support projects that study behaviour and brain activation in individuals with accidental brain damage in order to elucidate the neural mechanisms underlying specific cognitive, affective or social behaviours. The psychology of early development has a wealth of knowledge that is being recognised by other disciplines, which are interested in the long-term effects of child disorders such as autism and ADHD. Fostering the growth of developmental cognitive neuroscience in Canada will be one of the most important goals of GSC12 in the next decade.

2.3 Behavioural neuroscience: the genomic revolution. Much of our knowledge about ourselves rests on knowledge gleaned from animal models for the study of perceptual, cognitive, and affective processes and the effects of neural damage on these processes. This work is increasingly crucial and increasingly expensive – particularly as the methods of genomics and proteomics become part of our arsenal. The expansion of neural and behavioural genetics research in Canada will require support for studies on the genetic mechanisms underlying perceptual, cognitive, and affective processes, their neural representation and their abnormalities. Studies of transgenic, mutant and knockout mice and other species with known genomes allow for genetic manipulation of the brain and subsequent changes in behaviour. This research will involve psychologists and behavioural neuroscientists developing new approaches to neuro-behavioural research, often in combination with geneticists and molecular biologists.

3. STRATEGY and SPECIFIC PROPOSALS

The strategy to implement our vision involves four goals: (1) to build research expertise in the most up-to-date techniques in the life sciences, especially in genomics, proteomics and bioinformatics; (2) to cover the increasing costs of imaging and animal research; (3) to train our students in modern research procedures and equipment usage, including those of computational modelling and analysis; and (4) to build multidisciplinary research teams. For each goal, our request is for increases in the research grants fund (Type 1 proposals) to cover increasing base costs that extend into the foreseeable future. Psychology researchers have excelled with little funding in the past; we can no longer do so.

The GSC12 budget is $11.876M ($2.97M/year) with $1.188M ($297K/year) going into the reallocation pool. In 2001, GSC12 awarded 127 grants to 162 applicants (78.4% success) with a mean grant size of $25,766 ($17,309 for new applicants and $31,624 for renewals). To run a modern laboratory with a part-time technician, one graduate student, and an honours student, plus equipment, consumable lab supplies, and travel, the average grant needs to be at least $50,000 per year. Add animal or imaging costs, and that figure easily becomes $65,000. Although these amounts might seem unrealistic set against the historical funding profile of GSC12, they are an underestimate of what is necessary for cutting-edge research in BBCS today. Our aim in the reallocation exercise is to increase the mean GSC12 grant to $35,000 while maintaining a 75% success rate. To do this will require a return of the $1.188M from the reallocation pool plus an increase of $1.212M for a total of $2.4M ($600K/year).

3.1. Funding HQP. Psychology research in Canada is done on a shoestring, with little funding for technical assistance. With the technology required for research becoming increasingly complex, highly trained technical assistance is essential, and a keen (often unpaid) undergraduate no longer suffices. Our first request is, therefore, for increased funding for highly qualified research personnel. The training required varies, but includes neuroimaging, electrophysiological, neurochemistry, computational, neural, genetic, and bioinformatic techniques. These are areas of life science and computational science that are not traditionally associated with Psychology, but involve skills that are now required for psychological research to advance and to become fully integrated with recent advances in the life sciences and computational sciences. Special consideration must be given to researchers for adding expertise in genetics to their research skills. Many areas of psychology involve the application of genomic knowledge to the study of brain, behaviour and cognitive science. We request $250,000/ year for hiring HQP. This will provide up to 25 researchers an extra $10,000 to hire HQP to bring new technical expertise to their research.

3.2. Imaging and animal care costs. Current cognitive psychological research increasingly involves imaging technology, which has very significant operating costs. For example, costs typically run $1,000 per subject in a fMRI study. Most studies would require 5-10 subjects. Assuming 3 studies per year, the total costs would be $30,000. Animal care costs continue to rise. It costs, on average, $0.38 per rat per day and $0.20 per mouse per day for animal care and housing. To keep 120 rats/day for one year costs $16,644 per year. Transgenic and mutant mice can cost up to $150 (US) each! and require special care. We request $200K per year for imaging and animal care costs. This could provide up to $10,000 extra for 20 researchers each year.

3.3. Training HQP. Very few students begin their graduate programs knowing how to use the equipment and techniques required for their research. They must spend considerable time learning these techniques and there is a high cost for this training in terms of time on equipment, consumable lab supplies and faculty/technician time. The increased cost of training students has resulted in many labs taking only PDFs. However, there is an urgent need to train graduate students and to familiarize undergraduates with new research methodologies. The need for trainees in BBCS in Canada is crucial to fill the faculty vacancies as those hired in the 1960s retire [see Appendix 2]. Many hospitals and other health-related institutions also require personnel trained in neuro-imaging techniques. If we do not train more graduate students, we will have a serious shortage of PhDs in the next 10 years. Because honours students are pre-graduate students, funding must be available to encourage them to go to graduate school. We request $100K/year for training. This would provide 20 grants of $5000 to facilitate training HQP. While the majority of this would be directed toward graduate student training, some could be used to support honours student research and undergraduate students.

3.4. Interdisciplinary and international collaborations. To foster collaborations among investigators from different fields and different countries, we must increase the funds available for interdisciplinary collaboration. Since the creation of collaborations in the field of BBCS takes some time, investigators may require grants for pilot studies to seed new collaborations. For this reason, we include a joint proposal for neuroscience research with GSC30/31. The present proposal covers non-neuroscience collaborative research in psychology, international collaborations, and collaborations with non-NSERC researchers. It is costly to be involved in a collaborative research project. Experimental costs, travel, housing, and equipment fees are all involved. To encourage collaborative research, which is very much the future of our science, further base funding is necessary. We propose a budget of $50K/year to be used as requested by grantees to facilitate international and interdisciplinary research collaborations. This amount would cover 25 requests for $2000 or 7 requests for $7000, depending on the needs of the applicants.

3.5. Procedures for distributing the reallocation funds to grantees in GSC12. We propose that all reallocation funds be distributed by GSC12 during the February grant review meeting. In the minibudget, each grant will be given a score and a budget. The budget will be allocated in two parts, $X from the basic GSC12 budget and $Y from the reallocation budget. At the February meeting, a justification can be made for giving funds from the reallocation budget and grants with a joint neuroscience proposal can be recommended for extra funding from this joint budget.

4. CONSEQUENCES OF NO REALLOCATION FUNDS

According to the May 2001 Speech from the Throne, Canada ranks 15th in the world in R&D investment, and the key objective of the government is to be in the top 5 countries for R&D performance by 2010 [41]. GSC12 has long held that status [42]. Canada is ranked third (behind the U.S.A. and U.K.) in highly cited papers in Psychology and Psychiatry as well as in Neuroscience over the past two decades [Appendix 1, Tables 3A & B]. But this is not a reason to be complacent. As the costs of doing world-leading psychological research mount, there is a very real danger that Canada will slip from this standard. The areas of strength in Canadian psychology are in the NSERC-supported domains of BBCS, as reflected in the most cited 240 Canadian papers in the ISI database [42]. Some of these top researchers are supported by CIHR and SSHRC, but many are supported by NSERC. A disturbing feature is the number who are no longer in Canada: Of the top 50 cited authors in Psychology and Psychiatry [Appendix 1, Table 4], 42% (17/41) have left Canada. Of the top 10, 8 have left Canada and one is deceased, leaving only one in Canada. Likewise, 37% (18/49) of the top Neuroscience researchers (4 of the top 10) have left Canada [Appendix 1, Table 4]. So from 1981-1998, Canada ranked third in the world in Psychology/Neuroscience and now 40% of the top researchers contributing to this high ranking are no longer in Canada. Appendix 1, Table 2 shows the top 43 GSC12 grant holders in 2001. These are the leaders of Canadian psychology today: How many will stay in Canada? Funding for psychology must be increased if we are to retain our place in the world rankings. Indeed, we strongly believe that, given appropriate funding, we could rank ahead of the U.K.

5. IMPACT AND CONSEQUENCES OF THE IMPLEMENTATION OF THE 1998 REALLOCATIONS DECISIONS

GSC12 was awarded additional funds in the previous Reallocations Exercise to assist in two primary areas: neuroimaging costs (Pool 1), and animal care costs (Pool 2). In Year 1 (1999), we awarded reallocation funds on the basis of the overall excellence and needs. The situation became more difficult the following two years. In 2000, GSC12 was encouraged by NSERC to set aside a substantial portion of their budget for 2001, because NSERC's projections indicated severe pressure that year. This action created unexpected pressures during the adjudication process, and made it very difficult to award acceptable levels of funding to New and Continuing Applicants. The targeted funds were again awarded in the areas requested, and the remaining funds used to make up for the unexpected decrease in the budget pool. As expected, 2001 was a very difficult competition. Not only did the continuing applicant pool produce a bulge in budgetary needs, but the number of New applicants continued to increase at a faster rate than predicted (41 new applicants versus 23 in 2000). Again, all funded grants with research in the targeted areas were given additional money, but with NSERC's approval, some of the money was used to relieve the extreme pressure on the remaining applicants. Even so, the success rate was lower in 2001 than in 2000, and lower in 2000 than in 1999. The pressure on GSC12 is extreme, and we have acted in the most reasonable way, with NSERC’s guidance and consent, to deal with that pressure in recent years. In summary, it was not easy to implement the new funding decisions of the 1998 exercise; the separate pools complicated competition week considerably. Nevertheless, the new money made a real difference: in 2001, 53 of 127 applicants received an average $5400 increase from these funds.

6. CONCLUSIONS. See Executive summary

7. BIBLIOGRAPHY

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Barrie Frost: Co-editor, *Journal of Comparative Psychology*.
Jeff Galef: North American Editor, *Animal Behaviour*.

Ray Klein: Associate Editor, *Journal of Experimental Psychology: Human Perception & Performance*.

Bryan Kolb: Associate Editor, *Psychobiology* (1986-1990).
Morris Moscovitch: Co-editor-in-chief, *Neuropsychologia.*
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WaveMakers is a developer of voice recognition software.
[http://www.wavemakers.com/welcome/homepage.cfm].

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[42] The Institute of Scientific Information (ISI) database on "High impact papers: 1981-1998" ranked Canada third (behind the U.S.A. and U.K.) in highly cited papers in Psychology and Psychiatry as well as in Neuroscience over the past two decades [Appendix 1, Tables 3A & B show the top 20 countries on each database].