ENHANCING SUCCESSFUL RESEARCHERS

AMIDST THE INFORMATION EXPLOSION

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Civilization advances by extending the number of operations which we can perform without thinking about them. Alfred North Whitehead

The foregoing aphorism, composed by one of the great British thinkers of the early 20th century (Whitehead, a colleague of Bertrand Russell, was a mathematician, scientist, and philosopher), highlights both the importance of thinking and the value of inventing ways to free us from elementary operations (e.g., digging a ditch with a shovel) so we can spend more time thinking. During our recent cultural evolution, we have built machines that can perform billions of operations per second without our attention. The time we have saved by not having to perform what we now think of as trivial operations (e.g., doing arithmetic with paper and pencil) has been devoted increasingly to thinking. And a great deal of this thinking has been applied to the development and archiving of information aimed at further enhancing our ability to "perform operations without thinking about them!" Through positive feedback these processes have produced an information explosion. Pundits estimate that the amount of information in any field doubles every 15 years. In the sciences the rate of growth of new information seems almost overwhelming to the individual scientist.

The rate of growth of information related to our survival and well being is many orders of magnitude greater than the rate of evolution of our brains–our organs for processing information. The biological determinants of our brain's information processing capacities probably hasn't changed much in the last 50,000 years. Yet the volume of information we are expected to acquire and manipulate per unit time has increased dramatically. Thus, we cannot expect biological evolution to have much of an influence on our ability to adapt to these increasingly information-rich environments we find ourselves in. Whoever it was that said we only use 10% of our brain's capacity was speaking about him or herself for there is no scientific basis for such a claim! Thus, we cannot expect to cope with massively increasing amounts of information by simply using the previously unused 90% of our brain's capacity. We now know that information overload can lead to stress, and stress, as shown by Sapolsky's work, can actually kill hippocampal neurons, i.e., brain cells that are crucial for memory. So the information explosion may be self-limiting if we do not develop coping methods compatible with our biological limitations. One of our adaptive behavioral responses has been specialization into ever more narrow content areas. This too, may be self limiting if we do not take measures to ensure communication across the specialty domains (i.e., tower of Babel will ensue, etc.).

As scientists, we are certainly caught up in the information explosion, and as I was thinking about these matters, I could not suppress my urge to collect some data– something tangible to go by. So I decided to compare, in terms of information content per article, two issues of the *Journal of Comparative and Physiological Psychology*, one issue from April 1968 and one from April 1998 (the journal changed its name to *Behavioral Neuroscience* in about 1980). This is a 30-year time span; according to the rule that information doubles every 15 years, during a 30-year interval information will increase four fold. In order to compare the two journal issues, I computed the average number of authors, figures, pages, references and tables per article. The data are shown in the following table. These data show that the size of the article in 1998 is much larger than in 1968. The number of references increased more than four fold (a ratio of 4.7)

Variable Name	1968	1998	Ratio (1998/1968)
Authors	1.7	3.1	1.8
Figures	2.4	7.9	3.2
Pages	6.0	13.6	2.3
References	12.2	57.6	4.7
Tables	1.4	1.0	0.7

during the 30 year interval, a result roughly consistent with the 15-year rule. I conclude that current publications in *Behavioral Neuroscience* reflect a lot more information, thinking, scientific energy, and collaboration, compared to 30 years ago.

Over the past 30 years, just as there has been an escalation of standards for high quality scientific publication, there has also been a concomitant increase in the difficulty of securing funding from the National Institutes of Health (NIH) and the National Science Foundation (NSF). At NIH, the Division of Research Grants (DRG) has recently changed its name to the Center for Scientific Review (CSR), and along with its name change, the criteria for the peer evaluation of research proposals have been made more demanding. The new criteria focus attention on five dimensions that research proposals should address: significance, approach, innovation, investigator, and environment. What is new in these criteria is the explicit mention of innovation. In addition, collaborative arrangements are explicitly mentioned in regard to the research environment. More specifically, the verbatim descriptions for innovation and environment are:

> "Innovation. Does the project employ **novel** concepts, approaches or methods? Are the aims **original and innovative**? Does the project challenge existing paradigms or develop **new methodologies or technologies**?
>
> Environment. Does the scientific environment in which the work will be done contribute to the probability of success? Do the proposed experiments take advantage of unique features of the scientific environment or employ useful **collaborative arrangements**? Is there evidence of institutional support?"

These criteria make it clear that proposals, more than ever, must include innovative approaches and demonstrate interdisciplinary or interlaboratory collaborations.

Not only do contemporary grant proposals have to be four times as well informed as in 1968, the proposals also should contain explicit evidence for innovation and collaboration. Innovation and collaboration are believed by peer reviewers only if they are already demonstrated in the proposal with evidence from pilot studies. As you probably know, the forging of collaborative arrangements requires time-consuming discussions and new learning. Learning new material, while satisfying to most scholars, is usually quite time consuming compared to keeping up in your own specialty area. In order to collect the pilot data needed to address the demands for innovation and collaboration in today's grant proposals, one needs both time and money.

As most of you know, the challenges of maintaining an ongoing, funded research program are daunting. As we researchers accept this challenge we have to acknowledge that the process of doing research is much like a cottage industry in that the required operations cannot be performed without thinking about them! Thinking takes time. My perception is that most of the successful researchers that I know mostly live a zero sum game in terms of time. A new activity can only be added to the schedule if some other activity is deleted.

Given the current research climate, how can we enhance research productivity of the already successful researcher? In general, the mid-career scientist needs help with time and money! The Principal Investigator needs to concentrate on the creative, thought-based tasks that only he or she can do. Other tasks should be assigned to support staff. Concurrently, the principal investigators need additional resources for developing collaborations and innovations.

Although I can think of dozens of specific types of staff support and services that could be improved at KU and probably at most state-supported research universities, I want to suggest to you just two modifications of university operations that I think would have the biggest effects on increasing research productivity while having the least adverse impact in terms of cost of implementation. My two suggestions are: (1) link salary decisions directly to the desired research outcomes, and (2) establish internal research accounts for active principal investigators.

Linking Salary Decisions to Research Productivity

The core concept here is obvious, namely, rewards (reinforcers) increase the frequency and intensity of the behaviors that are perceived to produce the reward. If the decision is made to link salaries to research productivity then the implementation should consider the following points:

- The linkage should be specific and explicitly stated.

- The necessary evaluation component of implementation would benefit from judgements drawn from outside of the traditional departmental framework. Given the diverse specializations of researchers within some departments, expertise for judging research productivity (including quality) may possibly be found outside of departments rather than within them. In addition, although it is presumed that departments adhere to the conventional 40%-40%-20% formula for allocation of time to teaching research and service activities, respectively, there is no assurance that such a formula is adhered to because departments sometimes (often?) have values or missions that conflict with this formula.

- The research centers or institutes are one likely source of the needed extra-departmental peer evaluators of research productivity.

Advantages of linking salaries to research productivity are:

- Directly linking salary increases with research productivity will help maintain current levels of activity by successful principal investigators.

- Higher salaries would almost certainly improve recruiting of research scientists.

- Faculty perception of administrative efficacy would increase. To be understood, this point requires explanation. By not having a clear system of rewards for research success the administrators are deprived of a source of behavioral control related to research growth and maintenance. For the faculty that have their time largely controlled by research and the grants process ("largely controlled" means that evening and weekends are devoted to the research effort), the current incentives are extramural, not intramural. The local university administration is sometimes perceived as having little to give the researcher. Those with the money (i.e., NIH, NSF) and those peer reviewers who largely decide who gets the grant money do not reside on the campus. One way for the university administration to exert more influence is to make it clear through explicit responses that they do have resources to devote to the enterprises that they want to grow. In my view, a major reason that university administrators are sometimes perceived as having little influence is the poor financial support available from the state governments so the administrators haven't had enough money to stimulate change. And at the same time, the federal government continues to escalate its control by providing grant dollars or by threatening to terminate them unless expensive compliance issues are addressed.

- Some faculty who only recently became inactive in research may renew their research efforts. I emphasize "recently became inactive" because I think those long inactive simply will not be able to restart, primarily because the amount of new information to be mastered will be overwhelming.

- The probability of retaining the best faculty will increase. The efficiency of such faculty will also increase because they won't have to use their valuable time trying to develop offers elsewhere as a means increasing their salaries. Also, important collaborations can be broken up when a key researcher departs, and thus the departure can have an effect on research programs well beyond the loss of one valuable person.

Disadvantages of explicitly linking salary decisions to research productivity:

- It will be unrealistically expensive to do so.

- Anti-research forces on and off the campus will have a clear target to attack.

- The teaching-research conflict may be intensified unless the "different-roles" model of faculty activity is adopted. The different-roles model means a departure from the 40%-40%-20% standard formula of time allocation for the faculty. Most often, this means that those who prefer teaching activities over research activities will do more teaching than research (e.g., 70%-10%-20%, for teaching, research and service, respectively).

- Explicitly linking salary decisions to research productivity will probably produce salary differentials across disciplines that are even greater than the large discrepancies we currently have (e.g., classics vs. computer science).

Establishing Internal Accounts for Principal Investigators

My second suggestion for enhancing the research productivity for already successful researchers is to establish internal research accounts for principal investigators (P.I.s). Let me explain this idea by addressing three questions. Where would the money come from? Procedurally, how would the money be dispersed? What are the advantages and disadvantages of this idea?

Where will the money come from? The money, of course, would almost certainly have to come substantially from indirect cost reimbursement (overhead), but some portion could be drawn from the state-allocated part of the research budget (if there is any) or from private donations.

Procedurally, how would the money be dispersed? Two non-mutually exclusive methods come to mind.

Method 1: Upon actual submission of an NSF, NIH, or similar grant, the P.I. would automatically receive 5% of the year 01 budget to pursue the research aims of the grant.

Method 2: Funded investigators should receive yearly 10% of the indirect costs given to the university by the funding agency.

If only one method is selected, then I recommend Method 1 because this procedure will directly stimulate proposal submissions. Even successful researchers very often do not receive funding upon the first submission, and the odds are known to be low, about 1 in 5. A major proposal, requiring 150 to 300 hours to prepare, is more easily initiated if at least some payoff is a certainty.

Advantages of having internal accounts for P.I.s are many. These include:

- Submissions of grant proposals will increase because P.I.s and prospective P.I.s will know that writing the proposal is not an all-or-none gamble (related specifically to Method 1).

- The P.I. will have the flexibility to invest this money in the best possible way for the vitality of his or her research program.

- No justifying documents need be created for obtaining or using the money. This saves time!

- The money can be spent immediately when new opportunities arise.

- Because the accounts will be able to accumulate assets, SAVING and PLANNING will be amplified. Saving and planning are limited in the current extramural grant climate.

- Recruitment of research scientists will be improved.

- The funds will be used to strengthen specific laboratories. Building a laboratory's capabilities and survival chances are tantamount to building the university's research capability.

- The money can be used for developing pilot data with interdisciplinary collaborators, thereby making future proposals more competitive.

- The P.I.s fund will serve as the source of bridging funds to keep projects or personnel active when competing renewal proposals are not funded on the first submission.

- Important travel opportunities can be pursued without having to spend one's personal money and without having to approach administrators for ad hoc handouts (which saves everyone's time).

- Extra resources in the laboratory will increase the probability of bringing undergraduates into the research program.

Disadvantages of creating such accounts can also be anticipated. Some of these potential disadvantages are:

- The P.I.s will spend the money unproductively. This seems very unlikely because one of the strongest motivators for most research scientists is the desire to keep his or her research program on track. One of the scientist's most powerful rewards is the sense of discovery that arises from new and unexpected results from the laboratory's experiments. When scientists are cut off from direct access to the discovery experience, they often think about retiring–or becoming administrators.

- A few successful P.I.s will begin to exert unwelcome influence over their department or research center. This potential problem can be illustrated by a fictitious scenario. Imagine that Professor Rakus Markle amasses $150,000 in his internal account. When a faculty vacancy is to be filled, Professor Markle says "If, from among the three finalists we have identified, you hire Dr. Laser White, who could contribute greatly to my laboratory's capabilities, I will contribute $75,000 to Dr. White's start-up costs." Of course, this could happen, but the question is whether more good than harm would result from the consequences of having internal accounts.

- Such accounts under the control of the P.I. will lead to redundant equipment purchases or other redundancies of effort and thus be inefficient compared to "central" control of the same amount of money. This point is most frequently debated in the context of large equipment purchases (instruments that require a dedicated staff to operate them), and seems valid under circumstances where several laboratories can share the equipment and no single laboratory can commit the necessary resources. However, when smaller instruments are involved (e.g., a microtome or a stereotaxic instrument) the advantage of having immediate access to the instrument often far out weighs the cost of duplicating the instruments across several laboratories.

- Interdisciplinary research will actually be inhibited rather than stimulated. The P.I. may turn inward with the extra resources, but the new NIH review criteria, with their emphasis on innovation and collaboration, should act as a strong counter force to any such tendency.

- Administrative efficacy will be diminished because of the redistribution of funds. For example, a dean trying to create a start-up package, may fall short because he or she did not have the extra 10%. This is a distinct possibility, but I suspect that the 10% in the hands of the P.I. will have a greater overall beneficial effect on research productivity than the same amount in the hands of a higher level administrator who is usually thinking about issues more global than those that affect individual laboratories. In trying to attract new researchers to the university, it should not be forgotten that the already-present successful P.I.s need to be maintained as the base upon which subsequent growth occurs.

- The existence of such accounts for scientists will depress the non-science faculties. While there is some truth to this criticism, it can be pointed out that grant programs are available to non-science faculty.

- What amounts or percentages would be appropriate for grant applications ineligible for indirect costs? Policies would have to be developed to address this issue.

- P.I.s may pad their budgets to increase returns to the account (especially under Model 1). This, does not seem likely given the sophisticated acumen of NIH study sections to detect and eliminate any unnecessary budget items. In addition, experienced P.I.s know in advance that perceived over-budgeting will undermine confidence in the P.I. and reduce the proposal's score.

- The rate of low quality proposals will increase, with attendant harm to the reputations of the P.I. and the institution (under Model 1). This could occur. But most Ph.D. faculty are usually quite motivated to do their best once an intellectual challenge is accepted.

Addressing salary issues and establishing internal accounts will enhance the research productivity of successful researchers as they continue their careers in an environment where both competition and information are expanding at unprecedented rates.