Some of my professional discoveries about hunger provide a basis for sympathy with Roberts' thesis but also for criticism of his examples. In some instances, I can't tell if personal experience stimulated the hypothesis, my theorising triggered the self-observations, both, or neither.

For example, Booth et al. (1970) provided the first (group) evidence that protein is better than carbohydrate in a meal at keeping hunger at bay some hours afterwards. The finding has been replicated several times (most recently by Long et al. [2000]); indeed, the original pair of experiments was limited, like all single studies, and so needed to be extended by different designs (very differently by French et al. [1992]). The effect, moreover, may be the key to low-carbohydrate diets (like Atkins'): weight loss occurs only when energy intake is lowered, and reduction of hunger by the raised protein content may enable this self-restriction to be better sustained (Bravata et al. 2003). The autobiographical twist on this is that I had gained the impression that meals based on rice, even when I had eaten enough to feel very full, left me hungry again little more than an hour later. For a long while now, I have believed that I can prevent this (other) "Chinese restaurant syndrome" by including enough flesh food of some sort in the meal. Yet I can't tell if this effect is self-experimental evidence for the hunger-delaying effect of protein or autosuggestion from – or valid application of – my theory of late mobilisation and utilisation of assimilated amino acids through the alanine cycle.

On Roberts' ideas about sleep, he pleads that the basis of his anticipatory awakening is "surely not expectation." Yet it is likely that he was aware that he was not going to have his usual breakfast: I regularly wake early when I know I have something unusual to do when I get up. Quite apart from autosuggestion, Roberts fails to allow for some obvious mechanisms. For example, eating fruit in the evening could induce earlier waking because fruit fills the bladder more than drier foods do.

The most disastrous moves made by Roberts deploy the notion of a "set point" for body weight. This concept of a reference value is simply redundant when there are opposing negative feedback functions (Booth et al. 1976; Peck 1976). Furthermore, even for body temperature regulation, the hypothalamus has only countervailing networks for heat production and dispersal – no 37°C-setting neurones. The urgent scientific issues about obesity are the mechanisms by which a person can most easily lose more energy than they gain during and between meals (Blair et al. 1989; Booth 1998): "set" points that move (!) divert attention from the real scientific problems. Similarly mind-numbing is the unoperationalised notion cited by Roberts that flavour-calorie associations increase "palatability" (Booth 1990; Conner et al. 1988).

Basic mistakes undermine these designs and interpretations. One example will have to suffice here: sucrose is a compound of fructose and glucose and so is useless as a control for fructose. Indeed, a lot of fructose without glucose is poorly absorbed and the resulting upset could reduce hunger (Booth 1989, p. 249). Roberts can swap anecdotes with his readers for a very long time, but scientific understanding is not advanced until a literature-informed hypothesis is tested between or within groups in a fully controlled design shown to be double-blind.

To conclude, personal experience can be a good way to get new ideas. Deliberate manipulation of the environment and keeping an eye open for unusual consequences may accelerate the generation of hypotheses. Yet the only way that science progresses with new ideas is to test novel hypotheses against existing theories in a competent design. Individualised analysis of complex performance (Booth & Freeman 1993; Booth et al. 1983; 2003) is also grossly neglected but requires adequate design and aggregated data. Don't compare conclusions; find out about mechanisms.

Dionysians and Apollonians

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Abstract: There are two sorts of scientists: Dionysians, who rely on intuition, and Apollonians, who are more systematic. Self-experimentation is a Dionysian approach that is likely to open new lines of research. Unfortunately, the Dionysian approach does not allow one to predict the results of experiments. That is one reason why self-experimentation is not popular among granting agencies.

The title of this commentary is borrowed from a letter to *Science* by the Nobel laureate Albert Szent-Györgyi (Szent-Györgyi 1972). In it, Szent-Györgyi recalled that the terms Apollonian and Dionysian, proposed earlier by J. R. Platt (in a personal communication), reflect extremes of two different attitudes of mind that can be found probably in all walks of life, but apply especially well to scientific research. Apollonians tend to develop established lines to perfection, whereas Dionysians rely on intuition and are more likely to open new, unexpected lines of research

Self-experimentation, as demonstrated by Roberts, is evidently Dionysian. Roberts shows how the results of each experiment led to a new hypothesis, then to another self-experiment, and so forth. I can modestly confirm that I have also experienced a similar concatenation of ideas. For my M.D. thesis, I trained in the area of temperature regulation in relation to central nervous system physiology under J. Chatonnet (researching exclusively with dogs, which was still possible back then); then I did a post-doctorate under P. Dejours, a respiratory physiologist. Dejours proposed that I should check whether what he had discovered and termed "accrochage" – that is, the peripheral nervous signal for hyperventilation at the onset of exercise – would also take place with shivering. It did, but that is not my point here. Both of us served as subjects in an experiment with acute cold exposure aimed at arousing shivering. During these sessions, I experienced what J. Barcroft and F. Verzár had discovered and described as "basking in the cold": a sudden relief and relaxation between the bursts of shivering that accompany intense cold discomfort (Barcroft & F. Verzár 1931). This observation largely determined my future life in research, because after returning from Dejours' lab I started to study what caused "basking in the cold." This led to another fruitful experience. One day I had subjected myself to a hot bath in order to study the influence of core temperature on thermal comfort and was in a hurry because another subject was supposed to arrive in the lab any minute. While I was cleaning the bathtub with a hose, I became aware that the very cold water from the hose felt pleasant on my hand. The ice-cold water, usually unpleasant, felt good! It felt good because I was still hyperthermic and sweating. This was the beginning of a still-active line of research: first, on sensory pleasure, then, on other pleasures like taste: then, on phenomena like earning money or enjoying poetry. I have described the process of self-experimentation leading to new lines of research, and the sequence of events that determine lines of research in my book *La Quête du Plaisir* (Cabanac 1995).

Thus, my experience confirms Seth Roberts' experience. I congratulate *BBS* for giving a voice to such an unusual, and unpopular, view. The advantage of self-experimentation has been demonstrated in the target article. However, a profound disadvantage lies hidden in this type of approach, as recalled by Szent-Györgyi himself. The Dionysian approach of self-experimentation indeed favors "accidental" discoveries (by well-prepared minds), but it is impossible to predict what will be found, and what the next question will be. Yet, nowadays research is a profession, managed by professionals, with strict criteria. Large amounts of money are usually needed for research and this often comes from the public; hence, taxpayers must be confident that their contributions are well spent. In turn, granting committees tend to demand detailed descriptions of the research projects, with a cascade of experiments and their expected results predicted in advance. This is not

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how the Dionysian brain works. Since the Dionysian approach is often undertaken when the outcome of experiments is unpredictable, self-experimentation is rarely popular with granting agencies.

Linking self-experimentation to past and future science: Extended measures, individual subjects, and the power of graphical presentation

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Abstract: The case for the value of self-experimentation in advancing science is convincing. Important features of the method include (1) repeated measures of individual behavior, over extended time, to discover cause/effect relations, and (2) vivid graphical presentations. Large-scale research on Pavlovian conditioning and weight control is needed because verification could result in easy and inexpensive mitigation of a serious public health problem.

Several years ago, Irene Grote, a former student of mine and now a research scientist at the University of Kansas, expressed her conviction that increasing the frequency of self-experimentation among behavioral scientists would contribute significantly to the scientific understanding of behavior. I was not convinced and countered that self-experimentation was a fine tool for personal development and self-understanding, but I doubted its relevance to advancing science. Roberts' target article happily proves Dr. Grote right and leads the way in using a time-honored and powerful research method to bring experimental rigor to the task of integrating the principles of evolutionary theory and the principles of learning.

The first feature of Roberts' research that demands my attention is his use of repeated measures, over extended time, of the behavior of an individual organism to experimentally analyze the variables affecting behavior. Roberts' use of long baselines followed by systematic and repeated manipulations of independent variables is characteristic of the work of Pavlov, Skinner, and virtually all behavioral researchers whose work with nonhuman organisms led to our current understanding of behavioral processes operating during the lifetime of individual organisms.

Roberts' use of this experimental method in self-experimentation has added to its usefulness in two ways. First, self-experimentation allows experimenters a kind of extended access to the behavior of adult human subjects that is difficult – if not impossible – to achieve otherwise. Most people simply will not participate for years in someone else's scientific experiment, so the kind of long-term experiment that is usually possible only with nonhumans is now made possible with humans doing self-experimentation. Second, Roberts has extended the use of this experimental method to explore characteristics of human behavior that may have their origin in the history of the species. In doing so, he brings the experimental method to bear on hypotheses heretofore examined only in terms of correlational research, and his amazing graphs powerfully reveal the effects (or noneffects) of his independent variables. As pointed out by Smith et al. (2002b), "graphs constitute a distinct means of inference in their own right" and graphs "are uniquely suited for the coordination of scientific activities (experimental, numerical, and theoretical)" (p. 758).

The second arresting feature of Roberts' article is the potential importance, both theoretical and practical, of his theory that the set point for weight maintenance can be (and often is) changed via Pavlovian conditioning. If the role of Pavlovian conditioning is supported in the case of weight control, the theoretical importance of this finding extends well beyond the realm of weight change. The theory offers an entrée into the vast and almost unexplored borderland between evolutionary biology and principles of learning, and it brings experimental rigor to the task of integrating the principles of evolutionary biology and the principles of learning.

On the practical side, Roberts' data clearly call for a large-scale investigation under tightly controlled conditions to test the Pavlovian conditioning theory of set point. Should the hypothesis be confirmed, an easily implemented, inexpensive treatment will become available for losing unwanted weight and a major public health problem may be abated. The knowledge that conditioning accounts for some of the problems said to derive from "Stone Age" bodies living in modern environments should allow humans to engineer modern environments to make those environments work *for* them rather than *against* them, thus mitigating any mismatch between Stone Age life and modern life.

A third feature of the target article that stands out for this commentator is a sometimes subtle but pervasive message that our understanding of scientific method is limited by the grip of traditional formulations. As a graduate student, I was puzzled by textbooks on experimental psychology that proclaimed the researcher begins by "stating a hypothesis." I wanted to know how the experimenter came by the hypothesis and I suspected that it usually derived from casual observation (unsystematic induction), or worse, from a "theory" that was itself based on casual observation. This seemed almost to guarantee a great deal of wasted effort. In the target article, Roberts shows that self-experimentation is on a short list of methods that have been shown to generate scientific ideas systematically. By a concatenation of data derived from such experimental analysis and correlational data consistent with theories already supported by converging lines of evidence (theories such as the theory of natural selection), Roberts shows us a way to begin filling the "missing methods" cell in his table of scientific activities. And the way he goes about doing it is entirely consistent with the way the great behavioral researchers have always generated the ideas that eventually led to new discoveries: by systematically investigating what appeared to be a cause/effect relation in the behavior of an individual organism – often discovered while collecting data on something else.

From methodology to data analysis: Prospects for the $n = 1$ intrasubject design

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Abstract: The target article is important not only for *black-box* studies, but also for those interested in tracing cognitive processing and/or subjective experience (via systematic self-observation). I provide two examples taken from my own research. I then proceed to discuss how best to analyze data from the $n = 1$ study, which has a factorial design.

Self-experimentation, or what some term *systematic self-observation,* has a venerable history in psychology, going back to the Würzburg school (Humphrey 1951) and even earlier to the work of Ebbinghaus. Roberts eschews a focus on subjective experience, discussing, as he does, cause-effect relationships in behaviour. Yet, I would argue that the importance of his target article is not only for *black-box* studies, but also for those interested in tracing cognitive processing and/or subjective experience. I provide two examples from my own research.

Schacter (1976, p. 475) presents the "entoptic explanation" of hypnagogic imagery, which states that entoptics serve as the raw data for hypnagogia. To test this, we manipulated awareness of both entoptics and hypnagogia in the same observers – my two coauthors, Friedland and Salach-Nachum, serving in time-locked single-subject designs (Glicksohn et al. 1990–91). Systematic self-

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