1.0 The Evolution of Human Communication and Cognition

There have been three revolutions in the history of human
thought, and we are on the threshold of a fourth. The first took
place hundreds of thousands of years ago when language first
emerged in hominid evolution and the members of our species
became inclined--in response to some adaptive pressures whose
nature is still just the subject of vague conjecture [1]--to
trade amongst themselves in propositions that had truth value.
There is no question but that this change was revolutionary,
because we thereby became the first--and so far the only--species
able and willing to describe and explain the world we live in.
It remains a mystery--to me at any rate--why our anthropoid
cousins, the apes, who certainly seem smart enough, do not share
this inclination of ours. At any rate, this divergence between
our two respective species was a milestone in human communication
and cognition, making it possible for culture to develop and be
passed on by oral tradition.

That momentous adaptation seems to have had a neurological basis.
Injuries to certain areas of the left side of the
brain--Wernicke's area and Broca's area, to be exact--result in
language-specific deficits in speaking and understanding [2, 3].
So whatever the evolutionary changes underlying language were,
they were imprinted as permanent modifications of our neural
hardware.

The second cognitive revolution was the advent of writing, tens
of thousands of years ago. Spoken language had already allowed
the oral codification of thought; written language now made it
possible to preserve the code independent of any speaker/hearer.
It became, if you like, an implementation-independent code. No
one knows for sure whether there was any corresponding change in
our cerebral hardware. There is nominally a region in the left
frontal lobe--Exner's area--that is dubbed the "writing center,"
and there are certainly specific neurological problems associated
with "dyslexia" or reading disorder. But all of this neurology
is complicated and ill-understood, and no "pure" alexia
(inability to read), without any other associated visual or motor
problems, has been found. So it is more likely, I think, that
writing and reading were cognitive and motor skills that we
acquired without any organic evolutionary change in our brains;
they were merely learned adaptations of the same hardware we had
all along.

No precise starting point can be assigned to either science or
literature. The former began with the first true proposition
about the world and the latter either with the first such true
proposition that was also formulated elegantly, or perhaps with
the first untrue proposition. In either case, the oral tradition
was already equipped to produce both science and literature,
although perhaps science, being a little too constrained by the
limits of memory and accuracy in the word-of-mouth medium, was
the greater beneficiary of the advent of writing, with the
incomparably greater reliability and systematization it conferred
in preserving the words, and hence the thoughts, of others.

But there were constraints on writing too. For whereas spoken
language conformed well to both the transmitting and receiving
powers of human thinkers (perhaps as a reflection of its specific
dedicated neurology), writing was somewhat out of synch with
thought. It was slow. And worse than that, it had a much more
limited scope, for whereas a spoken proposition could be heard by
several people, even by multitudes, a written one could only be
read by one at a time. This could be done serially by limitless
numbers of readers, of course, and this was the real strength of
writing, but it was purchased at the price of becoming a much
less interactive medium of communication than speech. The form
and style of written discourse accordingly adapted to this
lapidary new medium--again, not neurologically, but consciously
and by convention--constraining the writer to be more precise in
some respects, but also allowing him more freedom to redraft and
reformulate his text in composing it. In becoming less
interactive, writing also became less spontaneous than speech,
more deliberate, and more systematic. One might also say it
became less social and more solipsistic, although its ultimate
social reach became much larger, limited only by the slow pace of
copyists in providing the text to disseminate.

The third revolution took place in our own millennium. With the
invention of moveable type and the printing press, the laborious
hand-copying of texts became obsolete, and both the tempo and the
scope of the written word increased enormously. Texts could be
distributed so much more quickly and widely that again the style
of communication underwent qualitative changes. If the
transition from the oral tradition to the written word made
communication more reflective and solitary than direct speech,
print restored an interactive element, at least among scholars,
and, if the scholarly "periodical" was not born with the advent
of printing, it certainly came into its own. Scholarship could
now be the collective, cumulative, and interactive enterprise it
had always been destined to be. Evolution had given us the
cognitive wherewithal and technology had given us the vehicle.

+ Page 41 +

Of course, there had already been a prominent exception to the
impersonal trend set in motion by writing, namely, private
letters. These made it possible for people to communicate even

when they were separated by great distances, although again the pace of the communication was much slower and less interactive than live conversation, and it continued to be so, even after the advent of print.

Many minor and major technological changes followed, but none, I think, qualify as revolutionary. The means of transportation improved, so the written word could be circulated more quickly and more widely. The typewriter (and eventually the word processor) made it much easier to generate and modify one's texts. Photocopying made it possible to duplicate, and desktop publishing to print, even texts that weren't worth duplicating and printing. And the telephone all but did in the art of letter writing altogether, probably because it restored the natural tempo of spoken communication to which the brain is constitutionally adapted. Of course, phoning had the disadvantage of not leaving a permanent record, but for that there were tape recorders, and so on.

The reason I single out as revolutionary only speech, writing, and print in this panorama of media transformations that shaped how we communicate is that I think only those three had a qualitative effect on how we think. In a nutshell, speech made it possible to make propositions, hand-writing made it possible to preserve them speaker-independently, and print made it possible to preserve them hand-writer-independently. All three had a dramatic effect on how we thought as well as on how we expressed our thoughts, so arguably they had an equally dramatic effect on what we thought. The rest of the technological developments were only quantitative refinements of the media created by speech, writing, and print. The purist might, with some justification, even hold that print was just a quantitative refinement of writing, but let's argue about that another time: the historic evidence for the impact of print is considerable.

+ Page 42 +

The two factors mediating the qualitative effects were speed and scale. Speech slowed thought down, but to a rate for which the brain made specific organic adaptations. Our average speaking rate is a biological parameter; it is a natural tempo. Hand-writing slowed it down still further, but here the adaptations were strategic and stylistic rather than neurological. In writing, the brain was underutilized. Evidence for this comes from the fact that when the typewriter and the word processor allowed the pace of writing to pick up again, we were quite ready to return to a tempo closer to our natural one for speech. On the other hand, the constraints of the written medium are substantive, and they affect both form and content, as anyone who has tried to use raw transcripts of spontaneous speech can attest. What is acceptable and understandable in spoken form is unlikely to be acceptable and understandable in written form, and vice versa.

In a sense, there are only three communication media as far as

our brains are concerned: the nonverbal medium in which we push,
pull, mime and gesticulate [4]; and two verbal media--the natural
one, consisting of oral speech (and perhaps sign language), and
the unnatural one, consisting of written speech. Two features
conspire to make writing unnatural. One is the constraint it
puts on the speed with which it allows thoughts to be expressed
(and hence also on the speed with which they can be formulated),
and the other is the constraint it puts on the interaction of
speaking thinkers--and hence again on the tempo of their
interdigitating thoughts, both collaborative and competitive.
Oral speech not only matches the natural speed of thought more
closely, it also conforms to the natural tempo of interpersonal
discourse. In comparison, written dialogue has always been
hopelessly slow: the difference between "real-time" dialogue and
off-line correspondence. Hopeless, that is, until the fourth
cognitive revolution, which is just about to take place with the
advent of "electronic skywriting."

+ Page 43 +

2.0   Scholarly Skywriting: A Personal Glimpse of the Potential
       Panorama

I must now turn from impressionistic history to personal
anecdote. My own skyward odyssey in the newest communication
medium, the airwaves of electronic telecommunication networks,
had its roots in a long-standing personal penchant for scholarly
letter-writing (to the point of once being cited in print as
"personal communication, pp. 14-20"). These days few share my
epistolary bent, which is dismissed as a doomed anachronism.
Scholars don't have the time. Inquiry is racing forward much too
rapidly for such genteel dawdling--forward toward, among other
things, due credit in print for one's every minute effort. So I
too had to resign myself to the slower turnaround but surer
rewards of conventional scholarly publication. In fact, a decade
and a half ago I founded a scholarly journal in the conventional
print medium, though Behavioral & Brain Sciences (BBS) is hardly
a conventional journal.

2.1 Behavioral and Brain Sciences

Modelled on Current Anthropology (CA, which was founded by the
anthropologist Sol Tax, who in turn modelled it on the extreme
participatory democratic practices of the native North American
peoples he studied), BBS's unique feature is "creative
disagreement" [5]. Specializing in important and influential
ideas and findings in the biobehavioral sciences, BBS, after a
round of particularly rigorous peer review (involving five to
eight referees representing the multiple areas that candidate
manuscripts must impinge upon), offers to the authors of accepted
papers the service of "open peer commentary." Their manuscript
is circulated to specialists across disciplines and around the
world, each invited to submit 1,000-word commentaries that
discuss, criticize, amplify, and supplement the work reported in

the target article, which is then published along with the
commentaries (often twenty or more) and the author's formal
response to them [6]. BBS's open peer commentary service has
evidently been found valuable by the world biobehavioral science
community, because already in its fourth year its "impact factor"
(citation ratio) had become one of the highest in its field [7,
8].

+ Page 44 +

2.2 Limitations of Print Journals

Like other print journals, BBS is prisoner to the temporal,
geographic, and (shall we call them) "internoetic" constraints of
the conventional paper publication medium. In that medium, new
ideas and findings are written up and then submitted for peer
review [9, 10]. The refereeing may take anywhere from three
weeks to three months. Then the author revises in response to
the peer evaluation and recommendations, and when the article is
finally accepted, it again takes from three to nine months or
more before the published version appears (perhaps earlier, when
circulated informally in preprint form). That's not the end of
the wait, however, but merely the beginning, for now the author
must wait until his peers actually read and respond in some way
to his work, incorporating it into their theory, doing further
experiments, or otherwise exploring the ramifications of his
contribution. After all, that's why creative scholars publish--
not to put another line on their resumes, but to collaborate with
their peers in expanding our collective body of knowledge.

It usually takes several years, however, before the literature
responds to an author's contribution (if it responds at all) and
by that time the author, more likely than not, is thinking about
something else. So a potentially vital spiral of peer
interactions, had it taken place in "real" cognitive time, never
materializes, and countless ideas are instead doomed to remain
stillborn. The culprit is again the factor of tempo: the fact
that the written medium is hopelessly out of synch with the
thinking mechanism and the organic potential it would have for
rapid interaction if only there were a medium that could support
the requisite rounds of feedback, in tempo giusto!

Hopeless, as noted earlier, until the forthcoming fourth
cognitive revolution makes it possible to restore scholarly
communication to a tempo much closer to the brain's natural
potential while still retaining the rigor, discipline, and
permanence of the refereed written medium.

+ Page 45 +

2.3 Discussion Groups on the Net

I will try to illustrate with an account of my own first
(unrefereed) glimpse of the Platonic world of scholarly
skywriting. Most of the world's universities and research

institutions are linked together by various international
electronic networks such as BITNET and Internet (called,
collectively, the "Net"). Electronic mail ("e-mail") can be sent
via the Net, usually within minutes, to London, Budapest, Tel
Aviv, Tokyo, lately even Minsk. But the feature that has the
most remarkable potential is multiple reciprocal e-mail:
electronic discussion groups in which every message is
immediately disseminated to all members.

These groups first formed themselves anarchically, on various
networks, the biggest of them called USENET, and were devoted
partly to technical discussion about computers and information,
the technologies that had built the Net, and otherwise to
"flaming": free-for-all back and forth messages by anyone, on any
topic under the sun. Next, discussion groups devoted to specific
topics (e.g., computers, politics, language, culture, and sex)
began to form, and these in turn split into "unmoderated" and
"moderated" groups. Anyone with an e-mail address whose
institution was connected to USENET could post to an unmoderated
group, and the message would automatically be sent to everyone
who was "subscribed" to the group.

It was because most of the unmoderated groups were quite chaotic
that the moderated groups were formed. In these, all submissions
had to be channeled through a "moderator," but this was usually
someone with no special qualifications or expertise, so the
quality of the information on the moderated groups was still very
uneven, and, with a few exceptions (principally technical
discussions about computing itself), these groups were mostly
havens for uninformed students and dilettantes rather than
respectable scholarly forums for learned specialists in the
subject matter under discussion, a subject matter that by now
ranged across the humanities, the social sciences, and the
natural sciences.

+ Page 46 +

This was the status quo on the Net--a communication medium with
revolutionary intellectual potential being used mostly as a
global graffiti board (in all fields other than computing
itself)--when I first sampled the skyways several years ago in a
large (unmoderated) USENET group called "comp.ai" (devoted to the
topic of artificial intelligence, a subfield of my own specialty,
cognitive science). I had heard that there was a lot of ongoing
discussion on comp.ai about something that had appeared in
BBS--Searle's "Chinese Room Argument" [11]. The content of that
discussion is not relevant here. Suffice it to say that about a
profound and complex topic a great deal of nonsense was being
posted on comp.ai by people who knew very little (mostly students
and computer programmers). This initial demography, and the
unscholarly level of discussion that prevailed because of it, was
and still is one of the principal obstacles to the Net's
realizing its real potential. For what true scholar would
condescend to join these innocents in serious scholarly
discussion, and in such an anarchic medium!

Well, draw your own conclusions, but that did not stop me.
Whether it was my partiality for letter-writing or for creative
disagreement, I decided to test out the airways, but consciously
applying self-imposed constraints, since the medium would not
provide them for me. My postings to comp.ai would be
conscientiously thought out and carefully written, as if they
were for a serious refereed journal, with a sophisticated
scholarly readership--for posterity, in fact. Hardest of all, I
would treat the contributions of my interlocutors as if they had
been serious and scholarly ones too, and when these were
uninformed or in error, I would endeavor to correct them in a
dignified and respectful way that would be informative and
instructive to all, solemnly trying to correct the Nth instance
of the same egregious mistake with a Nth new aspect or dimension
of the problem under discussion, always with the objective of
advancing the ideas for all skygazers. Indeed, critical to my
efforts at sobriety and self-discipline was maintaining for
myself a conscious fantasy that, silent among the thousands of
eyes trained skyward, were my peers, and not just the rookies I
was jousting with.

+ Page 47 +

Lest it be thought that this was all just some sort of altruistic
exhibition, however, let me hasten to report that I found myself
by far the greatest beneficiary of this exercise. For the
remarkable fact is that even under these primitive demographic
conditions my own ideas profited enormously from the skywriting
interactions. The problem under discussion (and it only became
evident to me during the discussion just what that problem was) I
dubbed, in the course of the skywriting, "the symbol grounding
problem," and it has since generated not only a series of (alas,
conventional, ground-based) papers [12, 13, 14], but also a
cottage industry in the form of a theme for workshops and
symposia [15], and soon, no doubt, dissertations. All this as a
consequence of aerobatics with mere rookies. "So what would it
have been like," I then asked myself, "if the best minds in the
field were on the Net, skywriting away with the rest of us?"

2.4 Psycoloquy

When I founded BBS fifteen years ago, I had been inspired by the
remarkable potential of "open peer commentary" as revealed
through an article by Gordon Hewes [16] in Sol Tax's commentary
journal, CA. That article was on the origin of language, a topic
that had been under an informal moratorium (as breeding only idle
conjectures) imposed by the Paris Societe Linguistique a century
earlier. Hewes and his animated commentators across disciplines
so piqued my own interest in the topic that I: (1) co-organized
an international conference under the auspices of the New York
Academy of Sciences [17] (a conference that effectively put an
end to the moratorium on the topic and went on to spawn an
uninhibited series of language-origins conferences, e.g.,

Raffler-Engel et al. [18]); and (2) I founded BBS, convinced that
Sol Tax's "CA Comment" principle could be generalized beyond its
discipline of origin.

A decade and half later my own rewarding experience with
electronic skywriting has convinced me that this newest medium's
unique potential to support and sustain open peer commentary must
now be made generally available too, so I have founded
Psycoloquy, a BBS of the air, unfettered by the temporal and
spatial constraints of the earthbound print medium.

+ Page 48 +

Originally initiated in 1985 by Bob Morecock of the University of
Houston as an electronic bulletin board called the "BITNET
Psychology Newsletter," Psycoloquy was transformed in 1989 into a
refereed electronic journal (ISSN Number 1055-0143). It is now
sponsored on an experimental basis by the Science Directorate of
the American Psychological Association. I am Co-Editor for
scientific contributions, and the Co-Editor for clinical, applied
and professional contributions is Perry London, Dean of the
Graduate School of Applied and Professional Psychology at Rutgers
University.

One of Psycoloquy's principal scholarly objectives is to
implement peer review on the Net in psychology and its related
fields (cognitive science, neuroscience, behavioral biology,
linguistics, and philosophy). All contributions are refereed by
a member of Psycoloquy's Editorial Board (currently 50 members
and growing), but the idea is not just to implement a
conventional journal in electronic form. Psycoloquy is
explicitly devoted to scholarly skywriting, the radically new
form of communication made possible by the Net, in which authors
post to Psycoloquy a brief report of current ideas and findings
on which they wish to elicit feedback from fellow specialists as
well as experts from related disciplines the world over.

The refereeing of each original posting and each item of peer
feedback on it is to be done very quickly, sometimes within a few
hours of receipt, so as to maintain the momentum and interactive
quality of this unique medium, just as if each contribution were
being written in the sky, for all peers to see and append to.
Skywriting promises to restore the speed of scholarly
communication to a rate much closer to the speed of thought,
while adding to it a global scope and an interactive dimension
that are without precedent in human communication, all conducted
through the discipline of the written medium, monitored by peer
review, and permanently archived for future reference. Scholarly
skywriting in Psycoloquy is intended especially for that
prepublication "pilot" stage of scientific inquiry in which peer
communication and feedback are still critically shaping the final
intellectual outcome. That formative stage is where the Net's
speed, scope, and interactive capabilities offer the possibility
of a phase transition in the evolution of knowledge, one in which
we break free from the earthbound inertia that has encumbered

human inquiry until now, soaring at last to the skyborn speeds to
which our minds were organically destined [19].

Psycoloquy appears in two forms. Its USENET version, called
"sci.psychology.digest," is "gatewayed" to the Net from
Princeton. Its BITNET version, formerly stored at Tulane
University and archived at the University of Houston, is now at
Princeton too. The BITNET version currently has around 2,500
individual subscribers and redistribution lists. The USENET
version (which is transmitted to sites rather than individuals,
and hence is not directly monitored for number of subscribers)
may well be reaching an order of magnitude more readers.

Psycoloquy is fully international, with subscribers in the
Americas, Europe, Eastern Europe, the Soviet Union, the Middle
and Far East, and growing parts of the third world (where
electronic journals promise to be a godsend for the libraries and
scholars who have hitherto been information deprived because of
currency restrictions and budget limitations).

Subscription to Psycoloquy is free. To subscribe, anyone with a
login on any of the networks can send the following one line e-
mail message to LISTSERV@PUCC.BITNET: "SUB PSYC First Name Last
Name" (omitting quotes and substituting your own first and last
name). The message must originate from the e-mail address at
which you wish to receive Psycoloquy. Subsequent postings are
sent to PSYC@PUCC.BITNET or to PSYC@PHOENIX.PRINCETON.EDU.

Psycoloquy currently appears about once a month, but we are
prepared to publish it much more frequently as the submission
rate and demand increase. Back issues of Psycoloquy are archived
at Princeton, and they can be retrieved from any Internet e-mail
address directly by a simple procedure called "anonymous FTP."
Princeton also has a service called "BITFTP" that allows issues
to be retrieved indirectly from BITNET by e-mail (other services
exist, for example, for JANET subscribers in the United Kingdom).
Soon, with the help of an experimental searchable database
provided by Bellcore and some collaborative efforts with the
American Mathematical Society, it should be possible not only to
retrieve items, but to do interactive full-text searches of the
Psycoloquy archive from both BITNET and Internet.

3.0 After the Revolution

This fourth revolution has not yet taken place. Some of the
impediments have already been noted: (1) the current demography
of the Net and the stereotype it has created of the medium as not
suitable for serious scholarly communication; (2) the ingrained
habits of a scholarly community adapted to the paper medium for
centuries; (3) the foot-dragging of the paper publishing
industry, with all its interests vested in the ground-based

technology; and (4) many prima facie doubts and objections (e.g., about quality, academic credit, and security), all of which are easily and decisively answerable [20], even though they keep getting raised again and again. (An attempt to lay to rest these prima facie objections once and for all is in preparation [21].)

It is a foregone conclusion that the revolution will come. My selfish concern is with getting it underway while I am still compos mentis and in a position to partake of its intellectual benefits! Allies in hastening its coming will be the libraries, whose budgets are overburdened with the expenses associated with the print medium; learned societies, whose primary motivation is to get carefully refereed scholarly information disseminated to the peer community as quickly and fully as possible; and the scholarly community itself, who will surely realize that it is they, not the publishers who merely give it the imprimatur, who are the controllers of the quality of the scholarly literature through peer review--not to mention that they are also the creators of the literature itself. (A strategic pro-revolutionary alliance may be in order.)

But the most important factor in hastening the onset of the fourth cognitive revolution will surely be the unique capabilities of the medium itself. Electronic journals should not and will not be mere clones of paper journals, ghosts in another medium. What we need, and what Psycoloquy will endeavor to help provide, are some dazzling demonstrations of the unique power of scholarly skywriting. I am convinced that once scholars have experienced it, they will become addicted for life, as I did. And once word gets out that there are some remarkable things happening in this medium, things that cannot be duplicated by any other means, these conditions will represent to the scholarly community an "offer they cannot refuse." We are then poised for a lightning-fast phase transition, again a unique feature of the scale and scope of this medium, one that will forever leave the land-based technology far behind, as scholarship is launched at last into the post-Gutenberg galaxy.

+ Page 51 +

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+ Page 53 +

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